An inventory of alien species and their threat to biodiversity and economy in Switzerland

Mit deutscher Zusammenfassung
Avec résumé en français

CABI Bioscience Switzerland Centre
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Frontispiece: common carp, Egyptian goose, raccoon, giant hogweed.
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Contents

List of Fact sheets

List of figures

List of tables

Abstracts

Globalization increases trade, travel and transport and is leading to an unprecedented homogenization of the world's biota by transport and subsequent establishment of organisms beyond their natural barriers. Some of these alien species become invasive and pose threats to the environment and human economics and health. This report on alien biota in Switzerland lists about 800 established alien species and characterises 107 invasive alien species (IAS) in Fact Sheets: five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two 'worms', seven fungi, one bacteria, and 48 plants. A general chapter explains some common patterns in pathways, impacts and management, and gives recommendations for the management of alien species. The main body of the report is organised into taxonomic groups, and includes an overview, lists of alien species, Fact Sheets on the invasive species, and an evaluation of the status, impacts, pathways, control options and recommendations. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references.

Mit der zunehmenden Globalisierung nimmt auch der Handel, Verkehr und das Reisen zu und führt zu einer noch nie dagewesenen Homogenisierung der Biodiversität; Organismen werden über die natürlichen Grenzen hinaus transportiert. Einige dieser Neuankömmlinge können sich etablieren, und wiederum einige von diesen werden invasiv und bedrohen die einheimische Vielfalt, richten wirtschaftlichen Schaden an oder schädigen die menschliche Gesundheit. Dieser Bericht über die gebietsfremden Arten der Schweiz listet über 800 etablierte gebietsfremde Arten auf und stellt die 107 Problemarten in Datenblättern vor: fünf Säugetiere, vier Vögel, ein Reptil, drei Amphibien, sieben Fische, vier Weichtiere, 16 Insekten, sechs Krebstiere, drei Spinnen, zwei 'Würmer', sieben Pilze, ein Bakterium und 48 Pflanzen. Das erste Kapitel erläutert einige allgemeine Einführungswege, negative Einflüsse und Gegenmassnahmen und gibt Vorschläge für den Umgang mit gebietsfremden Arten. Der Hauptteil besteht aus den Kapiteln zu den einzelnen taxonomischen Gruppen. Die Listen werden begleitet durch einen erläuternden Text, die Datenblätter stellen die Problemarten vor und schliesslich wird eine Auswertung der Situation, der Auswirkungen, der Einführungswege, mögliche Gegensteuerungsmassnahmen und Empfehlungen zu den jeweiligen taxonomischen Gruppen gegeben. Die Datenblätter bieten Information zu Taxonomie, Beschreibung, Ökologie, Herkunft, Einführungswege, Verbreitung, Auswirkungen, Ansätze zur Gegensteuerung und ein Literaturverzeichnis.

La mondialisation implique une augmentation du commerce et des transports et entraîne une uniformisation sans précédant des biomes par le transfert et l'implantation des organismes vivants au delà de leurs barrières naturelles. Certaines de ces espèces exotiques deviennent envahissantes et représentent une menace pour l'environnement, l'économie et la santé publique. Ce rapport sur les organismes biologiques exotiques en Suisse inventorie environ 800 espèces non-indigènes établies dans le pays et détaille 107 espèces envahissantes sous forme de fiches d'information : cinq mammifères, quatre oiseaux, un reptile, trois amphibiens, sept poissons, quatre mollusques, 16 insectes, six crustacés, trois araignées, deux « vers », sept champignons, une bactérie et 48 plantes. Un chapitre général explique les modes d'introduction principaux des espèces exotiques et leur impact sur le milieu. Il donne également des recommandations sur la gestion et la lutte contre les organismes envahissants. Le corps principal du rapport est présenté par groupe taxonomique pour chacun desquels sont proposés une discussion générale, la liste des espèces non-indigènes, les fiches d'information sur les principales espèces envahissantes et une évaluation du statut, de l'impact, des modes d'introduction, les méthodes de lutte et des recommandations générales. Les fiches résument pour des espèces particulièrement envahissantes ou potentiellement dangereuses les informations sur la taxonomie, la description, l'écologie, l'origine, l'introduction en Suisse et en Europe, la distribution, l'impact, la gestion et les références bibliographiques.

Summary

Globalization is increasing trade and travel on an unprecedented scale, and has inadvertently led to the increased transport and introduction of alien species, breaking down the natural barriers between countries and continents. Alien species are not bad *per se*, in fact many species are beneficial for humans, e.g. most crop species. However, some alien species have become harmful, and pose threats to the environment and humans. Invasive alien species (IAS) are increasingly recognized as one of the major threats to biodiversity.

All signatories to the Convention on Biological Diversity (CBD), including Switzerland, have agreed to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.

There is a widespread view that IAS are of less concern in Central Europe than on other continents (and more especially on islands). Possible reasons for this include the small size of nature reserves, the high human impact on all 'natural' environments, and the long association of alien species and humans leading to familiarisation and adaptation. However, the number of cases of dramatic impact is increasing and awareness among scientists and the public is steadily growing. Thus, the threats from IAS should not be underrated. One of the major consequences, which is undoubtedly unfolding before our eyes, is global homogenization, with the unique character of places such as Switzerland being lost, the characteristic flora and fauna invaded by organisms which reproduce to eventually form the largest proportion of biomass in certain ecosystems.

Time lags, i.e. the gap between establishment and invasion, makes prediction of invasiveness of alien species very difficult. Well-established species showing no hint of any harm to the environment may still become invasive in the future. There are three major categories of factors that determine the ability of a species to become invasive: intrinsic factors or species traits; extrinsic factors or relationships between the species and abiotic and biotic factors; and the human dimension, incorporating the importance of species to humans.

This report compiles information about alien species in Switzerland from published sources and experts in Switzerland and abroad. Imminent future bioinvasions are also included. The availability of national lists varies greatly between taxonomic groups. Thus, unfortunately, it is not possible to list all the alien species of Switzerland, since not all resident species are known yet. However, for groups that are well known, complete lists have been compiled. For some groups only invasive species rather than alien species are treated, and other groups could not be covered at all.

The broad taxonomic groupings used are vertebrates, crustaceans, insects, arachnids, molluscs, other animals, fungi and plants. For each group, we present an overview, a list of alien species, Fact Sheets for the invasive species, an evaluation of the status, impacts, pathways and control options for the group, and recommendations. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references.

Definitions of the important terms used in the report are given, since frequently-used terms such as 'invasive' are often used in different ways.

The situation regarding IAS in Switzerland is similar to that in other Central European countries, in particular Austria, which is also a land-locked country containing part of the Alps. This report lists about 800 alien species and characterises 107 IAS in Fact Sheets: five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two 'worms', seven fungi, one bacteria, and 48 plants.

Pathways can be divided into those for species deliberately introduced and those for species accidentally introduced. Pathways for deliberate introductions include the trade of species used in aquaculture, for fisheries, as forest trees, for agricultural purposes, for hunting, for soil improvement and solely to please humans as ornamentals. Most of these can also transport hitchhiking species and people can accidentally introduce species while travelling. In general, most aquatics and terrestrial invertebratesand diseases are accidental arrivals, whereas most plants and vertebrates are deliberately introduced. The global trend for the latter groups also holds true for Switzerland, e.g. 75% of the 20 Black List plants were introduced principally as ornamentals, and 35 of the 37 vertebrates were

deliberately introduced. Thus, many damaging invaders were deliberately introduced, often with little justification beyond the wish to “improve” the landscape, e.g. ornamental plants and waterfowl.

The impacts of IAS are often considerable, in particular when ecosystem functioning is altered or species are pushed to extinction, as has been shown for many bird species on islands. The environmental impacts can be divided into four major factors: competition, predation, hybridization and transmission of diseases. The most obvious examples for competition are between introduced and native plants for nutrients and exposure to sunlight. Resource competition has also led to the replacement of the native red squirrel (*Sciurus vulgaris*) by the introduced American grey squirrel (*S. carolinensis*) in almost all of Great Britain and it is predicted that this trend will continue on the continent. The musk rat (*Ondatra zibethicus*) causes declines of native mussels population (Unionidae) by predation and the amphipod *Dikerogammarus villosus* is a serious predator of native freshwater invertebrates. A well-known example of hybridization from Europe is the ruddy duck (*Oxyura jamaicensis*), which hybridizes with the endangered native white-headed duck (*O. leucocephala*). In some cases IAS can harbour diseases and act as a vector for those diseases to native species. This is the case with American introduced crayfish species to Europe, which are almost asymptomatic carriers of the alien crayfish plague (*Aphanomyces astaci*), but the native noble crayfish (*Astacus astacus*) is highly susceptible to the disease, and thus is struggling to coexist with populations of the American crayfish species.

In addition to impacts on biodiversity, many IAS cause enormous economic costs. These costs can arise through direct losses of agricultural and forestry products and through increased production costs associated with control measures. A North American study calculated costs of US$ 138 billion per annum to the USA from IAS. A recently released report estimates that weeds are costing agriculture in Australia about Aus$ 4 billion a year, whereas weed control in natural environments cost about Aus$ 20 million in the year from mid 2001 to mid 2002. In Europe, the costs of giant hogweed (*Heracleum mantegazzianum*) in Germany are estimated at € 10 million; € 1 million relating to each of the environment and health sectors, and the remainder represents costs to the agricultural and forestry sectors. Economic damage by the western corn rootworm (*Diabrotica virgifera*) is increasing as it spreads through Europe. Some IAS also have implications for human health, e.g. giant hogweed produces copious amounts of a sap containing phototoxic substances (furanocoumarins), which can lead to severe burns to the skin. The raccoon dog (*Nyctereutes procyonoides*), introduced as a fur animal, can, like the native red fox (*Vulpes vulpes*), act as a vector of the most dangerous parasitic disease vectored by mammals to humans in Central Europe, i.e. the fox tapeworm (*Echinococcus multilocularis*). Known impacts of species introduced into Switzerland are presented, although some recent invaders have not yet been reported to have impact in Switzerland; in these cases impacts assessed in other countries are given. Demonstration of environmental impacts is often difficult because of the complexity of ecosystems, but alien species occurring in high numbers, such as Japanese knotweed (*Reynoutria japonica*) totally covering riversides, or an animal biomass of alien species of up to 95% in the Rhine near Basel, must have impacts on the native ecosystem. All species use resources and are resources to other creatures and so they alter the web and nutrient flow of the ecosystems they are living in.

Recommendations for the management – in its widest sense – of groups of invasives and individual species are given in the respective chapters and Fact Sheets. Preparing a national strategy against IAS is recommended to deal with IAS in an appropriate way and as anticipated by the CBD. This action plan should identify the agency responsible for assessing the risks posed by introductions, provide funding mechanisms and technical advice and support for control options. Prevention measures against further bioinvasions need to be put in place to stem the tide of incoming new species arriving accidentally with trade and travel or introduced deliberately for various purposes. New deliberate introductions must be assessed as to the threat they may present and only introduced on the basis of a risk analysis and environmental impact assessment. This report indicates some important pathways for consideration and shows that most invasive species are deliberately introduced. The use of native plants and non-invasive alien plants for gardening and other purposes should be promoted. Laws regulating trade in plant species on the Black List would be a first step in the right direction to reduce the impact of these species. However, restrictions for species already widely distributed within Switzerland will not drastically change the situation unless the populations already present are eradicated or controlled. Fish introductions are regulated by the Fisheries Act, which names those species for which an authorization for release is needed, and species for which release is prohibited altogether. This is a good basis, although the law could be better adapted to the current situation, as described in the fish section. The aquarium and terrarium trade is another important sector that could be more strictly regulated to stop releases of pets into the wild. A major problem with introductions of IAS is that the costs when they invasive are borne by the public, while the financial incentives for introducing them lie with individuals or specific businesses. Development of economic tools that shift the burden of IAS to those who benefit from international trade and travel is a neglected approach (also called the ‘polluter pays’ principle). Appropriate tools would be fees and taxes, including fees levied on those who import the organisms or goods. Awareness raising is a significant tool in the prevention and management of IAS, since some member of the public would adhere to advice if they knew about its importance and the reason for it. Scientists and decision-makers also need better access to information about invasive species, their impacts, and management options. To address the impacts of those invasive species already present in Switzerland, their populations need to be managed: either eradicated or controlled. Possible targets for eradication are the sika deer (*Cervus nippon*), the mouflon (*Ovis orientalis*), and the ruddy shelduck (*Tadorna ferruginea*), which will otherwise increase its range and spread to neighbouring countries. A pilot national eradication / control programme against a prominent invader, e.g. a Black List plant species, is recommended as a case study. Monitoring populations of some alien species is recommended to detect any sudden increases indicating potential invasiveness. By doing this, control or even eradication efforts can be employed before the populations become unmanageable. While compiling the information for this report it became clear that more information about the status of IAS in Switzerland is needed. More studies on alien species are highly recommended to assess the importance of IAS and to demonstrate their significance to policy-makers and politicians.

Limited resources dictate the need for setting priorities and allocating funds where it will have the greatest impact in combating IAS. Important points, for example, are to critically assess the feasibility of different approaches, and to target species for which there is no conflict of interest. Opposition to action against less-important ornamentals on the Black List and species of direct human health concern (giant hogweed) should be negligible.

Zusammenfassung

Mit der zunehmenden Globilisierung ist ein starker Anstieg des Warentransportes, Verkehrs und Tourismus zu verzeichnen. Dies führt zu ungewollten wie beabsichtigten Einführungen von gebietsfremden Arten in einem noch nie dagewesenen Umfang, und der Verschmelzung von Biodiversitäten der unterschiedlichen Länder und Kontinente, so dass nur schwer zu überbrückende natürliche Ausbreitungsschranken plötzlich überwunden werden. Nicht alle gebietsfremden Arten sind automatisch als negativ zu bewerten. Tatsächlich sind viele Arten wichtige Bestandteile der Ökonomie eines Landes, man denke nur an die zahlreichen gebietsfremden Kulturpflanzen. Einige Arten entwickeln sich allerdings zu Problemarten und bedrohen die einheimische Biodiversität, richten wirtschaftlichen Schaden an oder stellen eine Gefahr für die Gesundheit dar.

Gebietsfremde Problemarten (invasive alien species) werden heute als eine Hauptbedrohung für die Biodiversität angesehen. Die Biodiversitätskonvention (CBD) verpflichtet die internationale Staatengemeinschaft Vorsorge gegen diese invasiven Arten zu treffen und diese gegebenenfalls zu bekämpfen.

Gebietsfremde Arten in Zentraleuropa werden oft als geringes Problem eingestuft, im Vergleich zu anderen Kontinenten und vor allem Inseln. Mögliche Gründe für diese Unterschiede sind die relativ kleinen Schutzgebiete, was die Möglichkeit für eine intensive Pflege eröffnet, die stark vom Menschen beeinflussten 'Naturräume' und das lange Zusammenleben von vielen gebietsfremden Arten mit dem Menschen, das zu vielfältigen Anpassungen geführt hat. Trotzdem nehmen die Fälle von dramatischen Auswirkungen von gebietsfremden Arten und das Bewusstsein in der Bevölkerung und bei den Wissenschaftlern zu. Zweifellos ist die globale Homogenisierung in vollem Gange und der einzigartige Charakter von lokalen Ökosystemen, wie zum Beispiel in der Schweiz, gehen für immer verloren, da die charakteristische Pflanzen- und Tierwelt von gebietsfremden Arten verändert wird und einige dieser Arten die grössten Anteile an der Biomasse von einigen Ökosystemen erreichen.

Die Zeitdifferenz, die zwischen der Ankunft einer Art und ihrer starken Ausbreitung auftreten kann, macht Voraussagungen der Invasivität von Arten aussserordentlich schwierig. Einige schon lange etablierte Arten können plötzlich und unerwartet invasiv werden. Drei Kategorien von Faktoren bestimmen die Invasivität von Arten: 1. die biologischen Merkmale einer Art, 2. das Zusammenspiel einer Art mit ihrer abiotischen und biotischen Umwelt und 3. die Beziehungen der Menschen zu dieser Art.

In diesem Bericht ist Information über gebietsfremde Arten der Schweiz sowohl von publizierten Dokumenten als auch von direktem Austausch mit Experten in der Schweiz und des Auslandes zusammengetragen. Bevorstehende Einwanderungen sind ebenfalls erfasst worden. Die Verfügbarkeit von Artenlisten in den einzelnen taxonomischen Gruppen ist sehr unterschiedlich, so dass es nicht möglich ist alle gebietsfremden Arten zu benennen. In einigen Gruppen ist das Wissen sogar der einheimische Arten so rudimentär, dass kein Versuch gemacht wurde, sie zu bearbeiten, und bei anderen Gruppen wurden nur Problemarten aufgenommen. Die Listen der gebietsfremden Arten wieder anderer Gruppen dagegen sind vollständig.

Die gebietsfremden Organismen wurden in folgende Gruppen aufgeteilt: Wirbeltiere, Krebstiere, Insekten, Spinnentiere, Weichtiere, andere Tiere, Pilze und Pflanzen. In jedem Kapitel befinden sich die Listen der gebietsfremden Arten, ein erläuternder Text, Datenblätter der Problemarten und eine Auswertung der Situation, der negativen Auswirkungen, der Einführungswege, der möglichen Gegensteuerungsmassnahmen und Empfehlungen für den Umgang mit diesen Arten. Die Datenblätter bieten Information zu Taxonomie, Beschreibung, Ökologie, Herkunft, Einführungswege, Verbreitung, Auswirkungen, Ansätze zur Gegensteuerung und ein Literaturverzeichnis.

Definitionen der wichtigsten Begriffe, wie sie in diesem Dokument benutzt werden, werden ebenfalls gegeben, da sie oftmals unterschiedlich gebraucht werden.

Die Situation der gebietsfremden Arten der Schweiz ist ähnlich wie in anderen mitteleuropäischen Ländern, vor allem Österreich, das eine ähnliche Topographie besitzt. Dieser Bericht über die gebietsfremden Arten der Schweiz listet über 800 etablierte gebietsfremde Arten auf und stellt die 107 Problemarten in Datenblättern vor: fünf Säugetiere, vier Vögel, ein Reptil, drei Amphibien, sieben Fische, vier Weichtiere, 16 Insekten, sechs Krebstiere, drei Spinnen, zwei 'Würmer', sieben Pilze, ein Bakterium und 48 Pflanzen.

Es können versehentlich eingeschleppte Arten und bewusst eingeführte Arten unterschieden werden. Eingeführt sind zum Beispiel Arten der Aquakulturen, der Fischerei, der Waldwirtschaft, der Landwirtschaft, der Jagd, zur Bodenverbesserung und einfach zur Bereicherung der Landschaft, wie Zierpflanzen. Viele der eingeführten Arten können allerdings andere Arten auf und in sich tragen und so einschleppen, und der reisende Mensch transportiert ebenfalls oftmals gebietsfremde Arten. Die meisten aquatischen und terrestrischen Wirbellosen und Krankheiten wurden versehentlich eingeschleppt, während Pflanzen und Wirbeltiere meist eingeführt worden sind. Dieser globale Trend findet sich auch bei den gebietsfremden Arten der Schweiz wieder, denn 75% der 20 Arten auf der 'Schwarzen Liste' wurden als Zierpflanzen eingeführt und 35 der 37 Wirbeltiere wurde zu einem bestimmten Zweck importiert. Das heisst, dass viele der Problemarten bewusst eingeführt wurden, oftmals mit einer geringfügigen Rechtfertigung, z.B. um die Landschaft mit Zierpflanzen und Wasservögeln zu 'bereichern'.

Die Auswirkungen, die gebietsfremde Arten auslösen können, sind oft beträchtlich, vor allem wenn die Funktion eines Ökosystems gestört wird, einheimische Arten verdrängt werden oder sogar aussterben, wie es bei Vogelarten auf Inseln dokumentiert worden ist. Vier Faktoren können zu solchen Problemen führen: 1. Konkurrenz zu einheimischen Arten, 2. ein gebietsfremder Räuber, 3. die Hybridisierung mit einheimischen Arten und 4. die Ausbreitung von Krankheiten durch einen gebietsfremden Vektor. Offensichtliche Beispiele für Konkurrenz sind der Kampf um Licht und Nährstoffe zwischen gebietsfremden und einheimischen Pflanzenarten. Der Konkurrenzkampf um Nahrung hat in Grossbrittanien zur fast völligen Verdrängung des Eichhörnchens (*Sciurus vulgaris*) durch das eingeführte Grauhörnchen (*S. carolinensis*) geführt und es ist zu befürchten, dass dieser Trend auch auf dem Festland weitergehen wird. Der Bisam (*Ondatra zibethicus*) hat als Räuber der einheimischen Muscheln (Unionidae) zu ihrem Rückgang beigetragen und der Amphipode *Dikerogammarus villosus* ist ein grosser Feind der einheimischen Wirbellosen der Gewässer. Ein bekanntes Beispiel für eine Hybridisierung ist die eingeführte Schwarzkopf-Ruderente (*Oxyura jamaicensis*), die sich mit der stark gefährdeten Weisskopf-Ruderente (*O. leucocephala*) verpaart. In einigen Fällen können gebietsfremde Arten Krankheiten unter einheimischen Arten verbreiten. Dies ist der Fall bei der berüchtigten Krebspest (*Aphanomyces astaci*), die von ebenfalls eingeführten nordamerikanischen Flusskrebsen, die fast keine Symptome zeigen, auf den einheimischen Flusskrebs (*Astacus astacus*), der dramatisch mit einem sofortigen Zusammenbruch der Population reagiert, übertragen werden.

Neben diesen Auswirkungen auf die Umwelt, können gebietsfremde Arten auch enorme ökonomische Schäden verursachen. Die Kosten können durch den Verlust von land- und forstwirtschaftlichen Produkten und durch erhöhte Produktionskosten durch Bekämpfungsmassnahmen entstehen. Eine nordamerikanische Studie hat die jährlichen Kosten von gebietsfremden Arten in der USA auf 13,8 Milliarden US Dollar berechnet. Ein anderer Bericht schätzt die Kosten durch Unkräuter für die australische Landwirtschaft auf 4 Milliarden Australische Dollar, und 20 Millionen Aus. $ wurden während eines Jahres zwischen Mitte 2001 und Mitte 2002 für die Unkrautbekämpfung auf naturnahen Flächen ausgegeben. Die Kosten durch den Riesenbärenklau (*Heracleum mantegazzianum*) in Deutschland werden auf 10 Millionen € geschätzt, wobei je eine Millionen im Umweltbereich und Gesundheitswesen anfallen und der Rest in Landwirtschaft und Forst. Der Westliche Maiswurzelbohrer (*Diabrotica virgifera*) dehnt seine Verbreitung weiter nach Nordwesten aus und bereitet grosse Schäden an den Maiskulturen. Einige gebietsfremde Arten schaden der menschlichen Gesundheit, so produziert der Riesenbärenklau grosse Mengen eines Saftes der phototoxische Substanzen (Furanocumarine), die zu starken Verbrennungen der Haut führen können, enthält. Der Marderhund (*Nyctereutes procyonoides*), als Pelztier eingeführt, kann, wie der einheimische Rotfuchs (*Vulpes vulpes*), als Vektor des Fuchsbandwurmes (*Echinococcus multilocularis*), der gefährlichsten Krankheit, die in Zentraleuropa von Säugetieren auf den Menschen übertragen wird, fungieren. Für diesem Bericht wurden bekannte Auswirkungen von gebietsfremden Arten in der Schweiz zusammengetragen. Für Arten, die noch nicht lange in der Schweiz vorkommen, wurde auf Berichten von Auswirkungen in anderen Ländern zurückgegriffen. Es muss erwähnt werden, dass Nachweise von Auswirkungen einer gebietsfremden Art in einem komplexen Ökosystem oft schwierig zu führen sind. Andererseits ist es offensichtlich, dass Arten wie der Japanische Staudenknöterich (*Reynoutria japonica*), der oft ganze Flussufer säumt, oder eine tierische Biomasse von gebietsfremden Arten von 95% im Rhein bei Basel, eine Auswirkung auf das Ökosystem haben müssen. Alle Arten verbrauchen Nährstoffe und dienen als Nährsfoff für andere Organismen und ändern so das Nahrungsnetz und den Nährstofffluss der Ökosysteme, die sie besiedeln.

In den Texten der jeweiligen Kapitel und den Datenblättern sind Empfehlungen zur Gegensteuerung (Prävention und Kontrolle) für die Gruppen und einzelnen Arten gegeben. Allgemein ist die Erstellung einer Nationalen Strategie im Hinblick auf gebietsfremde Arten zu empfehlen, um angemessene

Schritte ergreifen zu können, und es von der Biodiversitätskonvention gefordert ist. Dieser Plan sollte eine zuständige Behörde identifizieren, die die Risiken von Einführungen und Einschleppungen beurteilt, für finanzielle Mittel sorgt und technische Unterstützung zur Bekämpfung bereitstellt. Massnahmen zur Prävention um weitere Bioinvasionen zu stoppen oder zu vermindern müssen ausgearbeitet werden. Einführungen von neuen Organismen sollten vorher auf ihre möglichen Gefahren für die Umwelt untersucht werden und nur auf der Basis einer Risikoanalyse eingeführt werden. Die Analyse der wichtigsten Einführungswege zeigt unmissverständlich, dass die meisten Problemarten bewusst eingeführt wurden (und werden). Die Nutzung von einheimischen Arten und fremden Arten ohne Potential zur Invasivität zum Beispiel in Gärten, Parks und Forsten sollte mehr gefördert werden. Gesetze, die den Handel mit Pflanzenarten der 'Schwarzen Liste' regeln, wären ein konsequenter nächster Schritt, um die Auswirkungen dieser Arten zu reduzieren. Wenn die Arten allerdings schon eine weite Verbreitung in der Schweiz besitzen, können nur Kontrollmassnahmen oder eine erfolgreiche Ausrottung Abhilfe schaffen. Die Fischereiverordnung reguliert Fischaussetzungen, indem sie Arten benennt für die eine Bewilligung nötig ist und Arten, deren Aussetzung verboten ist. Diese solide Basis könnte noch verbessert werden, um der Situation besser zu entsprechen, wie in dem Teil über Fische beschrieben. Ein weiterer Sektor, der mehr reguliert werden sollte, ist der Handel mit Haustieren (vor allem Aquarium and Terrarium), der immer wieder zu Aussetzungen führt. Ein Grundproblem der Einführungen ist, dass die Kosten von Problemarten von der Öffentlichkeit getragen werden, während der finanzielle Nutzen der Einführung einzelnen Importeuren oder bestimmten Wirtschaftszweigen zugute kommt. Die Entwicklung von ökonomischen Programmen, die die Last auf die verteilt, die auch den Nutzen aus der Einfuhr haben, ist ein vernachlässigter Denkansatz (Verursacherprinzip genannt). Möglichkeiten wären gegeben durch die Erhebung von Gebühren und Steuern, die für den Importeur zu bezahahlen wären. Eine wichtige Vorgehensweise, um die Probleme mit gebietsfremden Arten unter Kontrolle zu kriegen, ist die Schaffung eines geschärftes Bewusstseins der Problematik in der Bevölkerung. Wissenschaftler und Entscheidungsträger benötigen ebenfalls mehr Information über gebietsfremde Problemarten, deren Auswirkungen und den Möglichkeiten für eine Gegensteuerung. Einige Problemarten müssten bekämpft oder ausgerottet werde, um ihre Auswirkungen wirkungsvoll zu minimieren. Mögliche Zielarten für eine Ausrottung sind der Sikahirsch (*Cervus nippon*), das Mufflon (*Ovis orientalis*) oder die Rostgans (*Tadorna ferruginea*), die sonst ihre Verbreitung weiter ausdehnt und die Nachbarländer erreichen wird. Für eine erste grossangelegte Ausrottung oder Bekämpfung ist ebenfalls eine Pflanzenart der 'Schwarzen Liste' zu empfehlen. Ausserdem wäre die Beobachtung der Populationen von gebietsfremden Arten empfehlenswert, um etwaige starke Zunahmen früh zu erkennen. In diesem Fall könnten Gegenmassnahmen ergriffen werden, bevor die Populationen zu gross werden. Beim Zusammentragen der Informationen wurde schnell klar, dass viel mehr Information über gebietsfremde Arten benotigt wird. Daher sind mehr Studien zur Bedeutung von gebietsfremden Arten nötig, um Entscheidungsträger und Politiker auf die Lage aufmerksam zu machen.

Die limitierten Ressourcen, die zur Verfügung stehen, zwingen Prioritäten zu setzen, um die finanziellen Mittel dort einzusetzen, wo sie die meiste Wirkung zeigen im Kampf gegen Problemarten. Dabei müssen wichtige Punkte berücksichtigt werden, etwa, welche Methode den grössten Nutzen bringt, oder welche Arten für Bekämpfungsmassnahmen zuerst in Betracht gezogen werden sollten. Arten mit einem hohen Potenzial für Konflikte versprechen weniger Erfolg. Wenn Arten der 'Schwarzen Liste', welche keine grosse Wichtigkeit als Zierpflanzen besitzen, oder Arten die den Menschen gefährden, als Ziele ausgewählt werden, ist der zu erwartende Widerstand gegen Massnahmen eher gering einzuschätzen.

Résumé

La globalisation a pour effet une augmentation sans précédant du commerce et des transports, dont une des conséquences est l'accroissement des déplacements et introductions d'espèces exotiques. Les espèces exotiques ne sont pas toutes nuisibles. En fait un grande nombre d'entre elles sont bénéfiques, comme par exemple les nombreuses plantes cultivées d'origine étrangère. Cependant, certaines espèces exotiques deviennent nuisibles et posent des problèmes à l'environnement et à l'homme en général. Les Espèces Exotiques Envahissantes (EEE) sont de plus en plus reconnues comme une des menaces les plus sérieuses posées à la biodiversité.

Tous les pays signataires de la convention sur la diversité biologique (CDB), dont la Suisse, se sont engagés à prévenir l'introduction, à contrôler ou éradiquer les espèces exotiques menaçant les écosystèmes, les habitats ou les espèces.

Il est communément avancé que les EEE causent moins de problèmes en Europe Centrale que dans d'autres continents ou régions. Les raisons possibles sont, entre autres, la taille limitée des réserves naturelles, l'impact humain important dans tous les milieux « naturels » et la longue association, en Europe, entre les espèces exotiques et l'homme, ayant conduit à une familiarisation de ces espèces et une adaptation à l'environnement humain. Cependant, le nombre de cas d'espèces exotiques causant des dégâts importants est en augmentation en Europe, un phénomène dont les chercheurs, mais également le public, ont de plus en plus conscience. De fait, la menace des espèces envahissantes ne doit pas être sous-estimée. Une des conséquences les plus visibles est le phénomène d'uniformisation, menant à la perte de paysages uniques, y compris en Suisse. La flore et la faune caractéristiques sont de plus en plus envahies par les organismes exotiques qui se reproduisent, pour finalement composer la plus grande partie de la biomasse de certains écosystèmes.

Le délai qui s'écoule entre la phase d'établissement et d'invasion d'une espèce exotique ('time lag'), rend la prédiction du phénomène d'invasion très difficile. Des espèces bien établies qui n'ont actuellement aucun impact reconnu sur l'environnement peuvent malgré tout devenir envahissantes dans le futur. Trois catégories de facteurs déterminent la capacité d'une espèce à devenir envahissante: les facteurs intrinsèques liés à l'espèce, les facteurs extrinsèques, c.-à-d. les relations entre l'espèce et les facteurs biotiques ou abiotiques, et la dimension humaine, par exemple l'importance de l'espèce pour l'homme.

Ce rapport est une compilation des connaissances sur les espèces exotiques en Suisse, rassemblées à partir de publications et d'avis d'experts suisses et étrangers. Des informations sur les invasions biologiques imminentes sont également inclues. La connaissance des espèces présentes en Suisse variant fortement d'un groupe taxonomique à l'autre (pour certains taxa, même les espèces indigènes sont loin d'être toutes connues), il n'a malheureusement pas été possible d'établir une liste exhaustive d'espèces exotiques pour tous les groupes. Une liste complète a été établie seulement pour les groupes taxonomiques bien connus. Pour certains groupes, seules les espèces envahissantes ont été compilées alors que quelques groupes n'ont pas pu être traités.

Les grands groupes taxonomiques traités sont les vertébrés, les crustacés, les insectes, les arachnides, les mollusques, les autres animaux, les champignons et les plantes. Pour chaque groupe, nous présentons une discussion générale, la liste des espèces non-indigènes, les fiches d'information sur les espèces envahissantes et une évaluation du statut, de l'impact, des modes d'introduction, les méthodes de lutte et des recommandations générales. Les fiches d'information résument, pour des espèces particulièrement envahissantes ou potentiellement dangereuses, les informations sur la taxonomie, la description, l'écologie, l'origine, l'introduction en Suisse et en Europe, la distribution, l'impact, la gestion et les références bibliographiques.

Les définitions des termes anglais les plus importants utilisés dans ce rapport sont données, parce que les mots fréquemment utilisés comme « invasive » sont parfois utilisés dans des sens différents.

La situation concernant les EEE en Suisse est similaire à celle d'autres pays d'Europe Centrale, en particulier l'Autriche, un pays également enclavé et Alpin. Ce rapport inventorie environ 800 espèces non-indigènes et détaille 107 espèces envahissantes sous forme de fiches d'information : cinq mammifères, quatre oiseaux, un reptile, trois amphibiens, sept poissons, quatre mollusques, 16 insectes, six crustacés, trois araignées, deux « vers », sept champignons, une bactérie et 48 plantes.

Les modes d'introduction des espèces exotiques sont différents selon qu'il s'agit d'espèces délibérément introduites ou d'espèces introduites accidentellement. Les introductions délibérées concernent principalement les espèces importées pour l'aquaculture, la pêche, la chasse, la sylviculture, l'agriculture, l'horticulture et la protection des sols. Les organismes introduits involontairement sont souvent transportés par inadvertance avec d'autres importations ou par des voyageurs. En général, la plupart des invertébrés et des pathogènes ont été introduits accidentellement, alors que les plantes et les vertébrés l'ont souvent été intentionnellement. Cette tendance est également valable pour la Suisse. Sur les 20 plantes envahissantes de la liste noire, 75% ont été introduites principalement en tant que plantes ornementales et 35 des 37 vertébrés exotiques établis en Suisse ont été introduits délibérément. Il est donc important de constater que beaucoup d'envahisseurs, dont certains parmi les plus nuisibles, ont été introduits intentionnellement, souvent sans autre soucis que d'améliorer le paysage, comme c'est le cas pour les plantes et animaux d'ornement.

L'impact des EEE est parfois considérable, en particulier quand l'envahisseur altère le fonctionnement d'un écosystème ou pousse les espèces indigènes vers l'extinction, comme cela a été souvent observé avec les oiseaux en milieu insulaire. Les impacts écologiques peuvent être causés par quatre mécanismes majeurs : la compétition, la prédation, l'hybridation et la transmission de maladies. Parmi les exemples les plus significatifs de compétition, nous pouvons citer la compétition entre les plantes indigènes et exotiques pour les nutriments et la lumière. La compétition pour les ressources a également conduit au remplacement de l'écureuil roux indigène (*Sciurus vulgaris*) par l'écureuil gris américain (*S. carolinensis*) dans la plus grande partie de la Grande-Bretagne, et on s'attend à un même phénomène sur le continent. Le rat musqué (*Ondatra zibethicus*) est responsable du déclin des populations de moules indigènes par prédation, et l'amphipode *Dikerogammarus villosus* est un sérieux prédateur des invertébrés aquatiques indigènes. Un exemple bien connu d'hybridation en Europe est illustré par l'érismature rousse (*Oxyura jamaicensis*), un canard américain qui s'hybride avec l'érismature à tête blanche (*O. leucocephala*), une espèce européenne en danger d'extinction. Dans certains cas, les EEE peuvent abriter des maladies et agir comme vecteur d'infection pour les espèces indigènes. C'est le cas des espèces américaines d'écrevisse introduites en Europe, porteuses résistantes de la peste de l'écrevisse (*Aphanomyces astaci*), alors que l'écrevisse européenne (*Astacus astacus*) est très sensible à la maladie et a du mal à survivre au côté des espèces américaines introduites.

En plus des impacts sur la biodiversité, les EEE ont des impacts considérables pour l'économie. Ces impacts économiques peuvent être liés aux pertes directes de produits agricoles ou forestiers ou à l'augmentation des coûts de production associés à la lutte contre les envahisseurs. Une étude américaine a calculé que les EEE coûtait aux Etats-Unis la somme de 138 milliards de dollars par an. De même, un récent rapport australien estime que les mauvaises herbes coûtent à l'agriculture australienne environ 4 milliards de dollars australiens par an et que le coût de la lutte contre les plantes envahissantes dans les milieux naturels atteint 20 millions de dollars par an. En Europe, le coût de la berce du Caucase (*Heracleum mantegazzianum*) est estimé à € 10 millions en Allemagne, un million chacun pour les secteurs de l'environnement et de la santé publique, le reste représentant le coût pour les secteurs agricoles et forestiers. L'impact économique de la chrysomèle des racines du maïs (*Diabrotica virgifera*) augmente en même temps que sa dissémination en Europe. Certaines EEE ont un impact sur la santé publique. Par exemple, la berce du Caucase contient des substances phototoxiques (furanocoumarines) qui peuvent causer des brûlures sérieuses. Le chien viverrin (*Nyctereutes procyonoides*), introduit pour sa fourrure, peut, comme le renard indigène (*Vulpes vulpes*), être vecteur le l'échinococcose du renard (*Echinococcus multilocularis*), une dangereuse maladie parasitaire pouvant être transmise à l'homme. Les impacts connus des espèces introduites en Suisse sont présentés dans ce rapport. Comme plusieurs envahisseurs récents n'ont pas encore montré d'impacts écologiques en Suisse, les impacts observés dans d'autres pays sont également présentés. Mesurer les impacts écologiques des EEE est souvent une tâche difficile à cause de la complexité des écosystèmes. Cependant, les espèces exotiques présentes en très grand nombre, comme la renouée du Japon qui couvre totalement les bords de certaines rivières, ou une faune aquatique exotique composant 95% de la biomasse animale dans le Rhin près de Bâle ont forcément un impact important sur les écosystèmes indigènes. Toutes les espèces utilisent des ressources et sont elle-mêmes ressources d'autres organismes vivants et, de ce fait, les espèces exotiques altèrent les chaînes alimentaires des écosystèmes dans lesquelles elles ont été introduites.

Des recommandations pour la gestion (au sens le plus large) des espèces envahissantes sont données dans les chapitres respectifs et les fiches d'information. Une stratégie nationale appropriée contre les EEE est recommandée afin de gérer le problème de la manière la plus appropriée, selon les exigences de la CDB. Le plan d'action devrait identifier l'agence responsable pour l'évaluation des risques posés par les introductions et proposer les mécanismes de financement ainsi que le support technique pour les moyens de lutte. Des mesures de prévention contre les invasions biologiques futures doivent être mises en place pour contenir l'implantation de nouvelles espèces, qu'elles soient accidentellement introduites avec le commerce ou les voyages ou importées de façon intentionnelle pour des raisons diverses. Les nouvelles introductions délibérées doivent être évaluées pour le danger qu'elles représentent et les espèces introduites uniquement après une analyse de risques et une étude d'impact écologique. Ce rapport mentionne les modes d'introduction les plus importants et montre qu'un grand nombre d'EEE ont été délibérément introduites. L'utilisation pour le jardinage de plantes indigènes et de plantes exotiques non-envahissantes devrait être promue. Une législation réglementant le commerce des plantes de la liste noire serait un premier pas dans la bonne direction pour réduire l'impact de ces espèces. Cependant, des restrictions d'utilisation pour les espèces déjà largement présentes en Suisse ne changeront pas grand-chose à la situation, à moins d'éradiquer ou de contrôler les populations déjà présentes. Les importations et implantations de poissons exotiques sont régulées par la loi fédérale sur la pêche, qui cite les espèces pour lesquelles une autorisation d'introduction est nécessaire, et celles dont l'introduction est prohibée. C'est une bonne base, bien que la loi pourrait être mieux adaptée à la situation actuelle, comme suggéré dans le chapitre relatif aux poissons. Le commerce des animaux d'aquarium et terrarium est un autre secteur important qui devrait être mieux régulé pour limiter les lâchers d'animaux de compagnie dans la nature. Un problème majeur lié aux EEE est que le coût de ces invasions est payé par le public alors que ces introductions sont motivées par des intérêts financiers privés. Le développement d'outils économiques transférant le coût des EEE aux bénéficiaires des échanges commerciaux impliquant ces organismes exotiques est une approche pour l'instant négligée (principe du pollueur-payeur). Par exemple, des contributions ou taxes pourraient être imposés aux importateurs d'organismes vivants ou de marchandises. La sensibilisation du public est également un outil important dans la prévention et la gestion des EEE. Une partie du public adhèrerait sans aucun doute aux recommandations s'il était au courant de leur importance et de leur raison d'être.

Les chercheurs et décisionnaires ont également besoin d'un meilleur accès à l'information concernant les espèces envahissantes, leur impact et les moyens de lutte. Pour limiter l'impact des espèces envahissantes déjà présentes en Suisse, leurs populations doivent être gérées, c.-à-d. éradiquées ou contrôlées. Parmi les espèces pouvant être éradiquées, on peut citer le cerf sika (*Cervus nippon*), le mouflon (*Ovis orientalis*) et la tadorne casarca (*Tadorna ferruginea*) qui, dans le cas contraire, risquent d'élargir leur distribution et d'envahir des pays voisins. Un programme national pilote d'éradication ou de lutte, par exemple contre une plante de la liste noire, est recommandé comme étude de cas. Il est également recommandé de surveiller les populations de certaines espèces exotiques pour détecter les hausses soudaines de population pouvant indiquer un caractère envahissant. En faisant cela, des programmes de contrôle, ou même d'éradication, pourraient être décidés avant que les populations ne deviennent totalement ingérables. En accumulant l'information nécessaire à la rédaction de ce rapport, il est apparu clairement que trop peu d'information était disponible sur les EEE en Suisse. Il est fortement recommandé d'étudier plus en détails ces espèces, en particulier leur impact, afin de démontrer leur importance aux décisionnaires et politiques.

Les ressources financières étant limitées, il est nécessaire de dicter des priorités dans la lutte contre les EEE et d'allouer ces ressources là où elles auront l'impact le plus important. Il est nécessaire d'évaluer de manière critique la faisabilité de différentes méthodes de lutte, et de cibler en priorité les espèces pour lesquelles il n'y a pas de conflit d'intérêt. Par exemple, parmi les plantes de la liste noire, une action contre la berce du Caucase, une plante de faible intérêt ornemental et posant de sérieux problèmes de santé publique, ne devrait pas susciter d'opposition.

1 Introduction

The values of societies and the views on issues such as alien species change over time, and today the seriousness of alien species with their detrimental impacts on biodiversity, economics and human health is widely accepted and management options for invasive alien species (IAS) are sought. In the past people did not have the knowledge we have today and took many familiar species with them to new areas they were settling. Acclimatization societies were established with the goal of introducing European species to the new colonies and the newly discovered species of exotic lands into Europe. Thus, people cheered the arrival of the English sparrow in North America. The poet William Cullen Bryant wrote in ‘The Old World Sparrow’:

> “A winged settler has taken his place
> With Teutons and men of the Celtic race.
> He has followed their path to our hemisphere;
> The Old World Sparrow at last is here.”

This report compiles published information about alien species and other information from experts in Switzerland and abroad on the alien flora and fauna of Switzerland. Species occurring in Europe but not (yet) in Switzerland but known to have invasive characteristics are also included in this publication. The fact that they are invasive and occur in neighbouring countries puts them on a Watch List for which monitoring and/or prevention measures would be advisable.

Names of scientists who wrote chapters are given at the beginning of each one, but the many other people whose help was vital in preparing this report are acknowledged at the end of this chapter.

Availability of lists varies tremendously between taxonomic groups, thus, unfortunately, it is not possible to list all the alien species of Switzerland. However, for groups that are well known, complete lists could be assembled. For some other groups only invasive species are given, and some groups are not covered at all. For these latter groups, lists of native species are not even available and the introduced or native status of many species discovered in Switzerland cannot be demonstrated with certainty. These species are called cryptogenic. It has to be emphasized that a report on the alien species of a region can only give a snapshot of the current situation, since more species will invade and be introduced as time goes by. As long as knowledge about the diversity and distribution of native taxa is incomplete, only invasions of taxonomically uncommon or high-impact species will be detected. Invasions of cryptic taxa often go unnoticed (Müller and Griebeler, 2002). In conclusion, a consistent approach between taxonomic groups is not possible due to gaps in knowledge. The groups are discussed in this report on the basis of the available knowledge, which reflects difficulties in monitoring and taxonomy and also the importance of the different groups.

The taxonomic groups chosen, i.e. vertebrates, insects, crustaceans, arachnids, molluscs, other animals, plants and fungi, are the basis of separate chapters presenting lists of alien species and additional information about them, Fact Sheets for the invasive species, and finally an evaluation of the status, impacts, pathways, control options and recommendations for the alien species of each group. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references. A special focus is given to information on impacts of the species on the environment and economy to indicate their detrimental nature and the importance of managing them. This information is often difficult to find but crucial to show the true potential threat to Switzerland without being hysterical about it.

All signatories to the Convention on Biological Diversity (CBD), including Switzerland, are obliged to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species. There are other international instruments, ratified by Switzerland, calling for management of invasive species, e.g. the Convention on the Conservation of Migratory Species of Wild Animals and the Convention on the Conservation of European Wildlife and Natural Habitats. This report can also be used in response to the call from the CBD Secretariat for countries to produce lists of alien species and can provide information for a national strategy on IAS.

The importance of IAS is increasingly recognized in Central Europe, indicated by the recently published book *Neobiota in Österreich* (Essl and Rabitsch, 2002) and the very recently produced *Gebietsfremde Arten; Positionspapier des Bundesamtes für Naturschutz* in Germany (Klingenstein et al., 2005).

The following sections of this chapter explain the definitions used in the report, then present a predominantly global perspective of the IAS issue, with examples from Switzerland. Evaluations of pathways, origins of the species, number of alien species in comparison to native species, their impacts, management options and other trends are given in the chapters on the taxonomic groups. An overall evaluation of these factors was attempted, but it became obvious that that was not a constructive exercise, since the clear trends in some taxonomic groups were diluted and combining groups with very different knowledge bases made it difficult to compare the results. However, within the groups, trends are often very obvious and for these readers are referred to the chapters on the taxonomic groups.

Definitions

Definitions used in relation to IAS are as varied as the species themselves. The term ‘invasive’, for instance, is used in one extreme, to describe a population that is expanding (invading somewhere) to another, for species which have a negative impact on native species, ecosystems and habitats. A set of widely used definitions is provided by the Convention on Biological Diversity, available on their websites (see Article 2, Use of Terms at: *http://www.biodiv.org/convention/articles.asp?lg=0&a+cbd-02* and Annex 2 of the item 8 at: *http://www.biodiv.org/doc/meeting.aspx?mtg=sbstta-06&tab=1*).

As long as the terms are not harmonized, it is crucial to give the definitions used in a document. Thus, short definitions used in this report are presented below. In some chapters, separate definitions were used for reasons of clarity, and these are given at the beginning of the relevant chapters.

Introduction: the movement, by direct or indirect human agency, of a species or lower taxon into a new area. Indirect agency is, for instance, the building of a canal, while direct movement includes deliberate and accidental introductions. This can be either within Switzerland or from another country into Switzerland, breaching formerly insurmountable barriers for the species. The most obvious natural barriers for a species in Switzerland are the Alps between the Ticino and the rest of the country, but also the different watersheds, towards the North Sea, the Black Sea and the Mediterranean Sea.

Deliberate introduction: the purposeful movement by humans of a species into a new area. This includes also species introduced into confinement, e.g. aquariums and zoos. Thus, the introduction is defined here as the initial movement into a new area. They can subsequently escape or be released into the environment.

Accidental introduction: a species utilizing humans or human delivery systems as vectors. This also includes contaminants and diseases of deliberately introduced species.

Native species: a species living within its natural range.

Alien species: a species introduced outside its natural distribution.

Invasive alien species (IAS): an alien species which threatens ecosystems, habitats and species. These are addressed under Article 8(h) of the CBD.

Some species are difficult to handle under these definitions because of a lack of information, e.g. it is often not possible to determine whether a European species arrived with human help or on its own wings or legs. Thus, these definitions should not be treated as cast in stone but are flexibly used for the purpose of this report.

Invasive alien species – a global overview

This report can only give a glimpse of the complex issue of IAS, to set the stage for an assessment of their importance. A good place to start browsing through the IAS literature is in books published on the topic, e.g. the classic Elton (1958), Drake et al. (1989), Di Castri et al. (1990), Williamson (1996), Mooney and Hobbs (2000), Shine et al. (2000), Low (2001), McNeely (2001), Wittenberg and Cock (2001), Baskin (2002), Kowarik and Starfinger (2002), Leppäkoski et al. (2002), Pimentel (2002), Kowarik (2003), Mooney et al. (2005) and others.

Changes in distribution of species are a natural phenomenon; ranges expand and retract and species colonize new areas outside their natural range by long-distance dispersal, for example reptiles on floating wood to new islands. However, these events are rare and mostly restricted by natural barriers. The relatively recent globalization of trade and travel has inadvertently led to the increased transport of organisms and introduction of alien species, tearing down these natural barriers. Alien species are not bad per se, in fact many species are used for human consumption, e.g. most crop species are aliens in the majority of regions where they are grown. However, some of them may subsequently become harmful and pose threats to the environment and human populations. IAS are increasingly recognized as one of the major threats to biodiversity. These negative effects are best documented in bird extinctions on islands where the majority since 1800 have been caused by IAS (BirdLife International, 2000). This global problem needs global and local responses, or, even better, proactive measures, and solutions.

The complexity of the IAS topic stems from the very different species involved, their diverse origins, the variety of pathways used, their varied impacts on new environments, their relationships with indigenous and other alien species, the ecosystem changes caused, their dependence on other factors such as global warming, their human dimensions including changes in political and ethical views, and their on-going evolution.

Invasive alien species are found in virtually every taxonomic group. The following examples will attest this statement.

- The West Nile virus causing encephalitis hitched a ride to the New World in an infected bird, mosquito or human (Enserink, 1999).
- The bacterium *Vibrio cholerae* (Pacini), the causal organism of the human disease cholera, is a member of brackish water communities and is frequently found in ballast water of ships (McCarthy and Khambaty, 1994), by which means some new highly virulent strains have been redistributed leading to epidemic outbreaks of cholera. Another bacterium, *Erwinia amylovora* (see Fact Sheet in chapter 9) is a serious threat to the fruit industry in Switzerland.
- Some fungal pathogens are amongst the IAS with the most disruptive impacts on ecosystems. Some well-known examples include fungi attacking trees, e.g. chestnut blight (*Cryphonectria parasitica* (Murrill) Barr) was introduced with alien chestnut trees to North America, where it virtually eradicated the American chestnut (*Castanea dentata* (Marsh.) Borkh.), which was a dominant tree in eastern forests, thereby changing the entire ecosystem and composition of the forests (Hendrickson, 2002) and is now, albeit with less severity, attacking trees in Switzerland.
- Weeds are another predominant group of IAS known to cause economic problems as well as deleterious effects on the environment. The giant reed (*Arundo donax* L.) is used in many countries, for example as windbreaks, and is readily invading natural areas; the small herb common ragweed (*Ambrosia artemisiifolia* L.) is swiftly expanding its exotic range in Europe causing severe allergic problems for the human population.
- Many different kinds of worms found their way to new areas with human assistance, especially parasitic worms from the Plathelminthes and Nemathelminthes, for example the nematode *Anguillicola crassus*, which attacks the native eel (*Anguilla anguilla* L.).
- A spectacular disaster caused by an introduced snail was the introduction of the carnivorous rosy wolfsnail (*Euglandina rosea* (Férussac)) to many subtropical and tropical islands destroying the diverse endemic snail faunas. Another example of an introduced mollusc in Europe is perhaps the most aggressive freshwater invader worldwide, the zebra mussel (*Dreissena polymorpha* (Pallas)), inflicting not only huge economic costs but also severe biotic changes as it functions as an ecosystem engineer species (Karateyev *et al*., 2002).
- Small introduced crustaceans dominate the fauna of many rivers and lakes worldwide due to the increased ship traffic that transports organisms in ballast water to new areas, and also to the creation of canals connecting formerly insurmountable natural barriers between watersheds. Thus, alien species (mainly crustaceans and molluscs) dominate the Rhine in total abundance and produce a biomass of more than 80 % (Haas *et al*., 2002).
- Interestingly, introduced insects, despite their diversity, have not shown a high potential for causing environmental problems, although they can be devastating pests in agriculture and forestry. However, several ant species destroy native faunas, especially on islands – but also, e.g. the Argentine ant (*Linepithema humile* (Mayr)), in southern Europe.
- The infamous cane toad (*Bufo marinus* (L.)) is spreading quickly through Australia feeding on everything smaller than itself and poisoning the bigger predators, such as quolls (*Dasyurus* spp. E. Geoffroy St.-Hilaire).
- One of the most devastating introduced reptiles is the brown tree snake (*Boiga irregularis* (Merrem)) on Pacific islands; it arrived on Guam on military equipment and brought a silent

spring to the island by feasting on the bird species. Moreover, it causes frequent power cuts and is a danger to babies because of its venom.

- The Nile perch (*Lates niloticus* (L.)), introduced into Lake Victoria to improve fisheries, caused the extinction of more than 100 fish species of the cichlid family; most of them endemic to the lake – before the predator came it was called an evolutionary laboratory, afterwards an ecological disaster.
- The American ruddy duck (*Oxyura jamaicensis* (Gmelin)) was introduced to England as an addition to the wildfowl fauna, where it ostensibly does no harm, but then it spread to Spain where it has swiftly endangered the native close relative, the white-headed duck (*O. leucocephala* (Scopoli)) by hybridization.
- Feral mammals introduced to islands brought many bird species to the brink of extinction or beyond by feeding on their eggs and chicks (e.g. Long, 2003).

However, some taxonomic groups seem to include more invasive species than others do. Mammals are a major threat to island faunas and floras. Whereas rats, mongooses, mustelids and feral cats devastate the local bird and reptile fauna of islands, feral goats (*Capra hircus* L.) can diminish the native flora drastically. Weeds alter the vegetation on many archipelagos to the detriment of the entire ecosystem. Island ecosystems, including isolated lakes, are particularly vulnerable to these invaders. However, all continents and habitats seem to be vulnerable to invasions, although there appear to be some differences between continents. In the highly populated area of Central Europe, IAS seem to be of less importance to biodiversity than on other continents with large tracts of more natural habitats. The smaller reserves in Central Europe are easier to manage and control of alien species in these areas is often more practical. The long association between introduced species and the human population in Europe is a very different situation compared to other continents, as all habitats are highly altered and human-made habitats dominate. These human-made habitats are often regarded as valuable heritage in Central Europe and some of them are dominated by alien species introduced centuries ago.

Comparing the numbers of species introduced to species that have established and species that have become invasive, one has to bear in mind the long lag phases which often occur. Most introduced species take some time before they become invasive, i.e. enter the log phase. Kowarik (2003) shows that for woody alien plants in one part of Germany, the average time lag between first introduction and expansion is about 147 years. The occurrence of time lags makes predictions on invasiveness of alien species very difficult. A species doing no harm today can still become an invasive of tomorrow, especially in combination with other global changes. There are three major factors that determine the ability of a species to become invasive:

1. Intrinsic factors or species traits, such as the ability to adapt to different conditions, a wide tolerance of abiotic factors, pre-adaptations to different climatic zones, and a high reproductive rate.
2. Extrinsic factors or relationships between the species and abiotic and biotic factors, such as the number of natural enemies, the number of competing species (native and alien), other interactions with native and alien species (pollination, dispersal, food source, ecosystem engineers), climatic conditions, soil conditions, degree of disturbance (natural and human-induced), global climate change, change in land-use patterns, and control and eradication of other IAS.
3. Human dimension. The attractiveness and importance of species to humans influence introduction pathways, vectors, the number of specimens introduced, the number of introductions, and the potential for eradication or control.

Predictions about the invasive potential of a species prior to introduction, as now made in Australia and New Zealand, remain difficult, despite recent progress in science. The best indicator is still whether a species has become invasive in a similar area elsewhere (i.e. its invasion history).

Status of alien species in Switzerland

As pointed out above, the accelerating pace of movement of people and goods is increasing the number of introductions of already established species and new arrivals. Therefore lists of alien species cannot be comprehensive, but give only a snapshot of the current knowledge. Moreover, the lack of both knowledge and taxonomists for some groups precludes lists for such groups being presented.

The situation regarding IAS in Switzerland is similar to that in other Central European countries, in particular Austria, which is also a land-locked country containing part of the Alps. Some of the taxonomic sections present numbers of alien species recorded in other countries for comparison. A comparison between countries for all taxa cannot be given here, since the definitions and criteria used differ considerably between country reports and make it impossible to use the figures for comparison with neighbouring countries. The different levels of knowledge for the different groups and countries is another source of inaccuracy. Some features specific to Switzerland will allow a different guild of species to invade. The deep, cold lakes, for example, are probably preventing or at least reducing invasions by aquatic weeds that thrive in warm, shallow water.

This report lists about 800 alien species and describes 107 IAS in Fact Sheets, i.e. five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two ‘worms’, seven fungi, one bacteria, and 48 plants. As mentioned above, some of these species, e.g. the grey squirrel (*Sciurus carolinensis* Gmelin), have not yet entered Switzerland, but their arrival in the near future is likely.

Pathways

Pathways can be divided into those for species deliberately introduced and those for species accidentally moved around. Examples of species in the first category are species used in aquaculture, for fisheries, as forest trees, for agricultural purposes, for hunting, and plants used for soil improvement and solely to please humans as ornamentals. Most of these can also transport hitchhiking species and people can accidentally introduce species on cargo, their boots, etc. To summarize, most aquatics and invertebrates in general, are accidental arrivals, whereas most plants and vertebrates are deliberately introduced. Minchin and Gollasch (2002) and Carlton and Ruiz (2005) give excellent accounts of pathways and vectors in more depth. The latter divide pathways into cause (why a species is transported), route (the geographical path) and vector (how a species is transported).

The global trend that vertebrates and plants are mainly deliberately introduced also holds true for Switzerland. 75% (15) of the 20 Black List plants were introduced chiefly as ornamentals and 35 of the 37 vertebrates have been deliberately introduced. In general, the introduction pathways of species into Europe, rather than into Switzerland, have been analysed in this report, since some species arrived in Switzerland by expanding their populations from neighbouring countries. In conclusion, many serious invaders were deliberately introduced, often without much incentive beyond the wish to colour the landscape, e.g. with ornamental plants and waterfowl.

Prediction and prevention of new invaders is difficult since trade in species can be changed by changing demands. A group not currently a problem may yet become problematic in the near future. If, for example, the pet trade in reptiles shifts from predominantly tropical and subtropical species to species originating in regions in the same latitudes as Europe, such as North America and China, the situation could become much worse.

Impacts of invasive alien species

The impacts of IAS are often considerable, in particular where ecosystem functioning is being altered or species are being pushed to extinction, as has been shown for many bird species. Most extinctions are likely to be caused by a combination of factors and are not attributable to a single cause, but there is no doubt that IAS play an important role. The environmental impacts can be divided into four major factors:

- competition,
- predation (including herbivory), and more subtle interactions such as
- hybridization and
- transmission of diseases.

All these factors alone or in concert with other factors can decrease biodiversity and cause extinction. The most obvious examples for competition are between introduced and native plants for nutrients and exposure to sunlight. Resource competition has also led to the replacement of the native red squirrel (*Sciurus vulgaris* L.) by the introduced American grey squirrel (*S. carolinensis*) in almost all of Great Britain and it is predicted that this trend will continue on the continent. The latter forages more efficiently for food and is stronger than the native species (Williamson, 1996). Impacts due to predation and herbivory are very extensive on island fauna and flora, as mentioned above. The brown tree snake eliminated most of the bird species on Guam, and feral goats are a menace to native vegetation on islands, where they were often released as a living food resource. A well-known example of hybridization from Europe is the ruddy duck, which hybridizes with the native white-headed duck, as mentioned above. In some cases IAS can harbour diseases and act as a vector for those diseases to native species. This is the case with American introduced crayfish species to Europe, which are almost asymptomatic carriers of the crayfish plague (*Aphanomyces astaci* Schikora), but the native noble crayfish (*Astacus astacus* (L.)) is highly susceptible to the disease, and thus is struggling to coexist with populations of the American crayfish species. Introduced species can interact with natives in a variety of ways and indirect effects can be very difficult to demonstrate. Direct and indirect effects can lead to very complex interactions and a combination of effects can cause complex impacts.

In addition to impacts on biodiversity, many IAS impose enormous economic costs. These costs can arise through direct losses of agricultural and forestry products and through increased production costs associated with control measures (US Congress, 1993; Pimentel et al., 2000). One often-cited example is the costs inflicted on water plants by the zebra mussel, which clogs water pipes and other structures in the Great Lakes in North America. Costs for environmental problems are more difficult to calculate than costs imposed in the agricultural and other economic sectors. A North American study calculated costs of US$ 138 billion per annum to the USA from IAS (Pimentel et al., 2000). Some of the costs given in this paper are estimates rather than actual, however, even give or take an order of magnitude, it is still an enormous figure and shows the importance of IAS. A recently released report (Sinden et al., 2004) estimates that weeds are costing agriculture in Australia about Aus$ 4 billion a year, around 20% of which is borne by the consumer, the other 80% by the producer. According to this report, costs associated with lost production and controlling weeds are equivalent to 0.5% of gross domestic product, or 14% of the value of agricultural production in Australia. The Aus$ 4 billion estimate is conservative, as it does not include the impact on the natural environment, the effect of pollen from the weeds on human health, and the cost of volunteer weed control. It also hides the combined Aus$ 1.8 billion cost to the economy of salinity and soil acidity. The amount spent on weed control rose by Aus$ 68,000 for each additional native plant that was threatened by the invasive weeds. Weed control in natural environments cost about Aus$ 20 million in the year from mid 2001 to mid 2002. Turning to Europe, the costs of *Heracleum mantegazzianum* Sommier et Levier (giant hogweed) in Germany are estimated at € 10 million; € 1 million each to the environment and health sectors, and the remainder represents costs to the economy.

Some IAS also have implications for human health. Giant hogweed was introduced from the Caucasus to Europe as an ornamental plant. It produces copious amounts of a sap containing phototoxic substances (furanocoumarins), which can lead to severe burns to the skin. Regularly children, in particular, are hospitalized after contact with the plant, especially when they have been playing with the hollow stems and petioles, using them as ‘peashooters’. The raccoon dog (*Nyctereutes procyonoides* Gray), introduced as a fur animal, can, like the native red fox (*Vulpes vulpes* (L.)), act as a vector of the most dangerous parasitic disease vectored by mammals to humans in Central Europe, i.e. the fox tapeworm (*Echinococcus multilocularis* Leuckart) (Thiess et al., 2001). Although the raccoon dog is only an additional vector, this can have effects on the population dynamics of the parasite and lead to an increase in the disease in humans.

Known impacts of species introduced into Switzerland are presented in the chapters on the taxonomic groups and their Fact Sheets. Some recent invaders are without demonstrated impact in Switzerland; in these cases impacts assessed in other countries are given. These provide a glimpse of the possible future. An example is *Procambarus clarkii* Girard (an American crayfish species) which has caused considerable economic losses in Italy (Gherardi et al., 1999). Demonstration of impacts is often difficult because of the complexity of ecosystems, but alien species occurring in high numbers, such as *Reynoutria japonica* Houtt. (Japanese knotweed) totally covering the banks of a stream in a valley, or an animal biomass of alien species of up to 95% in the Rhine near Basel, must have impacts on the native ecosystem. All species use resources and are resources to other creatures and so they alter the web and nutrient flow of the ecosystems they are living in.

Discussion

This report compiles the available information about IAS in Switzerland. During the compilation it became clear that it is impossible to list all alien organisms, for the simple reason that there is a gap in taxonomic knowledge, not only in Switzerland, but Europe and the world, reflecting a need for more taxonomic work. There are probably more than ten times the species described so far actually existing right now on the planet, and for the species that *have* been described we often know little more than their names. This gives a good indication that there will be more species of both native and alien origin found in Switzerland in the years to come. Since all knowledge and management are based on the concept of 'species', it seems obvious that taxonomic work is crucial.

Despite the widespread view that IAS are of less concern in Central Europe than on other continents (and more especially on islands) for various reasons, including the small size of nature reserves and the high human impact on all 'natural' environments, and the long association of alien species and humans leading to adaptation, however, the number of cases of dramatic impacts is increasing and the awareness among scientists and the public is steadily evolving. Thus, the threats from IAS should not be underrated. One of the major consequences, which is undoubtedly unfolding before our eyes, is global homogenization (catchily called McDonaldization), with the unique character of places such as Switzerland being lost, the characteristic flora and fauna invaded by organisms which often accomplish to form the largest biomasses in certain ecosystems. This is fact and cannot be argued about, while confirmation of impacts is difficult to obtain and can be controversial. The concept of 'bad species' and 'good species' in our ecosystems is a rather anthropomorphic view. Even if a population of a native species is enhanced, it is not necessarily good for the ecosystem but can disturb the natural balances and nutrient and energy flows in the ecosystem. After an era of exploitation, it is now time to address global warming and global swarming.

IAS should not be seen as a specific topic but rather as a part of conservation, trade, and other activities. The main question to be answered is not how to deal with IAS, but what should Switzerland look like, what are the goals for conservation, what should a particular nature reserve or the national park look like? These goals need to be set and IAS management will be part of this bigger picture to conserve and reinstate the unique ecosystems and habitats of Switzerland. The intact ecosystems can deliver ecosystem services in a sustainable manner.

Recommendations

This section gives some important advice and recommendations, which emerged while compiling the report. Recommendations for groups of invasives and specific species are given in more detail in the respective chapters and Fact Sheets.

Preparing a national strategy against IAS is recommended to deal with IAS in an appropriate way and as demanded by the CBD. This action plan should identify the agency responsible for assessing the risks posed by introductions, provide funding mechanisms and technical advice and support for control options. This is necessary not only to fulfil international commitments, but also to protect Switzerland's ecosystems from the detrimental effects of future invasions.

Prevention measures against further bioinvasions need to be put in place to stem the tide of incoming new species arriving accidentally with trade and travel or introduced deliberately for various purposes. New deliberate introductions must be assessed as to the threat they may present and only introduced on the basis of a risk analysis and environmental impact assessment. Scrutinizing imported goods can minimize accidental invasions. The report indicates some important pathways for consideration. Most of the known invasive species, apart from insects, are deliberately introduced, in particular as ornamentals and for fishing or hunting. The use of native plants and non-invasive alien plants for gardening should be promoted. Every meadow ploughed, pond filled, or forest cut for roads, homes or industrial zones leaves less space for the native flora and fauna. Gardens and parks supporting native plants could be a great boost for native biodiversity.

Laws regulating trade in plant species on the Black List would be a first step in the right direction to reduce the impact of these species on the environment, economics and human health. However, restrictions for species already widely distributed within Switzerland will not drastically change the situation unless the populations already present are eradicated or controlled. Arrivals of new species with potential for being invasive need to be targeted well before they secure a beachhead and become unmanageable. Fish introductions are regulated by the Fisheries Act, which names species for which an authorization for release is needed and species for which release is prohibited altogether. This is a good basis, although the law could be better adapted to the current situation. This is described in the chapter on fish. The aquarium and terrarium trade is another important sector that could be more strictly regulated to stop releases of pets into the wild. With the increasing prohibition of the red-eared slider

(*Trachemys scripta* Seidel) in Europe, other species will probably replace it in the pet trade. These species are not regulated and, if they are from a more temperate region, they would be of even more concern than the red-eared slider.

A major problem with introductions of IAS is that the costs when they establish and become invasive are borne by the public, while the financial incentives for introducing them lie with individuals or specific businesses. Development of economic tools that shift the burden of IAS to those who benefit from international trade and travel is a neglected approach. This is also called the 'polluter pays' principle. Appropriate tools would be fees and taxes, including fees levied on those who import the organisms or goods. The money raised can be used for prevention and management of IAS.

Awareness raising is a significant tool in the prevention and management of IAS, since some people would adhere to advice if they knew about its importance and the reason for it, e.g. 'freeing' of pets into the environment. Scientists and decision-makers also need better access to information about invasive species, their impacts, and management options. This lack of organization of information can be addressed by databases or global compendia. This report is a basis for collating information on published eradication and management methods for harmful species occurring in Switzerland (including key contacts).

Some key invasive groups to watch for in the future are plants, vertebrates, diseases and some invertebrates, as the most invasive species belong to these groups. Introductions of crayfish species, for instance, should be regulated; thus the European native species are of concern, although so far most attention is focussed on the American species.

To address the impacts of some invasive species already present in Switzerland, their populations need to be managed: either eradicated or controlled.

Monitoring for populations of some alien species is recommended to detect any sudden explosion in their populations and to watch for their potential invasiveness. By doing this, control or even eradication efforts can be employed before the populations become unmanageable. In most cases, the transition from a 'sleeper' species to an invasive species will go undetected without vigilant monitoring.

Despite the efforts in this report to document impacts of alien species which have invasive characteristics, much information is still needed to assess the different impacts, direct and indirect, to the native biodiversity. More studies on alien species are highly recommended to ascertain the importance of IAS and to demonstrate their significance to policy-makers and politicians.

The first Swiss-wide efforts to combat the populations of selected IAS are recommended. The most efficient control options need to be explored and implemented. Some species of high concern, such as giant hogweed, seem to be good targets for eradication campaigns throughout Switzerland. Populations of giant hogweed are currently exploding all over Europe (see, e.g., Kowarik (2003) for Germany and Czech Republic), they cause direct harm to people, and successful eradication has been achieved using mechanical and chemical control.

Priority setting is always difficult. The limited resources need to be spent where they have the greatest impact in combating IAS. Important points, for example, are to consider the feasibility of an approach (will the goal be reached?) and to target species with no conflict of interest. Opposition to action against less-important ornamentals on the Black List and species of direct human health concern (giant hogweed) will be negligible. Other possible targets for eradication are a deer species (sika deer – *Cervus nippon* Temminck) or the mouflon (*Ovis orientalis* Gmelin), both species with a weak lobby.

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References

Baskin, Y. (2002) A plague of rats and rubbervines. Island Press, Washington, DC, 377 pp.

BirdLife International (2000) *Threatened birds of the world*. Lynx Edicions and BirdLife International, Barcelona and Cambridge, UK, 852 pp.

Carlton, J.T. and G.M. Ruiz (2005) Vector science and integrated vector management in bioinvasion ecology: Conceptual frameworks. In: Mooney, H.A., McNeely, J., Neville, L.E., Schei, P.J. and Waage, J.K. (eds) *Invasive alien species: searching for solutions.* Island Press, Covelo, California (in press).

Di Castri, F., Hansen, A.J. and M. Debusche (eds) *Biological invasions in Europe and the Mediterranean basin*. Kluwer Academic Publishers, Dordrecht, Boston, London, 463 pp.

Drake, J.A., Mooney, H.A., di Castri, F., Groves, R.H., Kruger, F.J., Rejmánek, M. and M. Williamson (eds) *Biological invasions. A global perspective*. John Wiley & Sons, Chichester, New York, Brisbane, Toronto, Singapore, pp. 257-280.

Elton, C.S. (1958) *The ecology of invasions by animals and plants*. Chapman and Hall Ltd., London, 181 pp.

Enserink, M. (1999) Biological invaders sweep in. Science 285, 1834-1836.

Essl, F. and W. Rabitsch (2002) *Neobiota in Österreich*. Federal Environment Agency, 432 pp.

Gherardi F., Baldaccini, G.N., Barbaresi, S., Ercolini, P., De Luise, G., Mazzoni D. and M. Mori (1999) Alien crayfish: the situation of Italy. Crustacean Issues 11, 107-128.

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the river Rhine determines biodiversity and ecosystem function: An affair between amphipods and mussels. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, Boston, London, pp. 426-432.

Hendrickson, O. (2002) Invasive alien species in Canadian forests. In: Claudi, R., Nantel, P. and Muckle-Jeffs, E. (eds) *Alien invaders in Canada's waters, wetlands, and forests*. Canadian Forest Service, Ottawa, Canada, 320 pp.

Karateyev, A.Y., Burlakova, L.E. and D.K. Padilla (2002) Impacts of zebra mussels on aquatic communities and their role as ecosystem engineers. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management*. Kluwer Academic Publishers, Dordrecht, Boston, London, pp. 433-446.

Klingenstein, F., Kornacker, P.M., Martens, H. and U. Schippmann (2005) Gebietsfremde Arten; Positionspapier des Bundesamtes für Naturschutz. BfN, Bonn, 30 pp.

Kowarik, I. (2003) *Biologische Invasionen: Neophyten und Neozoen in Mitteleuropa*. Verlag Eugen Ulmer, Stuttgart, Germany, 380 pp.

Kowarik, I. and U. Starfinger (eds) *Biologische Invasionen: Herausforderung zum Handeln?* Lentz-Druck, Berlin, Germany, pp. 5-24.

Leppäkoski, E., Gollasch, S. and S. Olenin (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 412-425.

Long, J.L. (2003) *Introduced mammals of the world. Their history, distribution and influence*. CABI Publishing, Wallingford, UK, 589 pp.

Low, T. (2001) *Feral future; the untold story of Australia's exotic invaders*. Penguins Books Australia Ltd., Victoria, Australia, 394 pp.

McCarthy, S.A. and F.M. Khambaty (1994) International dissemination of epidemic *Vibrio cholerae* by cargo ship ballast and other non-potable waters. Applied Environmental Microbiology 60, 2597-2601.

McNeely J.A. (ed.) (2001) *The great reshuffling: human dimensions of invasive alien species.* IUCN, Gland, Switzerland and Cambridge, UK, 242 pp.

Minchin, D. and S. Gollasch (2002) Vectors – How exotics get around. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, Boston, London, pp. 183-192.

Mooney, H.A. and R.J. Hobbs (eds) *Invasive species in a changing world.* Island Press, Washington, USA, 457 pp.

Mooney, H.A., Mack, R.N., McNeely, J.A., Neville, L.E., Schei, P.J. and J.K. Waage (eds) (2005) *Invasive alien species: a new synthesis.* Island Press, Washington, Covelo & London, 368 pp.

Müller, J.C. and E.M. Griebeler (2002) Genetics on invasive species. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 173-182.

Pimentel, D. (ed.) (2002) *Biological invasions; economics and environmental costs of alien plant, animal, and microbe species.* CRC Press, Boca Raton, London, New York, Washington, D.C., 369 pp.

Pimentel, D., Lach, L., Zuniga, R. and D. Morrison (2000) Environmental and economic costs of nonindigenous species in the United States. *BioScience* 50, 53-65.

Shine, C., Williams, N. and L. Gündling (2000) *A guide to designing legal and institutional frameworks on alien invasive species.* IUCN, Gland, Switzerland and Cambridge and Bonn, 138 pp.

Sinden, J., Jones, R., Hester, S., Odom, D., Kalisch, C., James, R. and O. Cacho (2004) The economic impact of weeds in Australia. CRC for Australian Weed Management, Technical Series No. 8, 65 pp.

Thiess, A., Schuster, R., Nöckler, K. and H. Mix (2001) Helminthenfunde beim einheimischen Marderhund (*Nyctereutes procyonoides*, Gray, 1834). Berliner und Münchner Tierärztliche Wochenschrift 114, 273-276.

US Congress (1993) *Harmful nonindigenous species in the United States*. Office of Technology Assessment, OTA-F-565. U.S. Congress Government Printing Office, Washington, D.C., USA

Williamson, M. (1996) *Biological invasions.* Chapman & Hall, London, 244 pp.

Wittenberg, R. and M.J.W. Cock (eds) (2001) *Invasive alien species: a toolkit of best prevention and management practices.* CABI Publishing, Wallingford, UK, 228 pp.

2 Vertebrates – Vertebrata

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All the Fact Sheets for vertebrates have been placed at the end of this chapter. They are presented in alphabetical order to make individual ones easier to locate, not in taxonomical sequence as in the text and lists below.

Mammals – Mammalia

There are currently about eight mammalian neozoa with established populations in Switzerland (Table 2.1), another species (coypu) is irregularly found, and the grey squirrel is discussed as a threat to Switzerland. Of the established species, one is greatly reduced in numbers (European rabbit) due to unfavourable climatic conditions, hunting, and introduced diseases such as myxomatosis and rabbit haemorrhagic disease (RHD) (see below). Three have only small, localized populations (Siberian chipmunk, sika deer, mouflon), one is currently in the process of invasion (raccoon dog), two are well-established and spreading through Switzerland (raccoon, musk rat) and one is abundant (brown rat).

The **European rabbit** (*Oryctolagus cuniculus* L.) was widely distributed throughout Central and Southern Europe before the last glacial period (Kaetzke et al., 2003). During this period the distribution retracted dramatically and the European rabbit survived only on the Iberian Peninsula. Later it was distributed by humans, because it was prized for its meat, first along the Mediterranean Sea coast and then to Central Europe. However, it arrived relatively recently in Switzerland, where it was locally introduced in the 19th century (Long, 2003). The distribution in Switzerland was always very patchy in lowlands around Basel, Genève and in the Valais and Ticino (Hausser, 1995) with a decreasing trend in its population sizes. While the European rabbit was able to adapt very well to the hot and arid interior of Australia, it suffers under cold winter temperatures and is restricted by the depth of the snow which covers its food (Flux, 1994). The small population of the European rabbit in Switzerland and the very few suitable habitats render this alien species unimportant. This is an interesting contrast to many other countries around the globe where the species is recognized for its detrimental effects on agriculture, forestry and the environment, including the more than 800 islands where it has been introduced. It should be noted that releases of other alien members of the family Leporidae should be discouraged. A North American species introduced for hunting at several locations in Europe, including Switzerland, France and Italy is *Sylvilagus floridanus* (J.A. Allan). The main concern is the possibility of transmission of diseases to native species, e.g. myxomatosis and RHD.

The only introduced squirrel is the **Siberian chipmunk** (*Tamias sibiricus* (Laxmann)). It was released into parks in Genève by pet lovers and established a small but stable population (Long, 2003). Its native distribution covers a large part of northern Asia and it is expanding its range westwards, and arrived in Finland in recent years (Grzimek, 1975). This small beautiful squirrel is frequently kept as a pet and has escaped or been deliberately introduced in several European countries. In Switzerland only one small colony is known, but it has also established populations in Freiburg im Breisgau in Germany and in Italy (Personal observation; Andreotti et al., 2001). In Russia it is known to destroy half the average forest nut production and cause great damage to grain crops. Since the chipmunks mainly feed on the ground, they can severely affect crops and also damage gardens and orchards (Long, 2003). A Belgian study, which compared the abundance of birds in areas with and without the alien squirrel, concluded that *T. sibiricus* has no impact on bird populations (Riegel, 2001). In most of Europe, released populations have not increased and spread significantly, and it seems that the Siberian chipmunk is dependent on a rich food source, as it is most often found in parks and graveyards with a variety of different plant species (Krapp, 1978a, b). Thus, it should be regarded as a species with a low invasion potential. However, the release of pet animals should be of great concern and should probably be better regulated. In particular, the danger of diseases carried by alien pets to wildlife, other pets and humans should not be underrated, as demonstrated by the recent arrival of diseases with introduced pet rats from Africa to the USA.

Another squirrel species, although one that has not yet arrived in Switzerland, is of great concern, as it is established in Italy and spreading. The **grey squirrel** (*Sciurus carolinensis* Gmelin) (see Fact Sheet) is one of the rare cases where the impact on a native congeneric species, i.e. the red squirrel (*Sciurus* *vulgaris* L.), is well documented. In Great Britain, except for some mountainous conifer forests, the red squirrel has been replaced completely by the grey squirrel. Today, the population in northern Italy is rapidly expanding its range and threatens to invade Switzerland in the next 20 years or so. Swiss authorities should follow the expansion closely and put prevention methods in place to stop or delay the spread at the border. Whereas the invasion into the Ticino is more imminent, the modelled expansion of the grey squirrel to France is of greater concern, as from here it can expand into Switzerland around Genève. Moreover, if isolated populations outside the invasion front are encountered, they should be eradicated as long as they are small. Swiss authorities should also initiate discussion with Italian authorities to implement the approved action plan to eradicate the species in the Italian part of the Ticino valley.

The re-introduction of beavers in some countries has been problematic in the past. In some areas, at least in Austria and Finland and perhaps Germany (Geiter et al., 2002), the American congeneric *Castor canadensis* Kuhl was introduced instead of the **European beaver** (*C. fiber* L.) (Freye, 1978; Englisch, 2002). These two species are very similar and indeed were considered to be one species until recently, but the karyotypes differ. No further introductions of the American species should be made in Europe. The introductions of *C. fiber* of different origins within Europe seem to be of less concern in many parts, since the species is genetically relatively uniform, with only a few obvious subspecies. In general, specimens used for re-introductions should come from the same subspecies or populations, original to the specific area, whenever possible.

The North American **muskrat** (*Ondatra zibethicus* (L.)) (see Fact Sheet) showed a tremendous expansion of its range in Europe in the 100 years after its first introduction to Prague (Elton, 1958). A discussion of the process of the spread is given by Williamson (1996). The invasion front is moving swiftly southwards in Switzerland. It has the potential to colonize all aquatic bodies in the lowland parts of Switzerland. The damage to waterways and the costs to control this species are enormous (Reinhardt et al., 2003). However, given the severity of the damage and the negative impact on native mussels (Unionidae) through predation, an eradication or control programme should be considered. Options should be explored together with neighbouring countries, e.g. Germany. Eradication is probably not achievable given the large population already present in Switzerland and the existence of sources for new invasions in Germany and France. On the British Isle the muskrat was eradicated in 1939, but the population was still small and confined to several centres of introduction in England, Scotland and Ireland. The British Isles are not connected to continental Europe, thus it is easier to prevent re-infestation. It has also been suggested that the UK climate is not ideal for the species, so that eradication was more easily achieved.

Another large rodent, the **coypu** (*Myocastor coypus* (Molina)) has been found in Switzerland on several occasions and in different areas, mainly in the north-west (Hausser, 1995). Its origin is the southern half of South America and it is confined to water edges. Like the muskrat, it was deliberately introduced into the wild for hunting because of its fur; like most aquatic animals, it has very dense fur to help it conserve heat in cold water. However, most coypu colonies are derived from animals that escaped from fur farms and established short-lived populations in Central Europe. They are not well-adapted to cold winters, thus severe winters often cause high mortality and local extinction. In the Mediterranean area (e.g. southern France and northern Italy) coypu populations thrive and they damage dams by burrowing and reduce crop yields (Southern, 1964). It can be concluded that the coypu is unlikely to establish permanent populations and cause an environmental impact in Switzerland, because of the prolonged frost periods. Most of the sightings will be of single specimens or temporary populations. However, it needs to be stressed that it is difficult to be confident about this prediction. The coypu was successfully eradicated from England, and casualties amongst non-target organisms, which had been considerable during the muskrat eradication, were reduced by using cage traps and releasing non-target species back into the wild (Williamson, 1996).

The ubiquitous **brown rat** (*Rattus norvegicus* (Berkenhout)) (see Fact Sheet) is a species that adapted very well to human environments. The origin of the genus *Rattus* is the warm climate of South-east Asia, but *R. norvegicus* is from the northern part of the distribution, and is thus better adapted to a cold climate. However, it is surprising how well this species spread with humans all around the globe. Its omnivorous character, together with its ability to live in close vicinity to humans, led to its success. The recorded impacts from this rodent are considerable. Its negative impact on the environment is mainly evident on islands, where it has even caused bird extinctions. In urban areas, the normal habitat in Central Europe, the environmental impact is probably less pronounced, although it is an additional omnivorous predator. However, its impact on structures and foodstuffs and its role as a disease vector in human settlements are unambiguous and the brown rat is controlled in many cities.

The **raccoon** (*Procyon lotor* (L.)) (see Fact Sheet) is the only member of the family Procyonidae introduced to Europe. It was introduced from North America and released in Germany in 1934. From that and other subsequent releases, it spread through Germany and reached Switzerland in 1976. The spread continues and it will eventually inhabit the lowland parts of Switzerland to Genève in the south and the Valais. The impact of the species is disputed. A definitive conclusion cannot be reached without studies being carried out in Switzerland to assess its impact on the native wildlife and as a vector of diseases (Hohmann et al., 2002). This addition to the native fauna may have to be accepted, since control measures are not very effective and its impacts have not (yet) been demontrated. If incidences of diseases carried by the raccoon increase, hunters will have to focus more on this species.

The only introduced dog (Canidae) in Central Europe is the east Asian **raccoon dog** (*Nyctereutes procyonoides* (Gray)) (see Fact Sheet), which was for decades and at many places in the former USSR extensively released as a fur animal. The acclimatization of the species and the value of the fur are questionable. However, it spread westwards and recently reached France. Incorrect identification based on field observations by laypeople may be frequent, because they are not familiar with this species and it can be confused with other predators, such as the raccoon. Thus, identification of dead animals is the most reliable way of evaluating its spread through Europe. Opinions about its impact vary between it being a benign species and a species causing severe impact on native wildlife. One argument is that, as a generalist on abundant food resources, it does no harm to rare organisms. Others argue that predation on bird species and amphibians might have a negative impact (Kauhala, 1996). The status of many amphibians as endangered in Central Europe and the fact that amphibians were found in proportions of up to 45% in the diet of the raccoon dog (Barbu, 1972) indicates the potential harm. It also plays a role as a vector of diseases to humans and other predators (Weidema, 2000). It is recommended that the spread of the raccoon dog should be monitored and its impact in Switzerland evaluated. However, a control programme seems unlikely to achieve success, because of the raccoon dog's secretive behaviour and its continuing invasion from the East. The raccoon dog and the raccoon are two additional predators with which native animals have to cope. Thus, although the impacts of the introduced predatory species are not so different from those of native origin, if they add to the total predator load, they are likely increase the predatory pressure, and destabilize existing populations and population cycles.

The only established alien deer (Cervidae) in Switzerland is the **sika deer** (*Cervus nippon* Temminck). It is a fairly small deer species, intermediate in size between the native roe deer (*Capreolus capreolus* (L.)) and red deer (*Cervus elaphus* L.). The summer coat is chestnut brown to buff brown with white spots, while it is uniform grey-brown during winter. The rump patch is white with a black upper border and the white tail has a black stripe. The typical antlers have four points each. The sika deer is mostly nocturnal, although this might be an adaptation to disturbance and hunting, since most deer species, if undisturbed, would probably be diurnal. It was introduced from its original range in eastern Asia to several countries in Europe, as well as North America, Africa, Madagascar, Australia and New Zealand (Long, 2003), as a game animal, for meat, and as a conservation measure. The sika deer in its natural distribution range, like most (Asiatic) deer species, is under threat due to high hunting pressure and many subspecies are rare (Kurt, 1988). Many sika deer introductions were successful, including one in southern Germany, which was the source of the Swiss population. The enclosure near Schaffhausen was opened in 1941 and a slowly increasing population established (Hausser, 1995). This population is still restricted to the north of the river Rhine. The sika deer is a serious forest pest, browsing young trees and also removing bark (Welch et al., 2001). Native deer show the same behaviour and their large populations have created an unresolved problem in many places. However, an additional, alien, deer species can intensify tree damage (Eisfeld and Fischer, 1996). It can damage crops, as do other ungulates, and can be a road hazard. A serious threat to the native red deer could potentially come from hybridization with the alien sika deer (Krapp und Niethammer, 1986; Welch et al., 2001). However, hybridization has not yet been demonstrated in Germany or Austria (Geiter et al., 2002; Welch et al., 2001). Thus, there is an urgent need to monitor the Swiss population of sika deer and study whether hybridization with the red deer occurs. The outcome of the study will be important for a decision on how to manage the sika deer population – eradication, containment or 'harvest' hunting. The other fact to be taken into consideration is the status of the endangered populations of sika deer in its native range. A population in Switzerland could be valuable for the conservation of the species. A problem with many European populations is the lack of knowledge concerning which subspecies were introduced, and many are of mixed origins. Thus, given that sika deer is common in other introduced areas, the species should preferably be eradicated in Switzerland or at least contained in the infested area.

The **mouflon** (*Ovis orientalis* ssp. *musimon* Gmelin or *O. ammon* ssp. *musimon* (Pallas)) has established a small population over the last 20 years or so in the Valais, where they are slowly increasing in numbers. The mouflon is a member of a species-complex of wild sheep. The views on species status in that group vary considerably between authors. The mouflon was introduced to Central Europe from Corsica and Sardinia. However, the status of these populations is not clear. While some argue that the mouflon is native to these islands, Poplin (1979) and others provide evidence that the populations on Corsica and Sardinia are descendants from domestic animals that were introduced from Asia in the Neolithic Age. The animals were still very similar to their wild ancestors when brought to the Mediterranean islands. In about 1980, the mouflon entered the Valais from a population in France and established populations in the lower Valais. In some localities the mouflon competes with the chamois (*Rupicapra rupicapra* (L.)), but in general the environmental impact will not be significant (Andreotti et al., 2001). As long as the population in Switzerland is small, no significant economic damage will occur. A decision on the future of the mouflon in Switzerland needs to be taken before the populations spread any further. Excluding the game hunting aspect, it is an alien species with no value, and today the value of native species is a predominant consideration in nature conservation, therefore control of the species could be considered. It is recommended that the species at least be contained to the present infested area, using hunting as a measure of control.

A list of species presenting a potential threat to native biodiversity is not complete without mentioning **domestic animals**. Cats (*Felis catus* L.), ferrets (*Mustela furo* L.), dogs (*Canis familiaris* L.) and goats (*Capra hircus* L.) are examples of domestic animals for which an environmental impact is documented (Long, 2003). As with most IAS, the impacts of the above-mentioned domestic animals are greatest on islands, however there are demonstrated impacts in Europe. Domestic cats are very efficient hunters and will kill wild prey, despite being fed. Based on a survey, the total number of mammals, birds, amphibians and reptiles killed by domestic cats in England per year has been estimated to exceed 89 million, including 25 million birds (Woods et al., 2003). Feral cats, which depend entirely on wild food resources, add to this figure. Domestic populations can occur at high densities, because they are fed and belong to households. Urban and rural habitats, where the domestic cats mainly hunt, do not have many endangered species, but are a valuable habitat in highly populated Central Europe. Thus, the effect on native biodiversity is significant. However, a management plan for domestic cats, such as by-laws to keep cats indoors near nature reserves, is a thorny topic. The impact of hybridization with the wild cat (*Felis silvestris* Schreber) is not clear, but it seems to be a conservation issue in some areas (Randi et al., 2001).

The feral ferret is a domesticated form of the eastern polecat (*Mustela putorius* L.) and escaped animals are widely found. Potentially there could be damage to native small mammal and ground-nesting bird populations and from introgression of genes into the wild form, but there is very little information about feral ferrets in the wild (e.g. whether there are self-sustaining populations). Feral dogs are more of a problem for game animals than to biodiversity in Central Europe. Problems with feral goats in Central Europe, in contrast to island ecosystems on a global scale, are rare and local and limited to hybridization with the native ibex (*Capra ibex* (L.)).

About half of the alien mammal species occurring in (or threatening to invade) Switzerland (i.e. muskrat, coypu, grey squirrel, sika deer, raccoon and raccoon dog) are given as examples of species threatening European wildlife and habitats in the Appendix of Recommendation No. 77 (1999) on eradication of non-native terrestrial vertebrates of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (for details on the recommendation for management, see *http://www.nature.coe.int/english/main/Bern/texts/rec9977.htm)*. This recommendation was adopted by the Standing Committee and specifies the recommended action to be taken against IAS, including monitoring, control of sale, and efficacy of eradication efforts. The recommendation sets another framework for dealing with IAS in Europe.

Despite the low number of mammalian neozoa, some patterns can be observed and are discussed below. The ten species listed above are members of nine families. Two of these families have no native members in Europe: Capromyidae occur only in the New World, and Procyonidae in either the New World and east Asia or exclusively in the New World, depending on whether the red panda, *Ailurus fulgens* (Cuvier), is included or not. The different phylogenetic origin of the ten species is reflected in the very different biologies of the species, which include small rodents, large herbivores and carnivores.

Five species are of Asian origin (four from eastern Asia and one from western Asia), four from the New World (one of those from South America), and one is Mediterranean.

The pathways of their introductions reveal a clear pattern, which is generally true for introduced mammals: they were deliberately introduced into Europe. Only one species arrived as a stowaway animal in cargo, ships and other vehicles – the ubiquitous brown rat. The majority of the species are fur animals which were released and escaped from farms (four species); the two large ungulates were released to enrich the hunting fauna, one was used as a food resource and the other to enrich the fauna and for aesthetic reasons. One other interesting aspect is how the species arrived in Switzerland. The pathway analysis presented above shows how the species were transported into Europe. Only four of the ten species in Table 2.1 were actually introduced directly into Switzerland. The most (potentially) damaging species have spread into Switzerland from an introduction elsewhere in Europe, mainly Germany and France. This highlights the importance of international dialogue and collaboration on IAS issues.

Some of the most destructive alien species on a global scale are mammals (Long, 2003). Although the number of introduced species is fairly small in comparison to other groups, the impact is considered to be enormous, especially in island ecosystems. The large herbivores cause a major impact on plants because of their size and the amount they eat, while small carnivores (e.g. Mustelidae) and omnivorous mammals (e.g. Muridae) are intelligent and adaptable species, which are able to prey on a varied diet and can thrive in close proximity to humans. The latter trait facilitates their wide spread by human-mediated transport. The potential impacts of mammalian neozoa in Switzerland are discussed in the species descriptions and the Fact Sheets. Fact Sheets are provided for the five species which are likely to cause some impact. There is no obvious general pattern, besides the fact that the small mammals have had the highest impact through predation on native species and damage to human constructions, including waterways. The date of introduction and perceived impact show no correlation, since the potential for impact rather than the actual impact in Switzerland is used. Thus, the grey squirrel, which has not yet been found in Switzerland, is one of the species of concern. On the other hand, the two species introduced in the 19^{th} century comprise one highly damaging species and one which is now almost extinct.

The small number of introduced species means that general patterns observed in larger data pools are unlikely to be replicated, due to chance.

There are about 86 mammal species currently reproducing in Switzerland, of which nine are neozoa (coypu included), thus about 10% are introduced. When the list of species is compared to those of the neighbouring countries Austria and Germany, there is a high overlap in species composition (Englisch, 2002; Geiter et al., 2002). The total number is a little smaller (Austria: 11; Germany: 11); the most obvious difference is the absence of fallow deer (*Cervus dama* (L.)) and mink (*Mustela vison* Schreber), both established in the other two countries. Gibb and Flux (1973) list twice as many introduced mammals to New Zealand, i.e. 25, and the damage they cause is enormous, since the islands had only two native mammal species (both bats). The niches occupied elsewhere by terrestrial mammals were occupied in New Zealand by native bird species.

The management options for the species are discussed in the text on individual species, above. The invasive or potentially invasive species are very difficult targets for eradication and control. The same traits that make them successful in the invasion process renders them difficult to control, e.g. adaptability and a high fecundity.

Table 2.1: Established alien mammals in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Oryctolagus cuniculus (L., 1758)	Leporidae	Iberian Peninsula	19th century	Released for food	Alteration of plant succession Agricultural pest	The species does not thrive in Switzerland due to the cold winters
Tamias sibiricus (Laxmann, 1769)	Sciuridae	Asian	1975?	Escaped and released to establish population from pet lovers	Great damage to grain crops and forest nut production in its native area	Only small local population in parks in Genève
Sciurus carolinensis Gmelin, 1788	Sciuridae	Eastern North America	-	Released for aesthetic reasons	Replaces the native red squirrel Stripping bark of trees can cause damage in plantations	This species is not yet found in Switzerland, but is rapidly spreading in Italy
Ondatra zibethicus (L., 1766)	Arvicolidae	North America	1935	Escaped from fur farms and released to provide wild fur harvest	Dramatic economic costs due to damage to waterways Predation on native mussel populations	Effective control options should be considered
Myocastor coypus (Molina, 1782)	Capromyidae	South America	-	Escaped from fur farms and released to provide wild fur harvest	Damage to crops by feeding and water banks by burrowing	A permanent establishment seems unlikely because of harsh winters
Rattus norvegicus (Berkenhout, 1769)	Muridae	Southeast Russia and northern China	19th century	Transported inadvertently in ships and other vehicles	Transmission of human diseases High control costs Damage to crops and structures	Generally, urban populations are controlled

Table 2.1: Established alien mammals in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Procyon lotor (L. 1758)	Procyonidae	North and Central America	1976	Releases as a fur animal and to enrich the fauna Escapees from captivity	Predator of invertebrates and vertebrates, with a possible impact through bird nest predation Nuisance in urban areas Problem in orchards? Vector of diseases	It will spread through the entire Mittelland within the next few years/decades
Nyctereutes procyonoides Gray, 1834	Canidae	East Asia	2003	Acclimatization as a fur animal	Predator of vertebrates Vector of diseases	It is only currently spreading into Switzerland from Germany and France
Cervus nippon Temminck, 1836	Cervidae	South-eastern Russia, eastern China, Japan and Korea	1941	Released for sport hunting and for conservation of the species	Serious forest pest Hybridization with red deer (everywhere?)	Only one restricted population in Switzerland
Ovis orientalis musimon Gmelin, 1774	Bovidae	Western Asia	1985?	Released as a game animal	Local competition with chamois	Only a small population in the lower Valais

Birds – Aves

About a quarter of the 510 bird species recorded for Switzerland are alien. This is not surprising, since most birds are good flyers and many migrate regularly. The latter can easily go astray, especially during freak weather events. Hurricane 'Lothar', for example, was responsible for the accidental occurrence of a pelagic bird (generally found far out at sea), the European storm-petrel (*Hydrobates pelagicus* (L.)), in land-locked Switzerland (Keller and Zbinden, 2001). About 200 species breed regularly in Switzerland.

Some bird species are spreading naturally through Europe and into Switzerland. They are not included in the list, although their spread might be triggered by human alterations to the landscape. The spread of these species is indirectly facilitated by human action, but they are not alien as defined here. The collared dove (*Streptopelia decaocto* (Frivaldszky)) has spread phenomenally from the Balkans north-west through most of Europe (Glutz von Blotzheim, 1980). Several hypotheses have been put forward to account for this spread, including an increased amount of food in rural areas and genetic changes in the bird population, but there is no agreement on the explanation.

The species considered in this report are exclusively those which were released or escaped and became established, but not those that expanded their range to include Switzerland. However, species escaping from captivity and observed in the wild or found to breed irregularly are not included. Thus, the list provided here takes into account only birds with established populations in Switzerland or in neighbouring countries, from which spread into Switzerland can be reasonably expected.

Firstly, bird species with established populations in Switzerland (six species) are discussed, and secondly, alien species established in nearby countries which have the potential to spread to Switzerland are considered.

The **cormorant** (*Phalacrocorax carbo* L.) is a common guest during winter in Switzerland, but the first breeding pairs are now established along the Aare near Bern. The birds are probably from the population kept under semi-wild conditions in the zoo. Following the banning of hunting in numerous countries, the cormorant is spreading again in Europe and in many places the conflict between conservation and fishing interests is fervidly debated. Thus, in this specific case and in general, species should be held in secure captivity. Bearing in mind recently acquired knowledge about invasive bird species and the ease with which some are able to establish, keeping populations under semi-wild conditions in zoos and similar facilities is no longer always appropriate. In the recent past, zoos have increased this kind of open confinement to simulate a more natural situation for the benefit of visitors. Unfortunately, as it creates a new pathway for introductions, this approach has to be changed. A similar case is the cattle egret (*Bubulcus ibis* (L.)), which is frequently kept as free-flying populations in zoos, and individuals escape occasionally from captivity. Birds of exotic origin kept under semi-natural conditions can cause another problem: introgression of genes into native populations.

The **mute swan** (*Cygnus olor* (Gmelin)) (see Fact Sheet) was released on park ponds in the 17th century and has subsequently spread to all suitable habitats. It has a stable population, so only local problems occur, and it is also a popular species with the human population, so that control should be limited to public education concerning the impact of feeding waterfowl (Schmid et al., 1998). Stopping the feeding of the swans will eliminate the high densities of mute swans. The mute swans would then distribute themselves more evenly, due to their territoriality based on intraspecific aggression.

A second member of the Anatidae, the **greylag goose** (*Anser anser* (L.)), the wild form of the domestic goose, is not native in Switzerland, but has a growing breeding population in several places, apparently originating from illegally released specimens (Kestenholz and Heer, 2001), although the presence of wild birds that expanded their range cannot be ruled out. Greylag geese are native in an area extending from north-western to south-eastern Europe. They were probably released to enrich the local avifauna in Switzerland. It can be assumed that the populations will grow, without hunting pressure. No environmental impact is expected, since the Swiss population is not far from the southern border of the natural distribution, but there might be damage to crops and droppings on lawns close to lakes could mean the swans are considered a nuisance.

The **ruddy shelduck** (*Tadorna ferruginea* (Pallas)) (see Fact Sheet) is a Central Asian and northern African species, which is a favourite asset of waterfowl collections throughout Europe for its striking plumage of an almost orange-brown body and a whitish head. In many cases the birds are not kept in cages and regularly escape. Some isolated breeding pairs are recorded in many countries. However, Switzerland has the only viable population of this species in Europe, and it is in the process of building up numbers. Its spread to neighbouring countries should be prevented, since if it were to cause subsequent damage and environmental impact, Switzerland would have some responsibility. Therefore, it is recommended that this unnecessary population should be eliminated while it is of manageable size.

The **mandarin duck** (*Aix galericulata* (L.)) (see Fact Sheet) is the only alien duck species to have established in large numbers in Europe. As it is one of the most ornate waterfowl species, it was and is frequently held on park ponds in Europe, from where it escapes into the wild. Its origin is the eastern part of Asia, where populations have been dramatically reduced by habitat changes (mainly logging) and over-hunting. Consequently, the European populations might be of some importance for the species, especially if there is no demonstrated impact. Thus, a strategy for this species in Europe might recommend accepting it.

The native range of the **common pheasant** (*Phasianus colchicus* (L.)) covers a large part of Asia with about 40 subspecies described. It has been kept in pheasant exhibitions for at least a thousand years in Europe (Geiter et al., 2002). However, it is believed that it established in the wild much later, perhaps only in the 18th century, but its history cannot be established with certainty, since the numerous releases obscure the sustainability of wild populations. It is a favourite game bird all over Europe and millions are released every year. Thus naturalized populations are supported by frequent releases and are harvested by hunting, e.g. each year up to 20 million are released and 12 million are shot in the UK (Kestenholz and Heer, 2001). Almost all wild populations in Europe seem to be of hybrid origin from several subspecies, because of the many releases of different genetic material. Apparently, many wild populations are not able to sustain themselves without human help, e.g., by releases and winter feeding. Schmid et al. (1998) estimate a population of fewer than 1,000 for Switzerland, mainly in the lowland parts. It is recommended that releases of this alien species are stopped, so that naturalized populations may dwindle away.

One domestic species needs to be mentioned in this section, the **feral pigeon** (*Columba livia* f. *domestica* L.). It is descended from the rock dove (*Columba livia* L.), which lives on sea-cliffs and in mountains in southern Europe and the UK. The feral pigeon is abundant in most cities of Europe and elsewhere because members of the public supplement their natural food. Today they are often recognized as a problem species due to their faeces altering the colour and destroying the surfaces of old buildings, statues and other artificial structures, and for their role in spreading disease. Most control methods have not been successful. The main hindrance is feeding, making education of the public a crucial aspect of feral pigeon control in cities.

Species in other European countries which are expanding their range are discussed below, as they may enter Switzerland in the near future.

The most successful avian invader in Europe is the **Canada goose** (*Branta canadensis* (L.)), following extensive releases and the availability of suitable habitat for this North American species throughout Central and northern Europe. It is rapidly increasing its population and expanding its range (Delany, 1993). If this spread continues, it is likely to invade Switzerland in the near future. While single individuals ahead of an invasion front could be eliminated, the spread of the species in Europe could only be addressed through an international effort. Competition with native waterfowl has been frequently observed (Madsen et al., 1999) and hybridization with greylag goose is of concern in countries with native populations of the latter species (Gebhardt, 1996). The growing populations of Canada goose are a cause for concern due to damage to crops and faeces deposited in parks and on golf ranges (Kestenholz and Heer, 2001). In spring pastures they cause damage by grazing, trampling and fouling. Fouling is also responsible for eutrophication and associated algal blooms on small, still waters (Welch et al., 2001).

Another goose species, which in recent times rapidly spread from a nucleus population in the Netherlands, is the **Egyptian goose** (*Alopochen aegyptiacus* (L.)). Its native range is Sub-Saharan Africa, where it is a ubiquitous species. The Egyptian goose was already present in captivity in the UK in the 17th century, and probably around 1967 some birds escaped confinement in the Netherlands (Bezzel, 1996). If the affected countries employ no counter-measures it seems likely that the Egyptian goose will eventually spread into Switzerland, but that will take some time, unless further escapes occur in or close to Switzerland. Generally, as for other waterfowl, this species should be kept in closed cages to minimize escapes. During the breeding season, Egyptian geese are very aggressive, and this could have some impact on native waterfowl.

The introduction of North American **ruddy duck** (*Oxyura jamaicensis* (Gmelin)) (see Fact Sheet) into Europe led to one of the best-known cases of concern about an alien species in relation to conservation of a globally threatened native species, i.e. the white-headed duck (*Oxyura leucocephala* Scopoli)), classified as Vulnerable by IUCN (the World Conservation Union) (Hughes et al., 1999). The two species readily hybridize and it is likely that unless counter-measures are taken the white-headed duck population will be completely absorbed. A European action plan for eradication of the destructive invader has been set up to safeguard the small populations of white-headed duck in the western and eastern Mediterranean. The plan does not cover Asia, but it is to be hoped that the ruddy duck will be eradicated in continental Europe and considerably reduced in the UK, so that its spread to Asia becomes unlikely. The spread of the ruddy duck within the UK and then through Europe was facilitated by the fact that it is a migratory species. While the 'Action Plan for the White-headed Duck' (Green and Hughes, 1996) names eight threats and limiting factors, the introduction of the ruddy duck is the only one that is considered critical for its implementation. Tragically the white-headed duck population was just recovering in Spain, from a minimum of 22 birds in 1977 to about 2,700 today due to a conservation programme, but it is now being hit by hybridization with the ruddy duck. Over 4,200 ruddy ducks have now been shot in the UK, where shooting at large wintering sites is crucial to the success of the action plan. Switzerland has endorsed the eradication plans and agreed to take action against the ruddy duck within its borders. Shooting of the ruddy duck has to be conducted in a co-ordinated way by hunting and conservation authorities. Firstly, the correct identity has to be confirmed, since the two *Oxyura* species can be very similar. It is clear from the current situation that ruddy ducks thrive in Europe, build up large viable populations, and spread rapidly. Therefore, keeping ruddy ducks in captivity needs to be regulated. While the ultimate goal for such a serious problem species is the prohibition of keeping them in captivity, an interim measure should be the monitoring of all specimens kept and acceptance of collections only in secure facilities.

In Europe several parrot species frequently escape from captivity and some of those are able to establish in the wild under favourable conditions. Most of these colonies are in parks in cities, where a rich food source of fruit-bearing trees and bird feeders during the harsh winter time together with temperatures on average 2° C above the surrounding landscape allow their survival. The climate seems an important factor for these species that naturally inhabit lower latidudes. The most common parrot species are the **rose-ringed parakeet** (*Psittacula krameri* (Scopoli)) and the **monk parakeet** (*Myiopsitta monachus* (Boddaert)), which have established large colonies in several European cities, including some in neighbouring countries: France, Germany, Austria and Italy. There are single reports of breeding attempts of both species in Switzerland. They are apparently limited to city environments and it is not known whether there is any genetic exchange between the colonies in Europe. The colonies are probably isolated and will not spread that far. The rose-ringed parakeet nests in tree cavities, so that it will compete with native wildlife. The monk parakeet is unusual, building large communal nests on trees, buildings and power pylons. In their home ranges both species are recognized as agricultural pests. Other parrot species are found irregularly throughout Europe. Any parrots encountered in the wild in Switzerland should be captured.

This section, dealing with alien bird species established in Switzerland and those species that are established in neighbouring countries and spreading, illustrates the varied importance of bird families involved. There are four Anatidae, one Phasianidae and one Phalacrocoracidae established. Moreover, three further Anatidae are spreading in neighbouring countries and are expected to arrive in Switzerland in the near future. In addition, two Psittacidae are well established in cities of neighbouring countries. Thus, Anatidae dominate the species list of alien birds currently establishing colonies in the wild in Europe. Estimates of the number of established alien bird species in Europe vary depending on the author, but for example Kestenholz and Heer (2001) list 22 species, of which eight belong to the Anatidae and eight to the Phasianidae. In conclusion, the Swiss composition of alien birds mirrors the European situation, with the exception of having fewer introduced Phasianidae. The latter group has been predominantly released in the UK and France as game birds. The six established species in Switzerland represent about 3% of all breeding species (approximately 205). As birds are a vagile and migratory group, a comparison of breeding species is obviously the best approach to compare native versus alien species.

The total of six alien bird species established in Switzerland is comparable with neighbouring countries (Table 2.2), especially given that Germany is much bigger. Schuster (2002) lists five species (three Anatidae, one Phasianidae, one Psittacidae) for Austria. Ten alien bird species (six Anatidae, three Phasianidae, one Psittacidae) are found in Germany (Geiter et al., 2002). Italy (Andreotti et al., 2001) has about eight species, but the taxonomic composition is different with one Anatidae, one Odontophoridae, two Phasianidae, two Psittacidae, one Paradoxornithidae and one Estrildidae.

Table 2.2: Alien birds established (✓) in selected countries of Europe.

Family	Species	Germany	Austria	Switzerland	Italy
Anatidae	*Aix galericulata* (L.)	✓	✓	✓	
	Cygnus olor (Gmelin)	native	✓	✓	✓
	Branta canadensis (L.)	✓	✓		
	Alopochen aegyptiacus (L.)	✓			
	Anser cygnoides (L.)	✓			
	Anser indicus (Latham)	✓			
	Cygnus atratus (Latham)	✓			
	Tadorna ferruginea (Pallas)			✓	
	Anser anser (L.)	native	native	✓	
Phasianidae	*Phasianus colchicus* (L.)	✓	✓	✓	✓
	Meleagris gallopavo L.	✓			
	Syrmaticus reevesi (Gray)	✓			
	Alectoris chukar (Gray)				✓
Odontophoridae	*Colinus virginianus* (L.)				✓
Phalacrocoracidae	*Phalacrocorax carbo* L.	native	native	✓	native
Psittacidae	*Psittacula krameri* (Scopoli)	✓	✓		✓
	Myiopsitta monachus (Boddaert)				✓
Paradoxornithidae	*Paradoxornis alphonsianus* (Verreaux)				✓
Estrildidae	*Amandava amandava* (L.)				✓

After Geiter et al., 2002 (Germany); Schuster, 2002 (Austria); this report (Switzerland); Andreotti et al., 2001 (Italy).

The composition of established alien birds in Switzerland seems to reflect human activities, i.e. the frequency of release of the species, rather than their ecological traits. Therefore, an evaluation of what makes a bird species invasive is less informative than a discussion of the attractiveness of species to humans.

Due to the small number of six established species (or 11, if we consider the spreading species of neighbouring countries), there is no obvious pattern to their origin. Three of the established species are from within Europe, two from Asia, and one from Africa/Asia.

The year of introduction (i.e. when it was first found established in the wild) varies greatly. However, the very recent significant increase of establishment of species of Anatidae and Psittacidae, not only in Switzerland but also other European countries, gives rise to concern and points to the need to prevent further introductions.

The pathways of introduction differ greatly between the three main groups, but are characteristic for each group. The Anatidae are either released for aesthetic reasons (e.g. mute swan) or have escaped from the numerous ornamental waterfowl collections. The members of the Phasianidae are released as game birds for hunting. The Psittacidae are, of course, escapees from captivity. The success of establishment in all three groups is based on the support they receive from the human population, since some are released and most are fed in the wild (or receive some other human support).

The environmental and economic impact of established alien birds in Switzerland is probably fairly negligible and limited to some local effects. The exception on a European scale is the ruddy duck, which is the critical issue for a native globally endangered species. The possible and certain impacts are summarized in Table 2.3.

Birds seem to cause less concern and actual impact on biodiversity, as outlined above, than mammals, but their impressive capability for spread underlines the concern about both potential future spread and the unsatisfactory level of knowledge for predicting spread and impact. The rapid increase in the number of newly introduced bird species recorded in recent times and the spread of some older introductions underline the urgency of implementing effective strategies to address the issue.

The pathway analysis indicates where prevention of future introductions will be most efficient. The three major pathways identified are listed below, together with measures to help close them.

Escaped birds from captivity (Psittacidae and Anatidae). Measures to prevent escapes of alien bird species from captive collections can include strict standards of security for aviaries, a register and documented bird monitoring, and penal and administrative sanctions in the event of violation.

Released birds for aesthetic reasons and to enrich the native fauna (Anatidae). Legislation to prevent deliberate introductions should be established, or improved and implemented. As can be easily seen from the cases of species spreading through Europe towards Switzerland, this issue needs to be tackled on a European scale. The international conventions are in place and need to be implemented, e.g. Convention on Biological Diversity (CBD), Bern Convention, Bonn Convention, Ramsar Convention. It should be noted here that the domestic duck can also pose a problem for the wild mallard (*Anas platyrhynchos* (L.)) because of hybridization. These noticeable hybrids are most often observed in urban areas, but they should be eliminated in the wild.

Species released as game birds (Phasianidae). An environmental risk assessment needs to be undertaken for all species considered for release in Europe. In the past chukar (*Alectoris chukar* (Gray)) were released in the Alps, including Switzerland. They can hybridize with the native rock partridge (*Alectoris graeca* (Meisner)). The chukar is the eastern equivalent of the rock partridge. These releases are unnecessary and pose a potential danger to the indigenous rock partridge, which is one of the nine European endemic bird species.

Management options for the species which can cause problems are detailed in the text relating to the species and in the Fact Sheets, e.g. ruddy duck and ruddy shelduck should be shot.

Four main recommendations are drawn from this compilation:

- Based on international obligations to safeguard the globally endangered white-headed duck, the ruddy duck has to be eliminated (shot) whenever it is found in Switzerland. Furthermore, the species should not be kept in captivity.
- Switzerland has a responsibility in relation to the potential spread of the ruddy shelduck. It should prevent the spread of the Swiss population and consider eradicating it.
- Birds held in captivity should be monitored closely and escape prevented. Containment of birds under semi-wild conditions should be restricted or prohibited.
- All releases of birds into the wild should be subject to authorization, whereby releases of alien species should be avoided and releases of native birds should be made using genetic material typical of the region.

Table 2.3: Established birds (neozoa) in Switzerland and species to watch for (last three species).

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Phalacrocorax carbo L.	Phalacrocoracidae	Europe	2000	Escaped from captivity	Breeding colonies destroy trees and other vegetation below trees. Impact on fishery heatedly debated. Fish farms	First breeding attempts recorded
Cygnus olor (Gmelin)	Anatidae	North-eastern Europe	1690	Releases for aesthetic reasons	Decline of submerged aquatic vegetation	A much-liked species
Anser anser (L.)	Anatidae	Parts of Europe	1983	Released as an enrichment of the avifauna	Probably no environmental impact Damage of crop possible	Wild form of the domestic goose
Tadorna ferruginea (Pallas)	Anatidae	Central Asia and northern Africa	1997	Escaped from captivity	Aggressive behaviour towards other waterfowl	CH has responsibility for the only viable population in the introduced European range
Aix galericulata (L.)	Anatidae	East-Asia	1958	Escaped from captivity	Competition for tree holes with other cavity breeding species?	Population is small in CH, but other European populations expanding
Phasianus colchicus (L.)	Phasianidae	Asia	18th century?	Released as game	Competition with native game birds? Indirect effects by predator control to relieve pheasants from predation	Pheasant densities are mainly determined by the extent of releases
Branta canadensis (L.)	Anatidae	North America	-	Released as an enrichment of the avifauna	Competition with native waterfowl Hybridization with greylag goose Damage to crops Droppings can be a nuisance and cause eutrophication in water	Has not yet reached Switzerland
Alopochen aegyptiacus (L.)	Anatidae	Sub-Saharan Africa	-	Escaped from captivity	Aggressive behaviour towards other waterfowl	Has not yet reached Switzerland

Table 2.3: Established birds (neozoa) in Switzerland and species to watch for (last three species).

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Oxyura jamaicensis (Gmelin)	Anatidae	North America	-	Escaped from captivity	Hybridization with the globally endangered white-headed duck threatens the extinction of the latter species	There is no established population, only records of single birds. These need to be shot under an EU-wide effort.

Reptiles – Reptilia

Three snake species have been relocated within Switzerland, from southern locations to colder, northern localities. Two of these relocations were very local. The re-introduction of the European pond terrapin used alien genetic material. The only alien reptile species in Switzerland as a country are aquatic turtles released from aquariums, but they seem not to have established populations yet (Table 2.4).

The case of the **Italian wall lizard** (*Podarcis sicula* (Rafinesque-Schmaltz)) in Switzerland is rather mysterious (Hofer et al., 2001). It is not known whether the species is native or alien nor is it proven that an established population exists at all. Since specimens were found along the railway tracks in the Ticino, an accidental introduction from Italy seems likely.

The **dice snake** (*Natrix tessellata* (Laurenti)) is one of the most endangered snakes in Switzerland, because it is at the north-western limit of its range (thus it is naturally rare). It is native to the Ticino, but was released north of the Alps at several lakes (Gruschwitz et al., 1999). Although it is rare in Switzerland, it should not be relocated to the north of the Alps. At the Lac de Genève, where it now occurs together with another rare snake species, the viperine snake (*Natrix maura* (L.)), it is probably competing with the native species for food and habitat, since the two species have a rather similar biology, one occurring in south-western Europe and the other in south-eastern Europe (Hofer et al., 2001).

Small populations of the **western whip snake** (*Coluber viridiflavus* (Lacépède)) might have established at the Neuenburgersee and in the Valais, from specimens collected in the Ticino and released in these areas. The impacts of these populations are probably negligible and the populations themselves might not persist. Populations of the **Aesculapian snake** (*Elaphe longissima* (Laurenti)) at the Neuenburgersee and Bieler See may have originated in the same way and again have little impact. The latter species does seem to be established (Hofer et al., 2001).

The status of the **European pond terrapin** (*Emys orbicularis* (L.)) in Switzerland is not yet resolved (Hofer et al., 2001). Some populations might still be native, but there were many re-introductions of the species. In most instances the origin of the specimens released is not known, but releases of non-native material could lead to genetic introgression into possibly surviving native populations. However, this concern remains hypothetical because of the lack of knowledge of the status of extant populations.

The North American **red-eared slider** (*Trachemys scripta* (Seidel)) (see Fact Sheet) is representative here of a guild of potential IAS – aquatic turtles from several genera. In past years, several countries restricted the importation of this species, because of the potential threat. However, this merely leads to a shift to other species by the aquarium trade. The red-eared slider is still the species most often found in the wild in high numbers and many places, although, because of the direct releases in parks etc., the species is predominantly recorded around agglomerations (Geiger and Waitzmann, 1996). The red-eared slider is probably not yet established in the wild in Switzerland, but this might change through adaptation and future releases of specimens from a more northern natural distribution in North America. Reproduction has been repeatedly observed in areas of Europe with a Mediterranean climate. However, even without reproduction, the populations in certain areas of Switzerland are extremely high owing to frequent releases and the longevity of the species. Therefore there is the potential for native biodiversity to be affected, even if reproduction fails. A recent study by Cadi and Joly (2004) found both weight loss and high mortality in the native turtle *Emys orbicularis* (L.) in mixed groups and argues for applying a precautionary principle. The introduced species also outcompetes the native turtle for preferred basking places (Cadi and Joly, 2003). The red-eared slider is one of the species mentioned in the Recommendations of the Bern Convention, as described above.

Since no alien reptile species has established populations in Switzerland, no general pattern can be discussed here, except to note that the situation in neighbouring countries is rather similar.

Reptiles depend to a large extent on climate, especially temperature, because they can regulate their body temperature only to a certain degree. Thus, tropical and subtropical species, which are most frequently kept in terrariums, are not of concern, apart from escapes of the occasional crocodilian or dangerous snake. However, this is more a matter of interest for the media than a true threat. A real concern for native biodiversity are species from North America and east Asia (China), mainly turtles, which could become established in the Swiss climate. Two measures should be implemented to restrict this threat:

4. Raising awareness in the human population of the potential problem, and especially in herpetological clubs and organizations.

5. Implementing laws to minimize releases and escapes of species which could potentially cause problems, e.g. article 25 of the Eidgenössisches Tierschutzgesetz (Swiss Animal Protection Act) stipulates the penalties for releases of this kind.

Table 2.4: Established alien reptiles in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Natrix tessellata (Laurenti)	Colubridae	Ticino – Switzerland	1920s	Released	Competition with *Natrix maura*	Relocation within Switzerland
Emys orbicularis (L.)	Emydidae	?	1800s?	Released	Genetic introgression with native populations?	Re-introduction
Trachemys scripta (Seidel)	Emydidae	North America	Fairly recent	Released Escaped?	Competition with native turtles in Europe Predator Destroying and disturbing floating bird nests	Perhaps not established, but long-lived

Amphibians – Amphibia

Currently 20 amphibian species are found in Switzerland. One species (*Rana ridibunda* Pallas), i.e. 5% of the total Swiss species number, is introduced and established and will be discussed below and in a Fact Sheet. A second species has been relocated within Switzerland (*Triturus carnifex* (Laurenti)) and a third species is found occasionally but has not yet been able to establish a population, i.e. the North American bullfrog *Rana catesbeiana* Shaw (Table 2.5).

The **marsh frog** (*Rana ridibunda*) (see Fact Sheet) is the only introduced alien amphibian species at the national level. It was introduced between 1920 and 1950, probably from Hungary, as was the case with specimens released in the UK (Zeisset and Beebee, 2003). The most probable explanation for the introductions is that they were imports for human consumption. The marsh frog has now established with a wide distribution in Switzerland, mainly in the west and the Valais and in the north-eastern region. The species should not be supported, as native amphibian species are, by local conservation groups, and releases on conservation grounds or as a food resource need to be stopped. The role of the genetic peculiarities in the green frog complex are not fully understood, but in most places where the marsh frog is increasing the other two related species are decreasing. Thus, a displacement is evident.

Another species introduced into a new range is the **Italian crested newt** (*Triturus carnifex*) (see Fact Sheet), which is native to the south of Switzerland (Ticino) but was introduced to the canton of Genève. Genetic studies showed that the Genève population is closest genetically to a population in Tuscany, Italy (Arntzen, 2001). Most probably the species was imported for zoological experiments and released into a pond at the University of Genève. It completely replaced the closely related great crested newt (*Triturus cristatus* (Laurenti)) in that area. However, it is a complex situation and there is hybridization between the two species. The distribution and spread of the Italian crested newt should be monitored to provide information for future decisions about this species and its threat.

The **American bullfrog** (*Rana catesbeiana*) (see Fact Sheet) has not (yet) colonized Switzerland, but there are some recent unconfirmed records of the species. However, it is established in the neighbouring countries of Germany, France, and especially Italy in the Po valley with some rapidly expanding populations. Research has demonstrated its high potential to cause a decline in native amphibians and reptiles. Thus, bullfrogs should not be tolerated in the wild. Monitoring of suspect water bodies and raising awareness in the human population for this potential menace to native biodiversity is of high priority.

In Switzerland only one frog is introduced and established, this is 5% of the 20 amphibian species currently found in Switzerland. In Austria (Schuster and Rabitsch, 2002) and Germany (Geiter et al., 2002) no established amphibians are listed, although it is possible that the American bullfrog has established unnoticed in the recent past – there is an increasing number of records from Germany. The introduced species in Switzerland, the marsh frog, is native in Austria and Germany.

Species of edible frogs may be illegally released as a food resource and game animal. In certain areas, notably western Switzerland, *R. ridibunda* is still imported in large numbers for human consumption and it is likely that some escape. This has been particularly true in the past with less rigid control of transport and containment. Thus, the current populations have most probably developed from these escapees. It seems likely also that some amphibians are released or escape from captivity as pets. Thus the pet trade should have a responsibility to educate the public about the potential threat of alien species to native biodiversity. Trade in certain species, such as the American bullfrog, should be prohibited.

All three species discussed here are known to cause severe damage to native amphibians by preying on the smaller species, through competition as tadpoles, as vector of diseases, or through hybridization. No negative economic impact has been reported.

The major recommendations to reduce the risks caused by alien amphibian species are:

- A stricter regulation of the (pet) trade and implementation of laws and conventions.
- Besides the legislative options, the public needs to be made aware of the potential threats to native biodiversity. Some of them might voluntarily act in a more responsible way.
- Any established populations of American bullfrogs should be eradicated.

Table 2.5: Established alien amphibians in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Rana ridibunda Pallas	Ranidae	East Europe, probably Hungary	1920s?	Released (as food resource?) Escaped from imports for human consumption	Competition with native amphibians Genetic changes in native green frog complex	Spreading
Triturus carnifex (Laurenti)	Salamandridae	South Europe, including the Ticino	Few decades ago	Released or escaped from containment for scientific studies	Replaced the great crested newt	Native to Switzerland
Rana catesbeiana Shaw	Ranidae	Central and eastern North America	Recent	Released or escaped	Feeding on native amphibians and reptiles Competition with native amphibians Disease vector	Probably no breeding population in CH, as yet

Fish – Pisces

The situation with regard to introduced fish species in Switzerland is interesting because, with the exception of asp (*Aspius aspius* (L.)), all other species are individually mentioned in Appendixes 2 or 3 of the Fisheries Act of 1993 (Ordinance relevant to the federal fisheries law). In this Act, Appendix 2 describes situations (garden ponds, aquaculture plants, etc.) in which certain alien fish taxa can be released without authorization, while Appendix 3 names fish taxa which are unwanted in Switzerland. In this section, species mentioned in these two Appendixes are referred to as Appendix 2 and Appendix 3 species, respectively. A total of 15 species will be discussed below (Table 2.7), although in some cases natural breeding has not yet been reported from Switzerland. In such cases, populations are based on frequent releases. However, the species lists in Appendixes 2 and 3 suggest all 15 species should be dealt with here, since they are regulated in Switzerland. The common carp (*Cyprinus carpio* L.) is not included in the species discussed in this section, because it is assumed to be an archaeozoa, arriving with the Romans in Central Europe. It was also found in most of Europe before the glacial era. Organisms which occurred before glacial times in Central Europe often stimulate discussions about definitions of native and alien species.

The **bighead carp** (*Aristichthys nobilis* Richardson) (see Fact Sheet) has not yet been reported to reproduce in Switzerland. However, it is assumed that the species could breed, and that is the reason for adding the species to Appendix 3. It is reported to breed in the Danube (Donau).

The **asp** (*Aspius aspius*) is a very recent invader in Switzerland, first recorded in 1994 in the Rhine (Rhein) at Basel (Zaugg et al., 2003). It is probably expanding its range following its introduction into the Rhine in Germany, downstream of Basel. Its natural range seems to be Central and eastern Europe from Germany eastwards, including the Danube system. The Rhine population was either introduced for fishing purposes (Ladiges and Vogt, 1979) or spread from the Danube after the completion of the Rhine–Danube Canal. This is the only alien fish species which was not introduced directly into Switzerland but into a neighbouring country, in this case Germany, and is naturally spreading up the river Rhine. The asp is a large fish (up to one metre long) and prefers large rivers. It is one of the few cyprinids that is a piscivore. The adults eat mainly fish, but also mammals and birds, while the more gregarious living young eat smaller animals such as invertebrates. It is assumed that the species will colonize more parts of Switzerland. Since the natural range is close to Switzerland, the species might be acceptable, as a natural expansion rather than an invasion.

The **goldfish** (*Carassius auratus* (L.)) is a favourite species for aquariums and garden and park ponds. Today, it has acquired an almost pan-global distribution through its ornamental use. It either escapes or is released into the wild. Its native range is Central and eastern Asia. The *Carassius* species (two more are discussed below) are difficult to identify and some records might be misidentifications (Arnold, 1990). Goldfish feed on a wide range of food including plants and small animals. In some places they are regarded as a nuisance due to the production of stunted populations. They produce large numbers of individuals, which mature at a much reduced size, thereby diminishing the usefulness of the population for sport or commercial fishing (Lehtonen, 2002). There are indications that they compete with native fish species and increase turbidity through their bottom dwelling behaviour, as does the common carp, thereby altering the aquatic community. Introductions limited to closed systems are possible without authorization (Appendix 2 species).

The **crucian carp** (*Carassius carassius* (L.)) is probably native to Central and eastern Europe, but was widely distributed by humans throughout western Europe in the Middle Ages for fishing. It was in the recent past, if not still, being sold as a bait fish. The crucian carp is a hardy species that can survive adverse conditions, such as low oxygen levels and frost. It is also an Appendix 2 species, and therefore its use as a bait fish is illegal. The crucian carp is rarely found in Switzerland.

The third *Carassius* species is the **Prussian carp** (*Carassius gibelio* (Bloch)). The taxonomy of the three *Carassius* species is complicated and this species is sometimes considered conspecific with *C. auratus*. The species are very similar in many ways, including appearance, biology, food and potential impact. The actual distribution and the history of introductions and spread are not well known, since the species were probably often misidentified (Arnold, 1990). The Prussian carp is listed in Appendix 2, thus its release outside contained captivity must be authorized.

The **grass carp** (*Ctenopharyngodon idella* (Cuvier & Valenciensis) (see Fact Sheet) is of Chinese origin, but as it is one of the most important aquacultural fish, it has acquired a wide distribution on five continents. Although natural reproduction has not been reported in the wild in Switzerland, it is a species of concern because of its potential to cause massive impacts on ecosystems by removing higher aquatic plants and thereby causing shifts in the producer guilds to other plant species. This impact at the bottom of the food chain can cause major alterations to ecosystems. The grass carp showed some potential to control water weeds in Switzerland, but Müller (1995) concludes that it only controls the symptoms of eutrophication instead of ameliorating the causes of the deteriorating water quality. The grass carp is listed in Appendix 3 and therefore all releases are prohibited.

The **silver carp** (*Hypophthalmichthys molitrix* (Valenciensis)) (see Fact Sheet) is a highly specialized phytoplankton feeder. In many cases it was released to reduce phytoplankton densities or stop algal blooms. Its origin is China, but today it is found in many countries around the world. Spawning requires very specific conditions, but has been recorded in the Danube. Its reproduction in Switzerland cannot be ruled out with certainty, so the species was included in Appendix 3.

The **stone moroko** (*Pseudorasbora parva* (Temminck & Schlegel)) (see Fact Sheet) is a very small cyprinid. It is the only established fish species accidentally introduced to Europe and Switzerland, with shipments of grass carp from China. Whereas the deliberately introduced fish species are of value to the commercial or sports sectors, the stone moroko has no value to humans. Thus, the potential for conflicts over management and legislative measures for the species is reduced and it is an Appendix 3 species.

The **American catfish** (*Ameiurus melas* and *A. nebulosus* (Le Sueur)) (see Fact Sheet) belong to the family Ictaluridae, which is restricted to the subtropical and temperate zones of North America, and were introduced into Europe to investigate their potential as a fish for human consumption. However, they are of little value. The two species are very similar not only in appearance but also in their biology. They are listed in Appendix 3, because of their potential negative impacts on native biodiversity.

The brightly coloured **pumpkinseed** (*Lepomis gibbosus* (L.)) (see Fact Sheet) is an example of an ornamental fish introduced into Europe. It has an interesting breeding behaviour and is very showy. However, in some cases the species flourished and has reached high densities. In these circumstances, this predatory fish will almost certainly have an impact on the food web through selective feeding. It is an Appendix 3 species.

One of the most popular sport fish in North America, the **largemouth bass** (*Micropterus salmoides* (Lacépède) (see Fact Sheet), was widely distributed in North America outside its natural range, and imported to Europe in the 1880s. The adult is a specialized fish predator and a decline in native fish species was observed in Italy after its introduction (Welcomme, 1988). It was also one factor, amongst others, in the extinction of the Atitlán grebe (*Podilymbus gigas* Griscom) which was endemic to Guatemala (BirdLife International, 2000). The bird's population dropped drastically to 80 as a result of competition and predation by the introduced largemouth bass, but recovered to a high of 232 in 1975 when the numbers of the bass plummeted (LaBastille, 1984). Later the grebe became extinct through other factors.

The only established alien Percidae is the **pike-perch** (*Sander lucioperca* (L.)), a species from Central and eastern Europe. It is one of the most popular sport fishing species and a highly priced commercial fish. Hence it has been widely released and has built up self-sustaining populations. It prefers large rivers and lakes, where it is a ferocious solitary pelagic predator. In the UK negative impacts on native fish populations have been confirmed; populations of *Esox lucius* L. and *Perca fluviatilis* L. declined after the introduction of pike-perch (Welcomme, 1988). In Switzerland, releases of the pike-perch without authorization are allowed in contained water bodies and where the pike-perch already occurs without negative effects on the fauna and flora (Appendix 2 species). However, the latter is difficult to prove or disprove, so that this predatory species can be released in many open waters. It was found in 137 localities during the survey for the fish atlas of Switzerland (Zaugg et al., 2003). More rigid legislation would be desirable for this species.

The **rainbow trout** (*Oncorhynchus mykiss* Walbaum) is probably the most widely distributed freshwater fish species and may be regarded as a species of global distribution today. It is a highly prized game fish as well as being widely valued for commercial use. In Switzerland its natural reproduction is suspected but has been proved only in the 'Alpine Rhinesystem'. The observed populations are probably based on extensive stocking of the species. Zaugg et al. (2003) found it in 39% of the Swiss lakes and regarded it as a common species. A self-sustaining population is undesirable, because it would be difficult to control its spread or prevent competition for breeding grounds with the native brown trout (*Salmo trutta* ssp. *fario* L.). Where rainbow trout is extensively released, it will have a negative impact on native salmonids. Mahan (2002) showed that the introduction of the rainbow trout into a North American lake caused a decline of an endemic congeneric species (*O. negratis*) with local extinctions. Drake and Naiman (2000) explain the impact on the habitat. The exception of authorization (Appendix 2 species) for stocking in alpine lakes should be re-addressed, because of the potential impact on amphibians. Amphibian populations in naturally fishless ponds and lakes will suffer from introductions of alien predatory fish species.

A favourite species for fly-fishing, the **brook trout** (*Salvelinus fontinalis* (Mitchill)), is today a common species in alpine and subalpine lakes of Switzerland (Zaugg et al., 2003). This species probably competes with the native brown trout. Impacts on lake communities have not been studied in Switzerland. In a North American study Bechara et al. (1992) investigated the impact of brook trout on native communities. Overall, their results suggest that size-selective predation by brook trout can cause profound changes in the structure of epibenthic communities at primary as well as secondary trophic levels. Releases of this species are restricted, since it is also an Appendix 2 species.

The **lake trout** (*Salvelinus namaycush* (Walbaum)) was chosen to stock many high altitude lakes based on its cold-tolerant, northern distribution in North America. It is a large predatory fish, which can probably cause negative impacts on native fish species. The lake trout is a favourite in recreational fishing. Stocking alpine lakes with this Appendix 2 species is permitted. This will have an effect on amphibians sharing the habitat.

The frequent stocking of water bodies with alien fish species, and also native fish species from abroad, for sport and commercial fishing increases the possibility of introducing diseases (see for example the nematode *Anguillicola crassus* in the Nemathelminthes section in the chapter on ‘other selected invertbrate groups’), in addition to the issue of the potential establishment of the alien fish species themselves. Environmental risk studies are recommended before any fish introductions to investigate potential threats. Once the decision to introduce a species is taken, the material may be imported as eggs and some type of quarantine measures should be adopted for imported material prior to its release into natural waters.

The 15 introduced species in Switzerland belong to five families (Fig. 1.1) (as explained above, not all of the species definitely have established populations, but they are included here, since they are listed in Appendixes 2 and 3). Two families are naturally restricted to North America, thus they are new to Switzerland. The Cyprinidae are the most species-rich family in the world with about 2,000 species, so it is not surprising that the highest number of native as well as introduced species belong to this family. It is also interesting to note that eleven families with only one species occur in Switzerland, although several had more members before some became extinct. Today 50% of the salmonids in Switzerland are introduced (three species).

The high number of introduced salmonids reflects their popularity as game fish and for aquaculture. On the other hand, as Table 2.6 shows by comparing the total number of species per family and the number of species introduced to Switzerland, the number of species is a stochastic phenomenon – the smaller families produced a higher percentage of invaders.

Figure 2.1: Numbers of native and introduced fish species in different families in Switzerland.

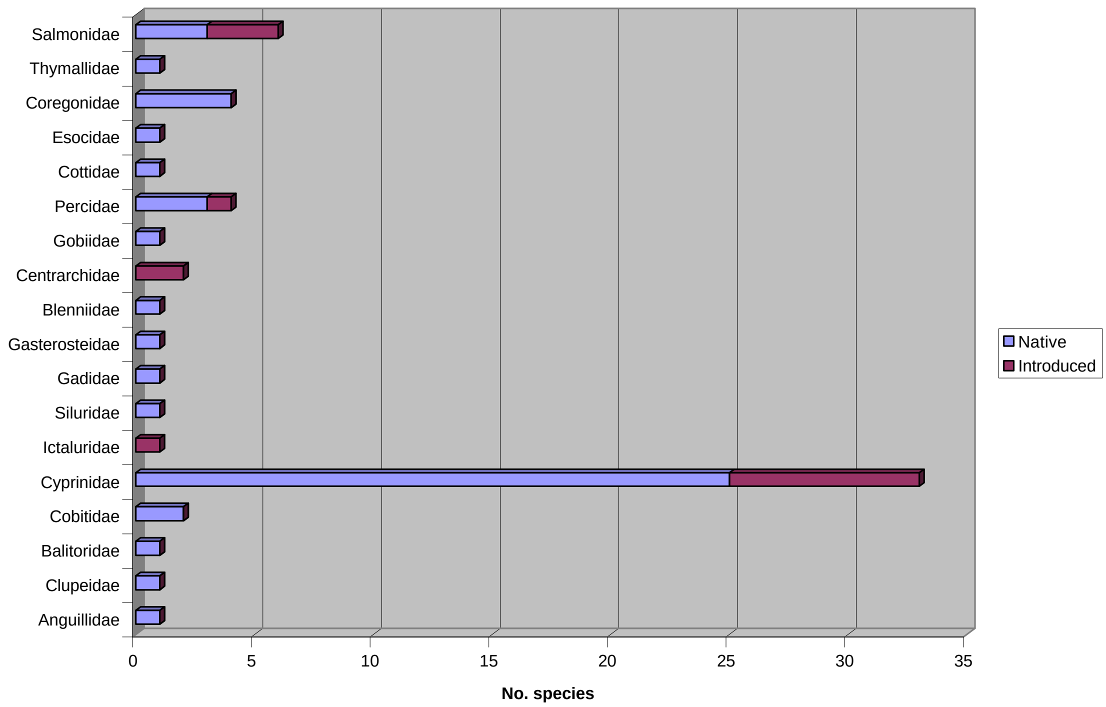

Table 2.6: Total number of members of five fish families worldwide and the number of species in these families introduced into Switzerland.

	Total no. species per family	No. species introduced to Switzerland	Percentage of introduced to total number [%]
Cyprinidae	2000	8	0.4
Ictaluridae	35	1	2.9
Centrarchidae	30	2	6.7
Percidae	159	1	0.6
Salmonidae	66	3	4.5

The lack of certainty about which species are actually established, and which of these are invasive, combined with the different definitions used in national reports, which leads to anomalies regarding which species are listed and how they are categorized, makes a comparison with other European countries such as Austria and Germany difficult. However, the situation appears to be very similar, with the exception of species from Central Europe which are native to Germany. As discussed above, many species are of North American and Asian origin and were widely introduced to Europe, so that they occur also in neighbouring countries.

The 15 introduced species represent about 25% of the current fish fauna. This value is fairly high compared with the figures for the other groups of vertebrates, in which introduced species form less than 10% of the Swiss fauna. This reflects the economic importance of fish species, but also indicates the potential threat to native biodiversity.

The origin of the 15 species is obviously correlated with the climate, since all species are from temperate climates in the Northern Hemisphere, with six each from North America and Asia, and three from other parts of Europe. Mikschi (2002) lists two cichlid species for thermal waters in Austria, and these tropical species can only survive in these warm waters. Three other species from the Neotropics (Poeciliidae) became extinct after their release in the same waters.

The exact pathways for fish introductions are often not known and in many cases introductions have been carried out with more than one motive. Taking the most likely pathways for each species, those released for commercial and sport fishing and aquaculture will amount to 11 of the 15 species. Two species are ornamental releases and escapes, and one was introduced as a control measure for unwanted vegetation. Interestingly, only one species arrived accidentally. However, its arrival is also connected with aquacultural practices, since it was a contaminant in grass carp shipments. In conclusion, the potential threats to native biodiversity are primarily due to fishing activities. Fish releases need to be considered carefully, their threats evaluated, and specimens quarantined to prevent spread of diseases. The number of introductions on a global scale has dramatically decreased since the 1960s, when they peaked, partially because growing awareness of possible negative consequences has led to legislation, but also because of a saturation effect as some species had been introduced to all suitable recipient areas (Welcomme, 1988).

The demonstrated impacts of the 15 species are detailed in Table 2.7 and in the accounts for individual species, above. They encompass the entire range of effects measured, i.e. predatory and grazing pressure, competition with native species, changes in water quality, community and food-web changes, disease vectoring and hybridization.

All potentially harmful species are regulated by Swiss law and are listed in Appendix 2 or 3. This is a very good basis for management of alien fish species in Switzerland, although some of the Appendix 2 species which harm native biodiversity can be stocked in alpine lakes without authorization. This is especially worrisome in the case of predatory fish released into previously fishless lakes, where they can damage the amphibian populations.

Therefore it is recommended that the species of Appendix 2 are re-addressed and stricter regulations are provided for those species.

Another point of concern are species native to Switzerland released outside their native range, as noted in the sections of this chapter on reptiles and amphibians. The roach (*Rutilus rutilus* (L.)), for example, is native to the northern side of the Alps but was released in the Ticino, where it competes with the native fish fauna.

Table 2.7: Alien fish species in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Aristichthys nobilis Richardson	Cyprinidae	China	?	Released for fishing	Changes of community and habitat?	Appendix 3 species
Aspius aspius (L.)	Cyprinidae	Central and eastern Europe	1994	Released for fishing in Germany Migration through new canal systems	Harmless	Not in the Appendixes
Carassius auratus (L.)	Cyprinidae	Central and eastern Asia	?	Released and escaped; imported as ornamental fish	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Carassius carassius (L.)	Cyprinidae	Europe	?	Released for fishing Bait fish	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Carassius gibelio (Bloch)	Cyprinidae	Probably Asia	?	Released for fishing	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Ctenopharyngodon idella (Cuvier & Valenciensis)	Cyprinidae	China	?	Aquaculture Released to control aquatic vegetation	Can change the ecosystem by removing aquatic plants	Appendix 3 species
Hypophthalmichthys molitrix (Valenciensis)	Cyprinidae	China	1970	Released for control of phytoplankton	Community and food-web changes by feeding on phytoplankton	Appendix 3 species
Pseudorasbora parva (Temminck & Schlegel)	Cyprinidae	East Asia	1990	Accidental introductions with other cyprinid imports	Community and food-web changes by selective feeding on zooplankton Chances in water chemistry No commercial value	Appendix 3 species

Table 2.7: Alien fish species in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Ameiurus melas and *A. nebulosus* (Le Sueur)	Ictaluridae	Central and eastern North America	?	Aquaculture Aquarium releases	Predator Competition with native fish species Little commercial value	Appendix 3 species
Lepomis gibbosus (L.)	Centrarchidae	Eastern North America	?	Ornamental reasons Released for fishing	Predator of small invertebrates and vertebrates	Appendix 3 species
Micropterus salmoides (Lacépède)	Centrarchidae	Central and eastern North America	?	Released for fishing	Decline of native fish species	Appendix 3 species
Sander lucioperca (L.)	Percidae	Central and eastern Europe	?	Released for fishing	Ferocious predator	Appendix 2 species
Oncorhynchus mykiss Walbaum	Salmonidae	North America Stock from Germany	1887	Released for fishing Aquaculture	Predator of native fish and amphibians Competition with native salmonids	Appendix 2 species
Salvelinus fontinalis (Mitchill)	Salmonidae	Eastern parts of North America Stock from Germany	1883	Released for fishing Aquaculture	Competition with native salmonids	Appendix 2 species
Salvelinus namaycush (Walbaum)	Salmonidae	North America	1888	Released for fishing	Predator of native fish Competition with native salmonids	Appendix 2 species

References

Andreotti, A., Baccetti, N., Perfetti, A., Besa, M., Genovesi, P. and V. Guberti (2001) Mammiferi e ucelli esotici in Italia: analisi del fenomeno, impatto sulla biodiversità e linee guida gestionali. Quaderni di Conservazione della Natura No 2, Min. Ambiente – Ist. Naz. Fauna Selvatica, 189 pp.

Arnold, A. (1990) *Eingebürgerte Fischarten.* Die Neue Brehm-Bücherei. A. Ziemsen Verlag, Wittenberg Lutherstadt, 144 pp.

Arntzen, J.W. (2001) Genetic variation in the Italian crested newt, *Triturus carnifex*, and the origin of a non-native population north of the Alps. Biodiversity and Conservation 10, 971-987.

Arntzen, J.W. and R.S. Thorpe (1999) Italian crested newts (*Triturus carnifex*) in the Basin of Geneva: distribution and genetic interactions with autochthonous species. Herpetologica 55 (4), 423-433.

Barbu, P. (1972) Beiträge zum Studium des Marderhundes, *Nyctereutes procyonoides ussuriensis* Matschie, 1907, aus dem Donaudelta. Säugetierk. Mitt. 20, 375-405.

Bechara, J. A., Moreau, G. and D. Planas (1992) Top-down effects of brook trout *Salvelinus fontinalis* in a boreal forest stream. Canadian Journal of Fisheries and Aquatic Sciences 49, 2093-2103.

Bezzel, E. (1996) Neubürger in der Vogelwelt Europas: Zoogeographisch-ökologische Situationsanalyse – Konsequenzen für den Naturschutz. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse*. Ecomed Verlagsgesellschaft, Landsberg, pp. 287-296.

Birdlife International (2000) *Threatened birds of the world*. Lynx Edicions and BirdLife International, Barcelona, Spain and Cambridge, UK, 864 pp.

Cady, A. and P. Joly (2003) Competition for basking places between the endangered European pond turtle (*Emys orbicularis galloitalica*) and the red-eared slider (*Trachemys scripta elegans*). Canadian Journal of Zoology 81 (8), 1392-1398.

Cady, A. and P. Joly (2004) Impact of the introduction of the red-eared slider (*Trachemys scripta elegans*) on survival rates of the European pond turtle (*Emys orbicularis*). Biodiversity and Conservation 13 (13), 2511-2518.

Delany, S.N. (1993) Introduced and escaped geese in Britain in summer 1991. Brit. Birds 86, 591-599.

Drake C.D. and J.R. Naiman (2000) An evaluation of restoration efforts in fishless lakes stocked with exotic trout. Conservation Biology 14 (6), 1807-1820.

Elton, C.S. (1958) *The ecology of invasions by animals and plants*. Methuen, London, UK, 181 pp.

Eisfeld, D. and U. Fischer (1996) Das Management eingebürgerter Huftierarten – widerstreitende Interessen, fehlende Konzepte. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse.* Ecomed Verlagsgesellschaft, Landsberg, pp. 287-296.

Englisch, H. (2002) Säugetiere (Mammalia). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 214-221.

Flux, J.E.C. (1994) World distribution. In: Thompson, H.V. and C.M. King (eds) *The European rabbit – the history of a successful colonizer*, pp. 8-21.

Freye, H.-A. (1978) Castor fiber Linnaeus, 1758 – Europäischer Biber. In: Niethammer, J. and F. Krapp (eds) *Handbuch der Säugetiere Europas. Band 1.* Aula Verlag, Wiebelsheim, pp. 184-200.

Gebhardt, H. (1996) Ecological and economical consequences of introductions of exotic wildlife (birds and mammals) in Germany. Wildlife Biology 2, 205-211.

Geiger, A. and M. Waitzmann (1996) Überlebensfähigkeit allochthoner Amphibien und Reptilien in Deutschland – Konsequenzen für den Artenschutz. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse*. Ecomed Verlagsgesellschaft, Landsberg, pp. 227-240.

Geiter, O., Homma, S. and R. Kinzelbach (2002) *Bestandsaufnahme und Bewertung von Neozoen in Deutschland*. Umweltbundesamt, 308 pp.

Gibb, J.A. and J.E.C. Flux (1973) The mammals. In: Williams, G.R. (ed) *The natural history of New Zealand*. A.H. and A.W. Reed, Welllington, pp. 334-371.

Glutz von Blotzheim, U.N. (ed) (1994) *Handbuch der Vögel Mitteleuropas, Band 9, Columbiformes – Piciformes.* Aula-Verlag, Wiebelsheim, Germany, 1148 pp.

Green, A.J. and B. Hughes (1996) Action plan for the white-headed duck *oxyura leucocephala*. In: Heredia, B., Rose, L. and M. Painter (eds) *Globally threatened birds in Europe*. Council of Europe Publishing, Strasbourg, pp. 119-146.

Gruschwitz, M., Sigrid, L., Mebert, K. and V. Lanka (1999) *Natrix tessellata* (Laurenti, 1768) – Würfelnatter. In: Böhme, W. (ed) *Handbuch der Reptilien und Amphibien Europas, Band 3 II A: Schlangen II, Serpentes II: Colubridae 2 (Boiginae, Natricinae).* Aula-Verlag, Wiebelsheim, pp. 482-815.

Grzimek, B. (1975) *Grzimek's Tierleben, Band 10-13.*

Hausser, J. (1995) *Säugetiere der Schweiz.* Birkhäuser Verlag, Basel, Boston, Berlin, 502 pp.

Hofer, U., Monney, J.-C. and G. Dušej (2001) *Die Reptilien der Schweiz. Verbreitung, Lebensräume, Schutz.* Birkenhäuser, Basel, Boston, Berlin, 202 pp.

Hohmann, U., Voigt, S. and U. Andreas (2002) Racoons take the offensive. A current assessment. In: Kowarik, I. and U. Starfinger (eds) *Biologische Invasionen. Herausforderung zum Handeln?* Neobiota 1, 191-192.

Hughes, B., Criado, J., Delany, S., Gallo-Ursi, U., Green, A.J., Grussu, M., Perrenou, C. and J.A. Torres (1999) The status of the North American ruddy duck *Oxyura jamaicensis* in the Western Palearctic: towards an action plan for eradication. Report by the Wildlife & Wetlands Trust to the Council of Europe.

Kaetzke, P., Niedermeier, J. and M. Masseti (2003) *Oryctolagus cuniculus* (Linnaeus, 1758) – Europäisches Wildkaninchen. In: Niethammer, J. and F. Krapp (eds) *Handbuch der Säugetiere Europas. Band 3/II*. Aula Verlag, Wiebelsheim, pp. 187-289.

Kauhala, K. (1996) Introduced carnivores in Europe with special reference to central and northern Europe. Wildlife Biology 2, 197-204.

Keller, V. and N. Zbinden (2001) Die Schweizer Vogelwelt an der Jahrhundertwende. Avifauna Report Sempach 1, 64 pp.

Kestenholz, M. and L. Heer (2001) *Absichtlich und unabsichtlich ausgesetzte Vogelarten in der Schweiz: Situationsanalyse und Massnahmenplan.* Schweizerische Vogelwarte Sempach und Schweizer Vogelschutz SVS – BirdLife Schweiz, Sempach und Zürich, 44 pp.

Krapp, F. (1978a) *Tamias striatus* (Linnaeus, 1758) – Chipmunk. In: Niethammer, J. and F. Krapp (eds) *Handbuch der Säugetiere Europas. Band 1.* Aula Verlag, Wiebelsheim, p. 115.

Krapp, F. (1978b) *Tamias sibiricus* (Linnaeus, 1758) – Burunduk. In: Niethammer, J. and F. Krapp (eds) *Handbuch der Säugetiere Europas. Band 1.* Aula Verlag, Wiebelsheim, pp. 116-121.

Krapp, F. and J. Niethammer (1986) *Cervus nippon* Temminck, 1836 – Sikahirsch. In: Niethammer, J. and F. Krapp (eds) *Handbuch der Säugetiere Europas. Band 2/II.* Aula Verlag, Wiesbaden, 159-172.

Kurt, F. (1988) Sikahirsche (Untergattung *Sika*). In: *Grzimeks Enzyklopädie Säugetiere*. Kindler Verlag GmbH, München, pp. 174-175.

LaBastille, A. (1984) Drastic decline in Guatemala's giant pied-billed grebe population. Environmental Conservation 11, 346-348.

Ladiges, W. and D. Vogt (1979) *Die Süsswasserfische Europas.* Paul Parey, Hamburg und Berlin, 299 pp.

Lehtonen, H. (2002) Alien freshwater fishes of Europe. In: Leppaekoski, E., Gollasch, S. and S. Olenin (eds) *Invasive aquatic species in Europe*, Kluwer, pp. 153-161.

Long, J.L. (2003) *Introduced mammals of the world. Their history, distribution and influence*. CABI, Wallingford, UK, 589 pp.

Madsen, J., Cracknell, G. and T. Fox (1999) Goose populations of the Western Palearctic. Wetlands International Publication, No. 48, 343 pp.

Mahan, K. (2002) The effect of an exotic species (*Oncorhynchus mykiss*), on an endemic population in an isolated caldera lake. Journal of Atawapaskat Research 1, 8-15.

Mikschi, E. (2002) Fische (Pisces). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, 197-204.

Müller, R. (1995) Besatzversuche mit ostasiatischen pflanzenfressenden Fischarten in der Schweiz. BUWAL, Schriftenreihe Umwelt Nr. 236, 75 pp.

Poplin, F. (1979) Origine du mouflon de Corse dans uns nouvelle perspective paléontologique: par marronage. Ann. Génét. Sél. Anim. 11, 133-143.

Randi, E., Pierpaoli, M., Beaumont, M., Ragni, B. and A. Sforzi (2001) Genetic identification of wild and domestic cats (*Felis silvestris*) and their hybrids using Bayesian clustering methods. Molecular Biology and Evolution 18 (9) 1679-1693.

Reinhardt, F., Herle, M. Bastiansen, F. and B. Streit (2003) *Economic impact of the spread of alien species in Germany*. Federal Environmental Agency of Germany, 190 pp.

Riegel , J., Lafontaine, R.-M., Pasteels, J. and P. Devillers (2001) Potential influence of the Siberian chipmunk *Tamias sibiricus* (Laxmann) on the regression of the bird fauna of the Forêt de Soignes, Brussels. *Cahiers d'Éthologie*.

Schmid, H., Luder, R., Naef-Daenzer, B., Graf, R. and N. Zbinden (1998) *Schweizer Brutvogelatlas. Verbreitung der Brutvögel in der Schweiz und im Fürstentum Liechtenstein 1993-1996.* Schweizerische Vogelwarte, Sempach.

Schuster, A. (2002) Vögel (Aves). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 209-214.

Schuster, A. and W. Rabitsch (2002) Lurche und Kriechtiere (Amphibia & Reptilia). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 205-209.

Southern, H.N. (1964) *The handbook of British mammals*. Oxford, 465 pp.

Weidema, I.R. (ed) (2000) *Introduced species in the Nordic countries*. Nordic Council of Ministers, Copenhagen, 242 pp.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318 pp.

Williamson, M. (1996) *Biological invasions*. Chapman & Hall, London, Weinhaim, New York, Tokyo, Melbourne, Madras, 244 pp.

Woods, M., McDonald, R. and S. Harris (2001) Predation of wildlife by domestic cats *Felis catus* in Great Britain. Mammal Review 33, 174-188.

Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) *Pisces, Atlas. Fauna Helvetica 7.* Centre Suisse de Cartographie de la Faune, 233 pp.

Zeisset, I. and T.J.C. Beebee (2003) Population genetics of a successful invader: the marsh frog *Rana ridibunda* in Britain. Molecular Ecology 12, 639-646.

Fact Sheets

Aix galericulata

Taxonomic status

Scientific name	Aix galericulata (L.)
Family	Anatidae
Taxonomic group	Anseriformes
English name	Mandarin duck
German name	Mandarinente
French name	Canard mandarin
Italian name	Anatra mandarina

Description and identification

Description	The male is unmistakable with its striking colours – ornamental orange 'sail' feathers and broad white tapering supercilium. Females with their grey head and white eye-ring are easy to recognize, but another alien duck, which sometimes escapes, the North American wood duck (*Aix sponsa* (L.) is very similar. They can be differentiatedt by the white pattern in the face.
Similar species	No similar native species, but see above for the wood duck.

Biology and ecology

Behaviour	The Mandarin duck breeds mainly in tree holes. The European population is resident, although it is migratory in its native range.
Food	Feeds on water plants and seeds.
Habitat	Forested margins of lakes and rivers. It prefers dense cover.

Origin East Siberia, north China and Japan.

Introduction and dispersal

History of introduction	The striking birds are a favourite species for waterfowl exhibitions and were/are kept in parks, from where they escaped during the 20th century. They built up an extensive population of about 7,000 individuals in the UK. Large populations are also found in the Netherlands and Germany. The Swiss first brood was found in 1958 near Basel.
Pathways of introduction	The species escaped from waterfowl collections and may also be illegally released in some places.
Dispersal	Birds spread locally when the population is growing, but they are capable of long-distance travel.

Current status

Actual and potential distribution in CH	There are about 15 breeding pairs in Switzerland throughout the Mittelland between Genève and Basel. In that area there is more, as yet unused, suitable habitat, which could be colonized, so a population increase is likely.
Introduced distribution	The largest introduced populations are found in England, the Netherlands, and Germany. There are also escapees in other countries.

Impacts

Environmental impact	There is a possibility of competition with the native goldeneye (*Bucephala clangula* (L.)) (and other cavity-nesting bird species) for tree holes.
Economic impact	Probably no economic impact.

Management options While the current small population could still be eradicated, the necessity for this is questionable. The main point to take into consideration is the small populations in its native range.

Information gaps Range of potential distribution in Europe. Impacts.

References

Literature

Burkhardt, M. and H. Schmid (2001) Vögel in der Schweiz. Schweizerische Vogelwarte, Sempach, 276 pp.
Davies, A. (1988) The distribution and status of the Mandarin duck Aix galericulata in Britain. Bird Study 35, 203-208.
Kestenholz, M. and L. Heer (2001) Absichtlich und unabsichtlich ausgesetzte Vogelarten in der Schweiz: Situationsanalyse und Massnahmenplan. Schweizerische Vogelwarte Sempach und Schweizer Vogelschutz SVS – BirdLife Schweiz, Sempach und Zürich, 44 pp.
Madge, S. and H. Burn (2002) Wassergeflügel. Marixverlag, 297 pp.
Rutschke, E. (1989) Die Wildenten Europas. Biologie, Ökologie, Verhalten. Aula Verlag, Wiebelsheim, 368 pp.
Schmid, H., Luder, R., Naef-Daenzer, B., Graf, R. and N. Zbinden (1998) Schweizer Brutvogelatlas. Verbreitung der Brutvögel in der Schweiz und im Fürstentum Liechtenstein 1993-1996. Schweizerische Vogelwarte, Sempach.

Ameiurus melas / nebulosus

Taxonomic status

Scientific name	*Ameiurus melas* and *A. nebulosus* (Le Sueur)
Family	Ictaluridae
Taxonomic group	Osteichthyes
English name	American catfish
German name	Katzenwels
French name	Poisson-chat
Italian name	Pesce gatto

Description and identification

Description	The two American catfish species are very similar in appearance and biology, thus are considered here together. The American catfish have a round body; more laterally depressed towards the rear, with a prominent head. Eight barbels (2 pairs below mouth, 1 above, and 1 on head near nostrils) and a pectoral spine are diagnostic. The body colour is dark. *A. melas*: Barbs on trailing edge of pectoral spines weak or absent *A. nebulosus*: Barbs on trailing edge of pectoral spines strong, even near tip.
Similar species	Both species are much smaller than the native catfish (which are in a different family), and the species can also be distinguished by their fins (see above).

Biology and ecology

Behaviour	The American catfish are nocturnal. The species can hear very well and distinguish between different noises. They are also able to sense electrical currents. Eggs are laid in shallow water and are guarded by one (or two?) parent(s), whose movements also enhance the available oxygen.
Food	Mainly bottom feeders, eating all available organic matter, including dead insects, etc.
Habitat	In shallow waters of lakes, rivers and ponds with a good cover of submerged vegetation on sandy or muddy soil.

Origin Central and eastern North America

Introduction and dispersal

History of introduction	The species were imported to Germany at the end of the 19th century for aquaculture, but they soon lost value as food. However, the species dispersed widely throughout Europe and reached Switzerland, too.
Pathways of introduction	Aquaculture and aquarium releases probably founded the existing populations.
Dispersal	Natural dispersal in river systems. They can survive periods of drought for several months by submerging in the mud of the riverbed.

Current status

Actual and potential distribution in CH	They are found in only a few, scattered sites. They are likely to colonize more of the lowland parts of Switzerland (they need warm water for spawning).
Introduced distribution	The two species are widely distributed in Europe today. However, due to difficulties in distinguishing them, the distributions of the

	individual species are not well known.

Impacts

Environmental impact	They are unpopular, because they form dense stunted populations. Their adaptability and ferocious feeding behaviour make them a grave threat to the native fish and amphibian fauna. In places, they have built up huge populations and replaced native fish species, probably through competition for food.
Economic impact	They have little sporting or commercial value.

Management options There is no great conflict of interest, as there is with many other species that are important for fishing, thus regulations are straightforward. The species are in Appendix 3 (see text for explanation) and their introduction is therefore forbidden.

Information gaps Actual distributions of the two American catfish species in Europe. Impact on community and habitat in Switzerland.

References

Literature

Arnold, A. (1990) Eingebürgerte Fischarten. Die Neue Brehm-Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt, 144 pp.
Geiter, O., Homma, S. and R. Kinzelbach (2002) Bestandsaufnahme und Bewertung von Neozoen in Deutschland. Umweltbundesamt, 308 pp.
Ladiges, W. and D. Vogt (1979) Die Süsswasserfische Europas. Paul Parey, Hamburg und Berlin, 299 pp.
Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318pp.
Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source *http://www.fishbase.org/search.cfm*

Aristichthys nobilis

Taxonomic status

Scientific name	*Aristichthys nobilis* Richardson
Family	Cyprinidae
Taxonomic group	Osteichthyes
English name	Bighead carp
German name	Gefleckter Tolstolob
French name	Carpe marbrée
Italian name	-

Description and identification

Description	A large (more than 1-m long) fish with a big head and oblique mouth. Small eyes are low on the head. Brown markings on light body.
Similar species	Distinguished from other species by the head; the mouth and eyes are quite distinctive.

Biology and ecology

Behaviour	A bottom-dwelling fish which prefers warm temperatures. The water temperatures need to exceed 22°C for egg laying. The larvae hatch just 1-2 days later.
Food	Feeds mainly on zooplankton. In colder environments it shifts to a more predatory behaviour.
Habitat	Occurs in rivers and lakes.

Origin China

Introduction and dispersal

History of introduction	Widely introduced for aquaculture and fishing.
Pathways of introduction	Frequent releases for commercial and recreational fishing.
Dispersal	Normal dispersal.

Current status

Actual and potential distribution in CH	Only rarely found in Switzerland.
Introduced distribution	Introduced to water bodies on several continents.

Impacts

Environmental impact	As a specialized zooplankton feeder it can alter the community and change the nutrient flow of the habitat.
Economic impact	Positive – commercial fish.

Management options An Appendix 3 species (see text for explanation) and its introduction is therefore prohibited.

Information gaps Impact on community and habitat. Monitoring of breeding in Europe.

References

Literature

Terofal, F. (1984) Süsswasserfische in europäischen Gewässern. Mosaik Verlag GmbH, München, 287 pp.
Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318pp.

Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source

http://www.fishbase.org/search.cfm
http://www.ku.lt/nemo/mainnemo.htm

Ctenopharyngodon idella

Taxonomic status

Scientific name	*Ctenopharyngodon idella* (Valenciennes)
Family	Cyprinidae
Taxonomic group	Osteichthyes
English name	Grass carp
German name	Graskarpfen
French name	Amour blanc
Italian name	-

Description and identification

Description	The grass carp is a large species of slender appearance. It is greenish above and whitish below. The large scales have a dark edge producing a neat pattern. It has no barbels and a very short snout.
Similar species	The set of characters given above allows the grass carp to be distinguished from other fish.

Biology and ecology

Behaviour	The grass carp prefers warm waters. When the temperature and other factors are met, it spawns over gravel in faster flowing parts of its habitat.
Food	Mainly, as the name implies, higher water plants.
Habitat	Standing water bodies, mainly fish ponds, where it is stocked. It prefers large, slow-flowing water bodies.
Origin	China

Introduction and dispersal

History of introduction	One of the world's most important aquaculture fish. It is also released to control water vegetation in eutrophic water bodies.
Pathways of introduction	Stocking of water bodies for weed control or as a food fish.
Dispersal	Dispersal can be extensive during spawning migration.

Current status

Actual and potential distribution in CH	The grass carp is found patchily in the Rhine watershed. The populations are based on stocking; no natural reproduction was found in Switzerland.
Introduced distribution	Introduced to water bodies on five continents.

Impacts

Environmental impact	Grass carps can remove a large percentage of the aquatic vegetation, which causes impacts that can ripple through the entire biological community, causing structural changes. It inhabits a fairly new niche in most areas and can alter the ecosystem.
Economic impact	Positive – important aquaculture fish and used for weed control.

Management options	An Appendix 3 species (see text for explanation) and its introduction is therefore prohibited.
Information gaps	Impact on community and habitat in Switzerland. Survey of breeding populations in Europe.

References

Literature

Ladiges, W. and D. Vogt (1979) Die Süsswasserfische Europas. Paul Parey, Hamburg und Berlin, 299 pp.

Maeceina, M.J., Cichra, M.F., Betsill, R.K. and P.W. Bettoli (1992) Limnological changes in a large reservoir following vegetation removal by grass carp. Journal of Freshwater Ecology 7 (1), 81-95.

Müller, R. (1995) Besatzversuche mit ostasiatischen pflanzenfressenden Fischarten in der Schweiz. BUWAL, Schriftenreihe Umwelt Nr. 236, 75 pp.

Terofal, F. (1984) Süsswasserfische in europäischen Gewässern. Mosaik Verlag GmbH, München, 287 pp.

Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318 pp.

Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source

http://www.fishbase.org/search.cfm

http://www.ku.lt/nemo/mainnemo.htm

http://nis.gsmfc.org/nis_factsheet.php?toc_id=182 Exhaustive discussion of impacts

Cygnus olor

Taxonomic status

Scientific name	*Cygnus olor* (Gmelin)
Family	Anatidae
Taxonomic group	Anseriformes
English name	Mute swan
German name	Höckerschwan
French name	Cygne tuberculé
Italian name	Cigno reale

Description and identification

Description	Unmistakable during summer. A large white swan, well-known from park ponds. Bill red with a black knob at the base (bigger in males). Wings produce noise during flight.
Similar species	During summer the only large white birds. Domestic geese are of stockier shape. In winter whooper swan (*Cygnus cygnus* (L.)) and Bewick's swan (*Cygnus columbianus* (Yarrell)) can be found in Switzerland; both have a dark bill with a yellow base and frequently utter calls.

Biology and ecology

Behaviour	Diurnal and tame, often in parks and on lakes, where fed by humans.
Food	Feeds on water plants from the surface; its long neck allows it to take submerged plants from the bottom of shallow water (up to 1.07 m deep). It also grazes on meadows.
Habitat	Lakes with shallow plant-rich areas are the preferred habitat. It can reach high densities, when fed by humans all year round.

Origin North-eastern Europe.

Introduction and dispersal

History of introduction	The mute swan was released on park ponds probably as early as 1690, but then in higher numbers at the end of the 19th century. At this time, they were introduced into most Central European countries.
Pathways of introduction	The white (= pure in an ethical sense) mute swan was released for aesthetic reasons on park ponds.
Dispersal	During the 20th century the mute swan spread from these ponds to all lakes and slow-flowing rivers that provided suitable habitat.

Current status

Actual and potential distribution in CH	The mute swan has colonized all suitable lakes and rivers in Switzerland. It has a stable population of about 500 pairs.
Introduced distribution	The mute swan has been introduced to most Central European countries and can be found westwards to the UK and the Pyrénées. The mute swan has also been introduced to New Zealand, Australia and North America.

Impacts

Environmental impact	No impact has been observed in Switzerland. However, in other regions the mute swans altered the community of shallow water by uprooting entire plants and overgrazing on submerged aquatic vegetation with a biomass reduction of up to 90%.

Economic impact	In the USA substantial damage to crops has been reported. Faeces can be a nuisance on lawns and agricultural fields.
Management options	If the population stays stable and no impact is reported, no management is necessary. Feeding of populations should be stopped through public education to prevent the growth of unnaturally dense populations. In some areas of North America, there are action plans to reduce mute swan populations by culling or manipulation of eggs. However, these action plans are facing strong opposition from lobby groups.
Information gaps	Impact in Switzerland. Best management practice.

References

Literature

Burkhardt, M. and H. Schmid (2001) Vögel in der Schweiz. Schweizerische Vogelwarte. Sempach, 276 pp.

Cobb, J.S. and M.M. Harlan (1980) Mute swan (*Cygnus olor*) feeding and territoriality affects diversity and density of rooted aquatic vegetation. American Zoologist 20, 882.

Kestenholz, M. and L. Heer (2001) Absichtlich und unabsichtlich ausgesetzte Vogelarten in der Schweiz: Situationsanalyse und Massnahmenplan. Schweizerische Vogelwarte Sempach und Schweizer Vogelschutz SVS – BirdLife Schweiz, Sempach and Zürich, 44 pp.

Lüps, P. and O. Biber (1984) Gewicht und Körpermasse bei Höckerschwänen (*Cygnus olor*) von Wohlensee bei bern. Ornithol. Beob. 81, 77-78.

Madge, S. and H. Burn (2002) Wassergeflügel. Marixverlag, 297 pp.

Schmid, H., Luder, R., Naef-Daenzer, B., Graf, R. and N. Zbinden (1998) Schweizer Brutvogelatlas. Verbreitung der Brutvögel in der Schweiz und im Fürstentum Liechtenstein 1993-1996. Schweizerische Vogelwarte, Sempach.

Hypophthalmichthys molitrix

Taxonomic status

Scientific name	*Hypophthalmichthys molitrix* (Valenciennes)
Family	Cyprinidae
Taxonomic group	Osteichthyes
English name	Silver carp
German name	Silberner Tolstolob
French name	Amour argenté
Italian name	-

Description and identification

Description	Silver carp is a large, laterally compressed cyprinid. The back is dark with silvery colouration on the rest of the body. The mouth is relatively large and up-turned.
Similar species	It is similar to the bighead carp, but lacks the dark spots and the eyes are higher on the head.

Biology and ecology

Behaviour	In its natural range, the silver carp migrates upstream for spawning. The eggs float in the current and develop rapidly. The larvae hatch after 1-2 days. Spawning females are between 3 and 10 years old.
Food	The silver carp is a specialized phytoplankton feeder. It cannot discriminate between plankton species within the particle size range it feeds on, so the food ingested is a reflection of the phytoplankton composition.
Habitat	Standing and slow-flowing conditions are preferred.

Origin China.

Introduction and dispersal

History of introduction	The silver carp is used in commercial fishing and aquaculture. Additionally, it has been released to control phytoplankton and to stop algal blooms. In Switzerland, the species has been released since 1970.
Pathways of introduction	It is introduced to reduce phytoplankton and stop algal blooms.
Dispersal	Dispersal can be extensive during spawning migration.

Current status

Actual and potential distribution in CH	The silver carp is currently found only at three places in Switzerland.
Introduced distribution	Today it is found on most continents, as a result of frequent releases.

Impacts

Environmental impact	Drastic changes in the food web, attributed to the silver carp's selective feeding on phytoplankton were shown for a lake in Poland stocked with this species. In some instances it was shown that the phytoplankton actually increased, since the species shifted its diet to zooplankton for unknown reasons. However, in any instance of fish stocking, the food web can be altered to the detriment of the natural ecosystem.
Economic impact	Positive – important aquaculture fish and used for phytoplankton control.

Management options An Appendix 3 species (see text for explanation) and its introduction is therefore prohibited.

Information gaps Impact on community and habitat in Switzerland. Survey of spawning populations in Europe.

References

Literature

Terofal, F. (1984) Süsswasserfische in europäischen Gewässern. Mosaik Verlag GmbH, München, 287 pp.

Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318 pp.

Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Zdanowski, B., Hutorowicz, A., Tunowski, J., Swiatecki, A., Olejnik, G., Krzywosz, T., Bialokoz, W., Chybowski, L., Krzywosz, W., Blocka, B. Hutorowicz, J., Robak, A., Prusik, S., Koprowska, L., Cieminski, J., Weglenska, T., Lewandowski K. and E. Jurkiewicz-Karnkowska (1999) Ecological effects of long-term pressure of phytophagous and seston-feeding fish on the structure and functioning of the shallow Lake Warniak (Mazurian Lakeland, Poland). Acta Hydrobiol. 41, Supplement 6, 29-47.

Other source

http://www.fishbase.org/search.cfm

http://www.ku.lt/nemo/mainnemo.htm

http://nis.gsmfc.org/nis_factsheet.php?toc_id=189

Lepomis gibbosus

Taxonomic status

Scientific name	*Lepomis gibbosus* (L.)
Family	Centrarchidae
Taxonomic group	Osteichthyes
English name	Pumpkinseed
German name	Sonnenbarsch
French name	Perche-soleil
Italian name	Persico sole

Description and identification

Description	The mature fish has a high back, nearing a disc form. The pumpkinseed is very brightly coloured with an intricate pattern on a variable ground colour, and a prominent black spot on the tip of the gill plate.
Similar species	The mature fish can be distinguished from other species by its characteristic shape and colouration.

Biology and ecology

Behaviour	In May and June territorial males build a nest in shallow water in the form of a shallow cavity on the bottom. Besides these territorial males, there are others, which sneak into the nest or imitate females and release their sperm onto freshly laid eggs. The territorial males guard the eggs and the small fish, and will even attack bigger fish.
Food	Diet consists mainly of small benthic organisms including insect larvae but also some fish and amphibian larvae.
Habitat	The shape of the body (high back and laterally compressed) is ideal for slow-flowing or standing water with dense vegetation. The preferred habitat is standing water with good sun exposure, high density of vegetation, and a sandy bottom. However, the fish are found in a wide variety of water bodies in Europe.

Origin Central and eastern North America.

Introduction and dispersal

History of introduction	The pumpkinseed was first imported and introduced into the wild in 1877.
Pathways of introduction	It was probably introduced as an ornamental fish for garden ponds and aquariums, since it is of little commercial value but brightly coloured.
Dispersal	Besides repeated releases from owners into the wild, it probably diffused from one country to another through the canal and river network.

Current status

Actual and potential distribution in CH	The pumpkinseed is found in the lowland parts of Switzerland – north, west, and south. However, not all suitable water bodies are colonized yet.
Introduced distribution	Besides many countries in most of Europe (except in the north and south of the continent) the species was also introduced into western North America, outside its natural range.

Impacts

Environmental impact — This predatory fish can occur in very high numbers and impact the native fauna by feeding on aquatic invertebrates, larvae of amphibians and fish eggs and fry. It can have a negative impact on zooplankton composition. This leads to a rippling effect through the food web and can alter the ecosystem.

Economic impact — A fish of little importance.

Management options — The pumpkinseed is frequently kept as an ornamental fish in ponds and aquariums, from where it is released into the wild. It is an Appendix 3 species (see text for explanation) and its introduction is therefore prohibited. The law should be implemented rigorously and owners of ornamental fish be educated about the threats to native biodiversity caused by irresponsible pet releases.

Information gaps — Impact on community and habitat in Switzerland.

References

Literature

Arnold, A. (1990) Eingebürgerte Fischarten. Die Neue Brehm-Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt, 144 pp.
Ladiges, W. and D. Vogt (1979) Die Süsswasserfische Europas. Paul Parey, Hamburg and Berlin, 299 pp.
Terofal, F. (1984) Süsswasserfische in europäischen Gewässern. Mosaik Verlag GmbH, München, 287 pp.
Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318pp.
Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source — *http://www.fishbase.org/search.cfm*

Micropterus salmoides

Taxonomic status

Scientific name	*Micropterus salmoides* (Lacépède)
Family	Centrarchidae
Taxonomic group	Osteichthyes
English name	Largemouth bass
German name	Forellenbarsch
French name	Black bass a grande bouche
Italian name	Persico trotta

Description and identification

Description	This is a fairly slender fish with a large mouth, as the name implies. Length is about 40-60 cm. The dorsal surface is greenish, fading into whitish ventrally. A black zigzag line runs laterally along the side of the fish. The head has dark stripes.
Similar species	The two *Micropterus* species introduced to Europe are distinguished by differences in the fins and the following character: *M. salmoides*: upper jaw extends beyond the eye. *M. dolomieu* Lacépède: upper jaw extends at least to mid-pupil, but not beyond the eye.

Biology and ecology

Behaviour	The spawning season of the largemouth bass is between March and July. The males build a nesting depression up to 1 m in diameter and 20 cm deep. After spawning, the male guards the eggs until the larvae hatch after 3-5 days.
Food	Young largemouth bass feed on plankton, but the food taken becomes gradually bigger with the increasing size of the fish. The mature fish are specialized hunters of other fish (piscivores).
Habitat	The largemouth bass prefers the warmer, shallower parts of lakes and sluggish rivers.

Origin Central and eastern North America.

Introduction and dispersal

History of introduction	It was imported to Europe in the 1880s, then bred in captivity and distributed throughout Europe.
Pathways of introduction	The largemouth bass is one of the most popular sport fish in North America. This is the main reason for the species being stocked almost on a global scale.
Dispersal	Normal dispersal within river systems and through canals.

Current status

Actual and potential distribution in CH	Although there are two recent records in the north-eastern part of Switzerland, the main range is south of the Alps in the Ticino, which is part of the Po watershed. Further establishment of the species north of the Alps is difficult to predict, since it appears to have disappeared from the locations where it was previously recorded in Germany, and thus the species might vanish in the absence of further stockings. However, there is no clear picture to base predictions on.
Introduced distribution	This popular species is widely relocated in North America, in addition to most countries in Europe, except the northern and south-eastern ones.

Impacts

Environmental impact	The largemouth bass is a specialized predator of fish. In Italy the introduction of the largemouth bass has caused a decline in native *Alburnus alborella* (de Filippi), *Esox lucius*, and *Perca fluviatilis*.
Economic impact	A very popular sport fish.

Management options An Appendix 3 species (see text for explanation) and its introduction is therefore prohibited, even in contained water bodies. This is based on its proven negative impact on native fish species.

Information gaps Impact on fish species in the Ticino.

References

Literature

Arnold, A. (1990) Eingebürgerte Fischarten. Die Neue Brehm-Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt, 144 pp.
Geiter, O., Homma, S. and R. Kinzelbach (2002) Bestandsaufnahme und Bewertung von Neozoen in Deutschland. Umweltbundesamt, 308 pp.
Ladiges, W. and D. Vogt (1979) Die Süsswasserfische Europas. Paul Parey, Hamburg und Berlin, 299 pp.
Terofal, F. (1984) Süsswasserfische in europäischen Gewässern. Mosaik Verlag GmbH, München, 287 pp.
Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318pp.
Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source *http://www.fishbase.org/search.cfm*

Nyctereutes procyonoides

Taxonomic status

Scientific name	*Nyctereutes procyonoides* Gray, 1834
Family	Canidae
Taxonomic group	Carnivora
English name	Raccoon dog
German name	Marderhund
French name	Chien viverrin
Italian name	Cane procione

Description and identification

Description	A small member of the Canidae with short legs, but it appears larger because of its long fur. The coat is grey-brown to blackish. The tail is short and bushy. It has a black face mask and a pointed muzzle.
Similar species	The raccoon (*Procyon lotor* (L.)) is similar in size and also has a black mask, but the raccoon dog has a brownish tail with a dark tip and no black rings, and the centre of the face is whitish.

Biology and ecology

Behaviour	The raccoon dog is mainly nocturnal or crepuscular and, owing to its secretive behaviour, only rarely observed. It spends the days in burrows or in reeds. It is dormant during the cold period of the year in the north of its distribution. The raccoon dog is a good swimmer but is largely terrestrial. It is found living solitarily, in pairs or in family groups. Larger aggregations were observed at good food sources. It is fairly active and can be nomadic.
Food	An omnivorous species, which feeds on whatever food item is in abundance, from plant parts to insects, amphibians, birds and small mammals. The proportions specific items contribute to the diet are variable between regions and seasons. At times, amphibians can make up to almost half of the diet.
Habitat	The raccoon dog has a wide range of habitats, but its preferred habitats are close to water and forests. It is also found in reed beds and swampy meadows. The highest-altitude record in Germany is at c. 800 m above sea level.

Origin East Asia.

Introduction and dispersal

History of introduction	The raccoon dog was extensively released as a fur animal in the former USSR, about 9,000 individuals were released between 1930 and 1950 according to documentary evidence. From the releases in eastern Europe, it spread rapidly westwards. The most western records are from France.
Pathways of introduction	The species was released as a fur animal in the former USSR.
Dispersal	The natural spread of the raccoon dog is astonishingly fast, because they can migrate up to 1,000 km, as documented in Russia, and proliferate with exceptionally high numbers of 5-8 young per litter.

Current status

Actual and potential	The range expansion of the raccoon dog is very difficult to

distribution in CH — demonstrate owing to their secretive and nocturnal behaviour. Thus, it might be more widespread today in Germany than records suggest. The first dead animal in 2003 in the Swiss Jura proved its existence in Switzerland. However, this could have been a migrating individual and evidence of a breeding population has still to be found. On the other hand it is likely that the species will expand further west, as it did in the past. It can be estimated that, in the long term, it will establish in the lowland parts of Switzerland, up to about 800 m above sea level.

Introduced distribution — The species was extensively released at many sites in the former USSR and has spread westwards. The delta of the Danube has a very dense population as it represents the favourite habitat for the raccoon dog. It has also colonized most of Finland and has been found as far west as France.

Impacts

Environmental impact — Opinions concerning its environmental impact vary somewhat, from no impact due to its broad diet, to severe impact on amphibians and game birds by predation and on badgers (*Meles meles* (L.)) and red foxes (Vulpes vulpes (L.)) by competition. The opponents of releases stress that the beneits of the acclimatization of the raccoon dog are questionable, as its fur is of inferior value. Studies in Central Europe would need to be carried out to evaluate the potential threats. It is a carrier of rabies and in 1995 during a 3-month period, 20 cases were found in Poland alone.

Economic impact — Apart from being a vector of rabies, no economic impact has been shown. On the other hand the costs of releases of the raccoon dog might not be recompensed by income because of the low value of the fur.

Management options — Because of their secretive behaviour, raccoon dogs are rarely shot, despite the lack of a closed season in Germany. Traps are generally not used in areas where the otter (*Lutra lutra* (L.)) occurs. The mortality factors documented included road kills and feral dogs.

Information gaps — The raccoon dog is well studied outside Central Europe, e.g. in Finland, but knowledge about its biology in Central Europe is rudimentary. The environmental impact of the raccoon dog in Central Europe should be investigated, e.g. competition with native predatory mammals and relationships between its diet and rare animals. Another research topic would be its significance as a disease vector.

References

Literature

Barbu, P. (1972) Beiträge zum Studium des Marderhundes, *Nyctereutes procyonoides ussuriensis* Matschie, 1907, aus dem Donaudelta. Säugetierk. Mitt. 20, 375-405.

Hausser, J. (1995) Säugetiere der Schweiz. Birkhäuser Verlag, Basel, Boston, Berlin, 344-348.

Long, J. L. (2003) Introduced mammals of the world. Their history, distribution and influence. CABI, Wallingford, 589 pp.

Lutz, W. (1996) Erfahrungen mit ausgewählten Säugetieren und ihr zukünftiger Status. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse.

Nowak, E. (1993) *Nyctereutes procyonoides* Gray, 1834 – Marderhund. In: Stubbe, M. and F. Krapp (eds) Handbuch der

Säugetiere Europas. Band 5/I. Akademische Verlagsgesellsschaft, Wiesbaden, pp. 215-248.

Ondatra zibethicus

Taxonomic status

Scientific name	*Ondatra zibethicus* (L.)
Family	Arvicolidae
Taxonomic group	Rodentia
English name	Muskrat
German name	Bisam
French name	Rat musqué
Italian name	Ondatra

Description and identification

Description	Largest member of the vole family (Arvicolidae) – it is not actually a rat species. Size is between that of the northern water vole (*Arvicola terrestris* (L.)) and the European beaver. Short, thick head with small, round ears on a body with no noticeable neck. Chestnut brown coat with the colour fading on the sides; underside is brown-grey to almost white. Tail is almost as long as the body and laterally compressed.
Similar species	Water voles: only half the size, tail shorter and round in diameter. Beaver has flat tail. Norway rat (*Rattus norvegicus* (Berkenhout)) has round tail and longer ears.

Biology and ecology

Behaviour	Very shy; crepuscular and nocturnal activities. On land clumsy, but swims and dives well. Builds dens in banks, but can also build nests out of plant material. Migrates in spring and autumn to colonize new areas.
Food	Mainly plants (submerged and other water plants, crops, grasses, fruit and vegetables), especially during winter also bivalves, snails and crustaceans.
Habitat	Along standing and slow-moving water.

Origin Most parts of North America.

Introduction and dispersal

History of introduction	The first record in Switzerland is from 1935. It then spread through the Jura to Basel (animals invaded from France are offspring from individuals which escaped from a fur farm in Belfort).
Pathways of introduction	Releases into the wild to harvest 'wild' fur and escapes from fur farms. In 1905 five specimens were released near Prague from where the species swiftly expanded. In many other countries it was subsequently successfully released because of its prized fur.
Dispersal	Periods of migration during spring and autumn, mainly along water bodies. High rate of reproduction (2-6 litters per year each with 1-6 young). The species spreads naturally by migration and it is progressing fast to the south in Switzerland along the main river systems.

Current status

Actual and potential distribution in CH	Distribution restricted to the north, but spreading rapidly to the south. It has the potential to colonize all rivers and standing water bodies in the lowland parts of Switzerland, the rate of colonization in the Alps is uncertain. It is restricted to water.
Introduced distribution	Introduced and spread to most of the Palaearctic; from France to

Japan and from Finland to Greece. Also established in Patagonia.

Impacts

Environmental impact — Environmental impact by feeding on rare plants. Can effectively destroy mussel populations (Unionidae), and reduce endangered species, thereby disconnecting populations of the bivalves.

Economic impact — This is the alien mammal species with the highest economic costs due to its burrowing activities. It damages canal banks, dykes and ditches, which can lead to floods. The annual incurred costs in Germany are detailed by Reinhardt et al. (2003) at a total of €12.4 million. A nationwide eradication programme could be warranted because of the enormous damage to waterways, and public health concerns, especially given the fact that the species is listed under Recommendation 77 of the Bern Convention (see text).

Management options — The species is trapped by hunters employed by the government. This technique was initiated very early on but could not halt the spread of the species over most of Central Europe.

Information gaps — The exact potential range in Switzerland is still unknown.

References

Hausser, J. (1995) Säugetiere der Schweiz. Birkhäuser Verlag, Basel, Boston, Berlin, pp. 344-348.

Long, J. L. (2003) Introduced mammals of the world. Their history, distribution and influence. CABI, Wallingford, 589 pp.

Niethammer, G. (1937) Die Einbürgerung von Säugetieren und Vögeln in Europa. Hamburg & Berlin.

Pietsch, M. (1982) *Ondatra zibethicus* (Linnaeus, 1766) – Bisamratte, Bisam. In: Niethammer, J. and F. Krapp (eds) Handbuch der Säugetiere Europas. Band 2/I. Akademische Verlagsgesellsschaft, Wiesbaden, pp. 177-192.

Reinhardt, F., Herle, M. Bastiansen, F. and B. Streit (2003) Economic impact of the spread of alien species in Germany. Federal Environmental Agency of Germany, 190 pp.

Oxyura jamaicensis

Taxonomic status

Scientific name	*Oxyura jamaicensis* (Gmelin)
Family	Anatidae
Taxonomic group	Anseriformes
English name	Ruddy duck
German name	Schwarzkopf-Ruderente
French name	Erismature rousse
Italian name	Gobbo rugginoso americano

Description and identification

Description	A small and stubby duck. The birds often stick their tails up above the water – during courtship in a fan shape. Generally, the shape of members of the stifftails (Oxyurini) is distinctive. The males are brightly coloured during summer with a reddish-brown plumage, conspicuous white cheeks and a light blue bill. The females are drabber.
Similar species	The only similar species is the European native representative of the stifftails, the white-headed duck (*Oxyura leucocephala* (Scopoli)), which is indeed difficult to distinguish, especially the females. However, the most prominent character of the white-headed duck is the swollen base of the bill.

Biology and ecology

Behaviour	Ruddy ducks are most active at dawn and dusk, andrest on the water during the day. They dive both for food and when alarmed, rather than flying away from danger, since they are poor flyers. They require large amounts of space to take off. The average brood size is about 8. They are a migratory species in parts of their native range.
Food	Food is primarily vegetarian, but they feed also on molluscs and other small animal items. Food is acquired by surface dives.
Habitat	They prefer lakes and reservoirs with open water and areas with dense cover for breeding.

Origin North America.

Introduction and dispersal

History of introduction	In the 1940s three pairs of ruddy ducks were introduced to captivity at Slimbridge/England. Soon after, some escaped and spread rapidly throughout the UK with an extraordinary rate of 15% increase per annum. Since 1965 the ruddy duck has been increasingly observed in continental Europe. The increase in continental records has been highly correlated with the increase in the UK ruddy duck population. Thus, although some birds might escape from captivity on the continent, by far the majority of the records are UK birds flying south. Most birds were found in the Netherlands and Spain, which is the major cause for concern, as explained below.
Pathways of introduction	Ruddy duck escaped from captivity. There might also have been some additional releases.
Dispersal	As a migratory bird, the species is capable of a rapid spread through Europe and potentially beyond, if not controlled.

Current status

Actual and potential distribution in CH	Ruddy ducks only irregularly reach Switzerland. Potentially they are probably capable of colonizing the lowland areas, although this is very unlikely given the extensive efforts to control the European populations. The first record in Switzerland was in 1981 with an average of 1-2 birds per subsequent year.
Introduced distribution	Introduced to England and rapidly spread through the UK. It is currently colonizing the continent, and will spread unless counter-measures are employed.

Impacts

Environmental impact	This is a high risk species. It readily hybridizes with the globally endangered white-headed duck. Unchecked, it is likely to completely absorb the white-headed duck population. Hybrids were found in the wild in Spain, the stronghold of the western Mediterranean white-headed duck population. Local control of the ruddy duck and the hybrids is reducing the threat, but as long as the source population in the UK is not controlled, it is a fight against windmills.
Economic impact	No economic impact has been described, but the impact on biodiversity is overwhelming.

Management options — The ruddy duck is being controlled in Europe, whereas the UK has the leading role in the eradication of the source population of invasions to the continent. Concerted eradication programmes are also in operation in Spain, Portugal and France. All European countries have recognized the urgency of the problem and agreed to take action against the ruddy duck. In the UK shooting of birds on large wintering sites has been highly successful.

Information gaps — Further research work into control techniques to determine the most efficient method.

References

Literature

Green, A.J. and B. Hughes (1996) Action plan for the White-headed Duck *Oxyura leucocephala*. In: Heredia, B., Rose, L. and M. Painter (eds) Globally threatened birds in Europe. Council of Europe Publishing, Strasbourg, pp. 119-146.

Hughes, B., Criado, J., Delany, S., Gallo-Ursi, U., Green, A.J., Grussu, M., Perrenou, C. and J.A. Torres (1999) The status of the North American ruddy duck *Oxyura jamaicensis* in the Western Palearctic: towards an action plan for eradication. Report by the Wildlife & Wetlands Trust to the Council of Europe.

Kestenholz, M. and L. Heer (2001) Absichtlich und unabsichtlich ausgesetzte Vogelarten in der Schweiz: Situationsanalyse und Massnahmenplan. Schweizerische Vogelwarte Sempach und Schweizer Vogelschutz SVS – BirdLife Schweiz, Sempach und Zürich, 44 pp.

Madge, S. and H. Burn (2002) Wassergeflügel. Marixverlag, 297 pp.

Other sources

Baz Hughes, The Wildfowl & Wetlands Trust, Slimbridge, Glos., UK.

Procyon lotor

Taxonomic status

Scientific name	*Procyon lotor* (L.)
Family	Procyonidae
Taxonomic group	Carnivora
English name	Raccoon
German name	Waschbär
French name	Raton laveur
Italian name	Procione

Description and identification

Description	The family Procyonidae is predominantly distributed in the New World and the only member introduced to Europe is the raccoon. It is similar in size to a red fox (*Vulpes vulpes* (L.)), but of different proportions with rather shorter legs and a roundish back. Upper parts are different nuances of grey, lighter below, with a bushy tail sporting 4-7 conspicuous black rings; black facial mask bordered above and below by white. This 'bank robber mask' and the tail are distinctive.
Similar species	Raccoon dog (*Nyctereutes procyonoides* (Gray)): as the name implies this species is of similar appearance, e.g. it has a black mask, although not related (Canidae); however the tail is of uniform colour. There are no other members of the Procyonidae in Europe.

Biology and ecology

Behaviour	The raccoon is mainly nocturnal and for this reason rarely seen, except in urban areas, where the populations are higher and the chances of seeing the animal foraging on rubbish is enhanced. Their dens are often in hollow trees, but also in the ground or they may be found sleeping on tree branches or inside buildings. While they mostly forage on the ground, they are excellent climbers and swimmers.
Food	Racoons are omnivorous. Hausser (1995) states that they feed on a mixture of plant material, invertebrates and vertebrates with a percentage of about 33% of each. Lutz (1980) found in long-term studies similar results - with birds in a quantitative proportion of 12%.
Habitat	The raccoon has a wide range of habitats as long as they are not too dry. The main habitats are forests along watercourses, but they adapt very well to rural and urban habitats.

Origin North and Central America.

Introduction and dispersal

History of introduction	The raccoon has been observed since 1976 in the north of Switzerland and the first was shot in 1978 near Wynigen. Since then the raccoon has expanded its range to the south.
Pathways of introduction	Fur farms and releases into the wild for harvesting 'wild' furs. The raccoon was not introduced to Switzerland, but in 1934 two pairs were released at the Edersee in Hesse, Germany. At the end of World War II, raccoons escaped from the zoo in Berlin. The species expanded from these areas in more or less concentric circles. More releases and escapes from fur farms in Russia supplemented the populations.

Dispersal	The raccoon spread naturally from the release/escape sites through Germany and reached Switzerland in the north, from where it has been colonizing Switzerland.

Current status

Actual and potential distribution in CH	The raccoon is still expanding its range into Switzerland. The current western border is in the canton of Bern. It will not colonize the upland areas of Switzerland, but it is expected to expand through the Mittelland to Genève and also some distance into the Valais.
Introduced distribution	Raccoons were introduced to different parts of Europe, e.g. France, Germany and Russia.

Impacts

Environmental impact	The raccoon is a highly adaptable omnivorous predator, thus will readily feed on all bird nests it encounters. It is not as much a hunter but a gatherer of food items. The impact on endangered bird species in intact habitats is probably often exaggerated, but in sub-optimal habitats the preying of the raccoon will add another factor to the demise of rare bird species. Competition is probably highest with the native badger (*Meles meles* (L.)). In conclusion, opinions about the impacts are somewhat divided with some experts arguing that it does not impact native wildlife, because it is an omnivorous species, and others stressing the impact on rare bird species.
Economic impact	In urban areas, raccoons can be fairly social and live at high densities, if enough food is available. This food is often gathered on rubbish dumps or from rubbish bins, where they can be a nuisance to people. They are efficient harvesters of resources like berries and fruits in orchards. Raccoons are vectors for several diseases, including rabies. The roundworm *Baylisascaris procyonis* is widespread in the Central European populations of the raccoon (74.4% of the raccoons in Hesse, Germany were infested) and can also be found in humans.

Management options The raccoon is hunted in Europe, apparently without any impact on its populations.

Information gaps The environmental impact of the raccoon is not understood. Its importance as a vector for diseases, which can be dangerous for humans and other animals, need more investigation.

References

Literature

Hausser, J. (1995) Säugetiere der Schweiz. Birkhäuser Verlag, Basel, Boston, Berlin, pp. 344-348.

Long, J. L. (2003) Introduced mammals of the world. Their history, distribution and influence. CABI, Wallingford: 589 pp.

Lutz, W. (1980) Teilergebnisse der Nahrungsanalysen am Waschbären (*Procyon lotor* L.) in Nordhessen. Z. Jagdwiss. 26, 61-66.

Lutz, W. (1996) Erfahrungen mit ausgewählten Säugetieren und ihr zukünftiger Status. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 297-310.

Stubbe, M. (1993) *Procyon lotor* (Linnaeus, 1758) – Waschbär. In: Stubbe, M. and F. Krapp (eds) Handbuch der Säugetiere Europas. Band 5/I. Akademische Verlagsgesellsschaft, Wiesbaden, pp. 331-364.

Pseudorasbora parva

Taxonomic status

Scientific name	*Pseudorasbora parva* (Temminck & Schlegel)
Family	Cyprinidae
Taxonomic group	Osteichthyes
English name	Stone moroko
German name	Blaubandbärbling
French name	Pseudorasbora
Italian name	-

Description and identification

Description	The stone moroko is a small cyprinid of about 10 cm in length; the males are the bigger, which is rarely observed within this family. It is of fairly slender appearance. The mouth is superior and transverse. Eyes are quite large. The back is brown, the sides greenish and the ventral parts silvery.
Similar species	The combination of characters and the fin formula (not presented here) distinguish the stone moroko from other fish species.

Biology and ecology

Behaviour	Stone morokos are gregarious fish. A peculiarity of the species is the ability to produce a rather loud ‘call’. The eggs are laid in chains on the vegetation. A female can produce a total of more than 900 eggs in several chains.
Food	This small cyprinid feeds mainly on zooplankton, but seems to be able to take algae when the preferred items are rare.
Habitat	The stone moroko is highly adaptable to different habitats, as the fast spread in Europe and records indicate. It is found in rivers, lakes, ponds and other small water bodies. The natural habitat is ponds in periodically inundated river flats.

Origin Eastern Asia.

Introduction and dispersal

History of introduction	It is assumed that the species was accidentally introduced to Romania with grass carp shipments from China. It spread rapidly along the river systems, e.g. upstream in the Danube, but it is likely that further accidental transport with other commercial fish loads enhanced the spread to the West. Today the range is predominantly the eastern part of Europe, but the first record for Switzerland was announced in 1990.
Pathways of introduction	The only established alien fish species in Switzerland that arrived accidentally, but it was in relation to fishery activities, as it was ‘hitch hiking’ with fish shipments.
Dispersal	Natural dispersal in river systems appears to be quite high.

Current status

Actual and potential distribution in CH	It has been found at only a few, scattered sites. It is likely to colonize the lowland parts of Switzerland.
Introduced distribution	Accidentally introduced to several countries in Europe and Asia.

Impacts

Environmental impact	The species is generally regarded as a pest as its very high reproductive rate produces dense populations, which compete with

fry of other species. High concentrations of this fish, although of small size, feeding on a specific diet such as zooplankton, has an impact on the water chemistry, thereby altering the natural ecosystem.

Economic impact — The stone moroko is of no economic interest.

Management options — Management of stone moroko does not face a conflict of interest, as many other important species for fishing do, thus regulations are straightforward. It is an Appendix 3 species (see text for explanation) and its introduction is therefore prohibited.

Information gaps — The actual distribution of this small fish species has not been adequately surveyed. Impact on community and habitat in Switzerland.

References

Literature

Arnold, A. (1990) Eingebürgerte Fischarten. Die Neue Brehm-Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt, 144 pp.

Lehtonen, H. (2002) Alien freshwater fishes of Europe. In: Leppaekoski, E., Gollasch, S. and S. Olenin (eds) Invasive aquatic species in Europe, Kluwer, pp. 153-161.

Welcomme, R.L. (1988) International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, 318 pp.

Zaugg, B., Stucki, P., Pedroli, J.-C. and A. Kirchhofer (2003) Pisces, Atlas. Fauna Helvetica 7, Centre Suisse de Cartographie de la Faune, 233 pp.

Other source — *http://www.fishbase.org/search.cfm*

Rana catesbeiana

Taxonomic status

Scientific name	*Rana catesbeiana* (Shaw)
Family	Ranidae
Taxonomic group	Anura
English name	American bullfrog
German name	Ochsenfrosch
French name	Grenouille taureau
Italian name	-

Description and identification

Description	A huge aquatic frog of about 15 cm in length, but sometimes reaching 20 cm. The back is green to brown, often mottled with darker shades, and the ventral parts are whitish. Tympanic membrane (ear drum) prominent and the same size (female) or bigger (male) than the eye. Dorsolateral ridges of glandular skin absent. One of the largest Anura in the world.
Similar species	The three native 'green' frogs are similar in colouration, but much smaller. If of similar size (*Rana ridibunda* Pallas can be large, too), the tympanum is always smaller than the eye. Vocal sac of native species is on the side of the head and not beneath the chin as with the bullfrog.

Biology and ecology

Behaviour	Freshwater inhabitants, highly aquatic. The egg batch forms a floating raft but is attached to vegetation and can contain up to 20,000 eggs. The bullfrog is mainly nocturnal, but the loud call, a deep pitched bellow (hence its name), can be heard during the day. It hibernates at the bottom of water bodies or in secluded places on land.
Food	Adult bullfrogs are voracious predators and eat everything they can overpower and swallow, including all kinds of invertebrates and small vertebrates. They are a threat to native amphibians and reptiles, because they can swallow all native species.
Habitat	Lakes, sluggish rivers and ponds with rich vegetation. Highly aquatic.

Origin The central and eastern parts of North America.

Introduction and dispersal

History of introduction	The bullfrog has been widely distributed by the aquarium trade. Specimens were also sold for ponds, a favourite asset of gardens. As they are the biggest edible frog, they were also released as a food resource.
Pathways of introduction	The main pathways into the wild are escapes from ponds and releases from aquariums after metamorphosis. In addition, they were released as a harvestable game animal for food.
Dispersal	They are capable of long-distance travel on land and will eventually disperse to suitable habitats, even if they are not connected.

Current status

Actual and potential distribution in CH	There are single unconfirmed observations in Switzerland. However, the bullfrog is found in the neighbouring countries; Germany, France and Italy. The danger of future releases persists.

	If the bullfrog can establish, it will be restricted to the lowlands of Switzerland.
Introduced distribution	Besides Europe, bullfrogs have been introduced to Hawai'i, the western USA and Canada, Mexico, the Caribbean, South America and Asia.

Impacts

Environmental impact	The environmental impacts of the American bullfrog are substantial. The adults devour all prey items they can swallow. The main concerns are the native frog species and reptiles such as turtles and snakes. Investigations of the gut content in Germany showed a high percentage of *Rana esculenta* Pallas. Tadpoles compete with native tadpoles and, as shown in the western USA, significantly decrease survivorship of the latter. The tadpoles can also have a significant impact on algae, which can affect the aquatic community structure. In general, the tadpoles are not eaten by fish, which gives them a competitive edge over the native frogs. Transmission of diseases to native amphibians is also possible.
Economic impact	No negative economic impact is reported.
Management options	The best management option, as always, is prevention. Specimens should not be released into the wild, not kept outside in ponds, and the problems arising from bullfrogs in nature must be communicated. Although the importation of American bullfrogs is now prohibited in several countries, a source, of which extent is not known, is private breeding colonies and trade. Bullfrogs can be caught by different means, such as nets, angling and hand catching, or they can be shot. As they can be very shy, control is more efficiently carried out at night by the light of a strong torch.
Information gaps	Distribution in Europe – populations may exist and build up before they are discovered. Impact in European communities.

References

Literature	Geiger, A. and M. Waitzmann (1996) Überlebensfähigkeit allochthoner Amphibien und Reptilien in Deutschland – Konsequenzen für den Artenschutz. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 227-240. Kupferberg, S. J. 1997. Bullfrog (*Rana catesbeiana*) invasion of a California river: the role of larval competition. Ecology 78 (6): 1736-1751. Schuster, A. and W. Rabitsch (2002) Lurche und Kriechtiere (Amphibia & Reptilia). In: Essl, F. and W. Rabitsch(eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 205-209.
Other sources	*http://www.zavod-symbiosis.si/bullfrog.htm* Gives an extensive list of references for Europe and outside Europe and links to European research *http://www.issg.org/database/species/ecology.asp?si=80&fr=1&sts=sss* Global Invasive Species Database of the IUCN ISSG *http://www.invasivespecies.gov/profiles/bullfrog.shtml* Exhaustive list of web-based information on the species

Rana ridibunda

Taxonomic status

Scientific name	*Rana ridibunda* Pallas
Family	Ranidae
Taxonomic group	Anura
English name	Marsh frog
German name	Seefrosch
French name	Grenouille rieuse
Italian name	Rana verde maggiore

Description and identification

Description	The marsh frog is the biggest frog in Europe, growing to almost the size of the American bullfrog (see Fact Sheet for *Rana catesbeiana* (Shaw)). Green to olive colouration. Very similar to the other 'green' frogs.
Similar species	The three native 'green' frogs are all very similar in colouration and appearance, but the marsh frog is the biggest and has a smooth, small wart on the hind foot. The vocal sacs are grey and not white. The vocal sacs at the side of the head distinguish it from other non-'green' frog species (at least the males). The croaking call is distinctive.

Biology and ecology

Behaviour	Gregarious, diurnal and nocturnal. It is an aquatic species, although it can be found far away from water. Eggs are laid in large submerged batches. Hibernates in general at the bottom of water bodies. The croaking can be heard during the day and night and is loud and distinctive, but variable. *Ridibunda* means laughing and refers to the call. It is frequently seen sun-basking on the banks.
Food	Adults are predators of insects, including flying stages, and other small prey items. They also devour young conspecific frogs (cannibalism) and *Hyla arborea* (L.). The tadpoles feed on vegetarian matter, e.g. algae.
Habitat	All kind of freshwater habitat.

Origin Eastern Europe.

Introduction and dispersal

History of introduction	The marsh frog was deliberately introduced west of its native range, most likely as food. It was probably released in the 1920s at Lac de Genève.
Pathways of introduction	In the first half of the 20th century, marsh frogs were deliberately released into the wild in Switzerland to establish colonies, probably as a food resource or to enrich the fauna. Moreover, it is likely that they have escaped from the food trade.
Dispersal	They are capable of long-distance travel on land and will eventually disperse to suitable habitats, even if the water bodies are not connected.

Current status

Actual and potential distribution in CH	Western Switzerland and the Valais are colonized with high numbers and the species is still spreading; there are also established populations in the north-east. A distribution map is available at the Internet link below. The species is probably able to

	establish in all lowland parts of Switzerland.
Introduced distribution	The species was introduced into other European countries, such as Italy and the UK.

Impacts

Environmental impact	The marsh frog is displacing the other two 'green' frogs in western Switzerland. The mechanisms are not fully understood, but the native species fall prey to their larger congeneric. Another interesting impact is genetic displacement. The genetics of the 'green' frog complex, comprising three species, is a unique and complicated case. It cannot be described in full here (see reference below for description of the phenomenon), but in short *Rana esculenta* L.is a species of hybrid origin between *R. ridibunda* and *R. lessonae* Camerano. However, it is more complex than that, because *R. esculenta* eliminates the *lessonae* genome from the germline and clonally transmits the *ridibunda* genome (hybridogenesis). The introduction of the marsh frog into this system alters the species composition and via a genetic mechanism appears to contribute to the species replacement, although competition might be equally important.
Economic impact	No negative economic impact is known.

Management options — The marsh frog is widely established in the west of Switzerland, and habitat management in favour of native amphibian species seems to be the only management option here. However, further releases should not be made anywhere in Switzerland, and especially not in the uncolonized areas.

Information gaps — Potential distribution in Switzerland. Environmental impact. Genetics of the 'green' frog complex in the introduced areas.

References

Literature

Arnold, E.N. and J.A. Burton (1979) Pareys Reptilien- und Amphibienführer Europas. Parey, Hamburg, Berlin, 270 pp.
Grossenbacher, K. (1988) Verbreitungsatlas der Amphibien der Schweiz. Schweizerischer Bund für Naturschutz. Documenta Faunistica Helvetiae 7, 207 pp.
Vorburger, C. and H.-U. Reyer (2003) A genetic mechanism of species replacement in European waterfrogs? Conservation Genetics 4, 141-155.

Other source

http://lepus.unine.ch/carto/
Distribution maps of the CSCF and KARCH

Rattus norvegicus

Taxonomic status

Scientific name	*Rattus norvegicus* (Berkenhout)
Family	Muridae
Taxonomic group	Rodentia
English name	Brown rat
German name	Wanderratte
French name	Rat surmulot
Italian name	Ratto delle chiaviche

Description and identification

Description	A large robust rat with a blunt muzzle. Ears and eyes fairly small. Naked tail shorter than body length. Fur greyish to brown, lighter ventrally.
Similar species	Black rat (*Rattus rattus* (L.)) is not always black, and can have similar colouration to the brown rat. The tail of the black rat is longer than the head-body length. It has a rather slim appearance and a pointed muzzle. Also, the black rats' ears are longer.

Biology and ecology

Behaviour	Nocturnal or crepuscular. Mostly terrestrial but swims very well. Invaded almost all habitats worldwide, but mostly in connection with humans. In Central Europe most brown rats live in close proximity to humans, but they are also found along rivers and lakes in dense vegetation in the wild. Nests are built in holes or burrows with paper, grass or similar material.
Food	The brown rat is a true omnivorous species, using every available food resource, from fruits, seeds and bird eggs to invertebrates and carrion.
Habitat	In Europe, mainly in close relationship with humans, but also 'wild' populations along water edges.

Origin South-eastern Russia and northern China.

Introduction and dispersal

History of introduction	Very widely introduced throughout the world. Today, the brown rat occurs on all continents. Both rat species were and are permanent passengers travelling with humans in all kind of vehicles. *R. rattus* was the first rat species introduced into Europe and *R. norvegicus* followed it on the same routes, displacing the former species in many places. The black rat is an Archaeozoon, i.e. introduced before 1492. The arrival of the brown rat in Europe is uncertain and still debated. The first record for Switzerland is probably in 1809.
Pathways of introduction	Rats are transported as stowaways in ships, containers, etc. Thus they are accidentally introduced while most vertebrates are intentionally released or at least imported and subsequently escape from confinement. The successful spread of rats is based on their adaptation to human environments. While they are shy and inconspicuous, they prefer the proximity to humans.
Dispersal	The brown rat was probably introduced many times and at different places, mainly arriving at ports with ships. Although brown rats are rather territorial throughout most of the year, they spread when food is scarce and migrations have been observed. This, in connection with their phenomenal breeding throughout the year, is the basis for their success in establishment and spread. They can

have 6 litters per year with 7-10 young in each. They reach maturity at about 4 months.

Current status

Actual and potential distribution in CH: The brown rat occurs mainly in cities and along rivers in the lowland parts of Switzerland. In the urban habitat it is abundant and has colonized its potential range within Switzerland.

Introduced distribution: The brown rat has been widely introduced throughout the world, although it is most obvious on islands, where the impact to native biodiversity is immense. In Africa and South America the rats are basically confined to coastal ports and large cities and their immediate vicinity.

Impacts

Environmental impact: When brown rats are introduced to formerly predator-free islands, they can be a major predator in sea bird colonies and for flightless (and frightless) birds and insects. This has led to extinctions of bird populations, and also to successful eradication campaigns against this species. Increasing bird populations after eradication of rats confirm the negative impacts. However, in their urban environment in Switzerland this effect will be less drastic, but there is no doubt that the species is an additional predator, in particular on bird nests close to the ground.

Economic impact: Rats are known to damage crops, stored products and structures all around the world. The faeces and vectored diseases are of even greater concern than direct feeding on foodstuffs. Biting on electrical wire can lead to power cuts. The costs incurred are enormous, given the fact that in some cities the headcount of rats is higher that its human inhabitants. Several diseases are transmitted to humans via either fleas or faeces contaminating foodstuffs. In most cities rats are controlled by costly measures with variable success.

Management options: In most cities and towns, rats are part of a control campaign, using mainly poisonous baits. Eradication of rats on islands has been achieved using anticoagulant poisons in bait stations and area-wide droppings from helicopters. The size of the islands where successful eradication campaigns can be undertaken is currently increasing. This is a very important tool for conservation on islands.

Information gaps: The environmental impacts of rats in a land-locked country have not been studied to any extent.

References

Literature

Atkinson, I.A.E. and B.D. Bell (1973) Offshore and outlying islands. In: Williams, G.R. (ed) The natural history of New Zealand: an ecological survey, 15, 372-392.

Becker, K. (1978) *Rattus norvegicus* (Berkenhout, 1769) – Wanderratte. In: Niethammer, J. and F. Krapp (eds) Handbuch der Säugetiere Europas. Band 1. Aula Verlag, Wiebelsheim, pp. 401-420.

Corbet, G. and D. Ovenden (1982) Pareys Buch der Säugetiere: alle wildlebenden Säugetiere Europas. Parey, Hamburg, Berlin, 240 pp.

Empson, R.A. and C.M. Miskelly (1999) The risks, costs and benefits of using brodifacoum to eradicate rats from Kapiti Island, New Zealand. New Zealand Journal of Ecology 23, 241-254.

Long, J. L. (2003) Introduced mammals of the world. Their history, distribution and influence. CABI, Wallingford, 589 pp.

Sciurus carolinensis

Taxonomic status

Scientific name	*Sciurus carolinensis* Gmelin
Family	Sciuridae
Taxonomic group	Rodentia
English name	Grey squirrel
German name	Grauhörnchen
French name	L'Ecureuil gris
Italian name	Scoiattolo grigio

Description and identification

Description	A large typical squirrel, which is seen frequently on the ground, where it travels long distances. The summer fur is reddish with a distinct rusty line laterally along the sides, whereas the winter fur is largely grey. The tail always has white hairs. It never sports ear tufts. In parks it is very tame and often accustomed to taking food from people.
Similar species	Red squirrel (*Sciurus vulgaris* L.) is smaller, with conspicuous ear tufts in winter, more uniformly coloured and its tail has no white hairs.

Biology and ecology

Behaviour	Diurnal. Although it is a real tree squirrel, it is often found on the ground and is a good swimmer. Territorial. Nest is up to 60 cm in diameter and comprises leaves in trees or tree holes. When food is in abundance, nuts, etc. are stored in holes in the ground. This food is an important resource during the winter months, since it does not hibernate.
Food	Mainly nuts, berries, flowers, fruits of different trees, but also insects, small birds and small red squirrels taken from their nests. Oaks (*Quercus* spp.) are probably the most important food trees for the grey squirrel.
Habitat	Mixed woodland and forest, but also urban areas, such as parks and gardens.

Origin	Eastern part of North America (where it is called the eastern gray squirrel).

Introduction and dispersal

History of introduction	It has not yet been found in Switzerland. Between 1876 and 1929 about 27 releases were undertaken in England to establish the grey squirrel. Today it has colonized most of Great Britain and replaced the native red squirrel, which survives only in mountainous areas with coniferous trees. In Italy, the grey squirrel was first introduced into Piedmont in the north-west of the country in 1948, thus close to the Swiss border. Subsequent releases were made in other areas in north-western Italy in 1966 and 1994. In recent decades the nucleus population of Piedmont has shown a rapid increase.
Pathways of introduction	The grey squirrel was released to enrich the diversity of wildlife and for aesthetic reasons.
Dispersal	From its point of introduction the grey squirrel has rapidly expanded its range since 1970. The species maintained a stable population during a lag phase of some 20 years before it entered a log phase of spread. Its exponential range expansion is consistent with the

models proposed in the IAS literature. The natural spread is faster along rivers and increased as the population reached the continuous broadleaf forests. It is likely to arrive soon in the south of Switzerland, i.e. the Ticino. However, the main invasion of Switzerland will probably be via France and Genève. This process will take a considerable time. Estimates from a model suggest that it will reach France in about 30- 50 years. Data collected in the UK and Italy suggest that the grey squirrel could rapidly and successfully colonize a wide area of continental Europe, covering the entire range of the red squirrel, in the medium to long term.

Current status

Actual and potential distribution in CH	It has not yet been recorded from Switzerland, but it is spreading just south of the border in Italy.
Introduced distribution	The grey squirrel has been introduced in the Western Cape near Cape Town in South Africa, in Australia, in the western parts of North America, and in England and Italy. In England it has colonized almost the entire country and in Italy it is rapidly spreading.

Impacts

Environmental impact	The main concern is that the grey squirrel outcompetes the native red squirrel and replaces it, as happened in Great Britai. Several hypotheses to explain how the grey squirrel replaces the red squirrel have been proposed, but the mechanism has not yet been conclusively established. The fact remains that in England and Wales in 1955, about 80% of the forests where grey squirrels were found no longer contained red squirrels. A combination of factors are probably involved in the complex relationship between the two squirrel species. The grey squirrel is more aggressive in direct encounters, takes a wider variety of food items, occasionally eats young red squirrels in their nests, and might vector diseases (parapoxvirus). The grey squirrel, like the red squirrel, is a predator of young birds, so that an introduced predator is replacing the suppressed native one in its niche. However, the extent of predation might vary between the two species.
Economic impact	The most serious damage is done to forestry hardwoods by strip barking and biting out the leading shoot, in severe cases killing small trees. It can also be a nuisance species in gardens to the extent that squirrel-proof bird feeders were designed.

Management options	Opposition and a lengthy judicial enquiry have considerably delayed eradication efforts in Italy. Today, eradication seems no longer feasible and a strategy to delay the spread has been proposed. Corridors of potential spread and key conservation areas for the red squirrel will be targeted with eradication or control measures. Grey squirrels can be caught using live-traps baited with maize. Captured animals can be euthanized using halothane. This procedure is a humane method for killing the captured animals. In a study by Bertolino and Genovesi (2003) trapping was very successful and non-target species were not captured.
Information gaps	The mechanism of replacement of the native squirrel by the introduced species is still not fully understood. Prevention measures to delay the arrival of the grey squirrel in Switzerland or better effective control in Italy should be explored.

References

Literature

Bertolino, S. and P. Genovesi (2003) Spread and attempted eradication of the grey squirrel (*Sciurus carolinensis*) in Italy, and consequences for the red squirrel (*Sciurus vulgaris*) in Eurasia. Biological Conservation 109, 351-358.

Long, J. L. (2003) Introduced mammals of the world. Their history, distribution and influence. CABI, Wallingford, 589 pp.

Lurz, P.W.W., Rushton, S.P., Wauters, L.A., Bertolino, S., Currado, I., Mazzoglio, P.J. and M.D.F. Shirley (2001) Predicting grey squirrel expansion in North Italy: a spatially explicit modelling approach. Landscape Ecology 16, 407-420.

Wiltafsky, H. and J. Niethammer (1978) *Sciurus carolinensis* Gmelin, 1788 – Grauhörnchen. In: Niethammer, J. and F. Krapp (eds) Handbuch der Säugetiere Europas. Band 1. Akademische Verlagsgesellschaft, Wiesbaden, pp. 106-113.

Tadorna ferruginea

Taxonomic status

Scientific name	*Tadorna ferruginea* (Pallas)
Family	Anatidae
Taxonomic group	Anseriformes
English name	Ruddy shelduck
German name	Rostgans
French name	Tadorne casarca
Italian name	Casarca

Description and identification

Description	Unmistakable with its striking plumage. The only completely reddish-brown waterfowl species. A demonstrative species with its colouration and loud calls.
Similar species	Ruddy shelducks, with their almost orange-coloured bodies fading to almost white on their heads, look completely different from all other European wildfowl.

Biology and ecology

Behaviour	Diurnal and noisy. Found on the water surface or grazing on land. Breeds in tree holes or buildings.
Food	Grazes on land, also dabbles and feeds while swimming, including upending in water.
Habitat	Predominantly plants. Breeds and winters beside coastal lakes and deltas and also on inland lakes, rivers and marshes on high-altitude plateaus. In Switzerland found mainly along rivers and in reservoirs.

Origin Asia, west to Turkey and Romania; northern Africa.

Introduction and dispersal

History of introduction	In the late 1990s numbers of known breeding pairs slowly but steadily increased. The population was probably founded by escaped birds. Irregular single breeding pairs have been recorded from several countries, but they are isolated breeding attempts, in contrast to the Swiss situation.
Pathways of introduction	Escaped from zoos, parks or similar.
Dispersal	There is still a very small population in Switzerland, but there is potential for further spread.

Current status

Actual and potential distribution in CH	Ruddy shelduck is breeding mainly in the northern and eastern parts of Switzerland, with about ten breeding pairs, but if the population continues to increase it could colonize all major rivers and lakes.
Introduced distribution	Escapees from confinement are recorded in many European countries and some isolated breeding pairs have been observed.

Impacts

Environmental impact	Ruddy shelducks are very aggressive during the breeding period and chase away all other wildfowl species, except for mute swans (*Cygnus olor* (Gmelin)) and coots (*Fulica atra* L.). However, a definite impact has not been confirmed.
Economic impact	Damage to crops is possible, but only if the population dramatically

increases.

Management options	Switzerland has the only, albeit small, viable population of ruddy shelduck in the introduced European range. If the population were to expand, it could reach neighbouring countries and cause impacts on native wildfowl through its aggressive behaviour. Thus, Switzerland has a responsibility to deal with the species and impede the spread. It is recommended that the population, which is of no benefit, be eliminated. As long as the population is still small, eradication is feasible. Furthermore, keeping birds under semi-wild conditions should be stopped.
Information gaps	Impact in Switzerland.

References

Literature

Burkhardt, M. and H. Schmid (2001) Vögel in der Schweiz. Schweizerische Vogelwarte, Sempach, 276 pp.
Kestenholz, M. and L. Heer (2001) Absichtlich und unabsichtlich ausgesetzte Vogelarten in der Schweiz: Situationsanalyse und Massnahmenplan. Schweizerische Vogelwarte Sempach und Schweizer Vogelschutz SVS – BirdLife Schweiz, Sempach and Zürich, 44 pp.
Madge, S. and H. Burn (2002) Wassergeflügel. Marixverlag, 297 pp.
Vinicombe, K.E. and A.H.J. Harrop (1999) Ruddy shelducks in Britain and Ireland, 1986-1994. British Birds 92, 225-255.

Trachemys scripta

Taxonomic status

Scientific name	*Trachemys scripta* (Seidel)
Family	Emydidae
Taxonomic group	Testudines
English name	Red-eared slider
German name	Rotwangen-Schmuckschildkröte
French name	Tortue de floride
Italian name	-

Description and identification

Description	A typical aquatic turtle with oval carapace, weakly keeled. Olive to brown in colour with bars, stripes and spots. The prominent feature giving it its name is the orange stripe behind the eye. Generally, they are sold when they are very small (2-3 cm in length), but they can grow to about 30 cm, outgrowing most aquariums.
Similar species	The red spot or stripe behind the eye, if visible, gives the species away. However, European pond terrapins (*Emys orbicularis* (L.)) can be very similar and species from the entire globe are regularly found in the wild, making identification extremely difficult.

Biology and ecology

Behaviour	Freshwater inhabitants that lay their eggs in sandy banks. For a good part of the day, they sun-bask to increase their body temperature.
Food	The young eat aquatic insects, crustaceans, molluscs and frog eggs and tadpoles, whereas the mature slider changes its diet to include more plant material.
Habitat	In water, mainly slow-flowing rivers, swamps, ponds and lakes.

Origin The south-east of North America and Central America.

Introduction and dispersal

History of introduction	North America exports about 3-4 million specimens a year to Europe and Asia in the pet trade. They are bred in captivity in the USA and sold when they are still young, around 2-3 cm in length.
Pathways of introduction	Dumping of aquarium inhabitants by their owners is the main pathway into the wild. Often sliders outgrow their aquarium since they can reach almost 30 cm in length. Some may also escape from garden and park ponds.
Dispersal	They do not disperse well, but in open water systems they can spread. However, many releases are made into ponds, where they accumulate, accelerating their impacts.

Current status

Actual and potential distribution in CH	They are regularly found throughout Switzerland, especially near or in urban areas. They thrive best in the lowland parts of Switzerland. Reproduction in the wild has not yet been confirmed, but sliders can live as long as humans.
Introduced distribution	They are found in non-native parts of North America as well as in Europe and Asia. Reproduction has been observed in the wild in the Mediterranean region of Europe.

Impacts

Environmental impact	Experiments have shown competition with native turtles. Red-eared sliders may also have a large negative impact on amphibians (eggs and tadpoles) in ponds with extremely high numbers of the invader. Floating bird nests destroyed by sun-basking sliders have been reported.
Economic impact	No economic impact has been reported.

Management options

Prevention of further releases of the red-eared slider and other turtles has priority. The laws need to be enforced to stop releases. Moreover, people have to be informed about the potential negative impacts to native biodiversity and habitats. The pet trade has a responsibility to educate new owners not to dump them, and should take them back if owners can no longer keep them.

Information gaps

Impact.

References

Literature

Geiger, A. and M. Waitzmann (1996) Überlebensfähigkeit allochthoner Amphibien und Reptilien in Deutschland – Konsequenzen für den Artenschutz. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 227-240.

Hofer, U., Monney, J.-C. and G. Dušej (2001) Die Reptilien der Schweiz. Verbreitung, Lebensräume, Schutz. Birkenhäuser, Basel, Boston, Berlin, 202 pp.

Schuster, A. and W. Rabitsch (2002) Lurche und Kriechtiere (Amphibia & Reptilia). In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 205-209.

Triturus carnifex

Taxonomic status

Scientific name	*Triturus carnifex* (Laurenti)
Family	Salamandridae
Taxonomic group	Urodela
English name	Italian crested newt
German name	Alpen-Kammmolch
French name	Triton crêté italien
Italian name	Tritone crestato meridionale

Description and identification

Description	This is a large newt, up to 18 cm in length. It is black on the dorsal surface, and orange ventrally, with dark markings and fine white spots at the side of the head. The dorsal crest is jagged and broken at the base of the tail.
Similar species	It is a fairly distinctive species, but the great crested newt (*Triturus cristatus* (Laurenti)) is of similar appearance (in fact they were often considered to be conspecific). The best way of distinguishing them is the lack of white speckles on the sides of the body of the invader (in which the spots are restricted to the head).

Biology and ecology

Behaviour	A rather aquatic newt. In some areas it is found in the water throughout the year, while in others it is terrestrial outside the breeding season. The eggs are laid, in a typical newt style, singly and wrapped in leaves.
Food	Carnivorous, feeding on insects, worms, crustaceans, etc.
Habitat	All standing and sluggish water with dense vegetation.

Origin Ticino and Italy.

Introduction and dispersal

History of introduction	Introduced into the canton of Genève. Most probably they were released from a scientific research station.
Pathways of introduction	Probably released or escaped from a research station.
Dispersal	They do not disperse well outside water, but if suitable habitats exist as 'corridors', the potential for spread exists.

Current status

Actual and potential distribution in CH	The Ticino lies within their native range, which includes Italy, parts of Austria and former Yugoslavia. They have been introduced to Genève and along the Lac de Genève.
Introduced distribution	Also introduced into the UK.

Impacts

Environmental impact	The Italian crested newt completely replaced the great crested newt in the canton of Genève after its introduction. The mechanism is not known. The two species might also hybridize.
Economic impact	No negative economic impact is known.

Management options No further releases should be made. Monitoring of the actual distribution and its spread would be helpful for future decision-making.

Information gaps Potential distribution in Switzerland. Mechanism of replacement of the native newt by the closely related invader. The species were often considered to be conspecific. Does hybridization occur?

References

Literature

Arnold, E.N. and J.A. Burton (1979) Pareys Reptilien- und Amphibienführer Europas. Parey, Hamburg, Berlin, 270 pp.

Grossenbacher, K. (1988) Verbreitungsatlas der Amphibien der Schweiz. Schweizerischer Bund für Naturschutz. Documenta Faunistica Helvetiae 7, 207 pp.

Other source

http://lepus.unine.ch/carto/
Distibution maps of the CSCF and KARCH

3 Crustaceans – Crustacea

Prepared by Rüdiger Wittenberg

It is not possible to draw up a comprehensive list of established alien crustaceans in Switzerland owing to gaps in knowledge for some groups and some regions. Another complicating factor is the rapid changes in species composition in the large rivers. Some new invaders are showing an explosive expansion in their ranges and densities. Despite these shortcomings, a preliminary list has been compiled using available information. As with all lists of alien and invasive alien species, it is crucial to update and add new information about distribution, impacts and management options as it becomes available. However, this list is believed to be a good basis for future expansion, since a comparison with neighbouring Austria shows similarities in species and species numbers.

Table 3.1 summarizes available information on 17 established alien crustacean species in Switzerland. Six of them are considered to be harmful to the environment. More information on these species is presented in the Fact Sheets at the end of this chapter.

There is little information available on ***Daphnia parvula*** Fordyce (Cladocera) and ***Atyaephyra desmaresti*** (Millet) (Atyidae) and their invasions might be of little significance for native biodiversity.

The copepod ***Cyclops vicinus*** Uljanin is thought to have impacted native species by its predatory behaviour.

The amphipod ***Corophium curvispinum*** (Sars) (Corophiidae) (see Fact Sheet) is a considerable threat to native ecosystems. This species is an ecosystem engineer and occurs at fairly high densities. In the Rhine between Basel and Bodensee it was the species with the third highest number of specimens per square metre, i.e. about 9,200 individuals (Rey and Ortlepp, 2002).

Six members of the family Gammaridae are established alien species in Swiss waters. Four of these are of Ponto–Caspian origin, while one invaded Central Europe from south-western Europe and one species came from North America. Of the three species ***Echinogammarus ischnus*** (Behning), ***E. trichiatus*** (Martynov) and ***E. berilloni*** Catta only the first-named is known to have a negative impact on the environment (see Table 3.1), while insufficient is currently known about the other species to judge. The American species ***Gammarus tigrinus*** Sexton may change the food web after invasion. Two *Dikerogammarus* species have invaded Switzerland, ***D. haemobaphes*** (Eichwald) and ***D. villosus*** (Soyinski). The latter species is the largerst of the invaders and has considerable impact on the ecosystem (see Fact Sheet).

Introduced freshwater crayfish species, comprising four species in two families, Astacidae and Cambaridae, represent one of the greatest threats to Swiss biodiversity. ***Astacus leptodactylus*** Eschscholtz (see Fact Sheet) introduced from parts of south-eastern Europe and south-western Asia is of least concern, although it can potentially compete with native crayfish. The other three species (***Pacifastacus leniusculus*** (Dana), ***Orconectes limosus*** (Rafinesque) and ***Procambarus clarkii*** Girard) (see Fact Sheets) are of North American origin. They are not susceptible to the crayfish plague (see the chapter on Fungi), but they are vectors of the disease, carrying it into European crayfish (*Astacus astacus* (L.)) populations. The severity of the disease in these populations raises grave concerns about the survival of the native crayfish species.

The three Isopoda species (see Table 3.1) may not pose a threat to Swiss freshwater ecosystems, despite the enormous densities of the tiny Ponto–Caspian invader ***Jaera istri*** Veuille.

With respect to the taxonomic composition of the established species, two groups are dominant, i.e. the amphipods with seven species and the crayfish with four species. The amphipods are a successful group of about 6,000 species (Pöckl, 2002). They often dominate ecosystems in numbers of individuals as well as in biomass owing to their high fecundity under optimal conditions. Their omnivorous behaviour renders them adaptive to changing species compositions. The rapid invasions and build up of tremendous densities of alien amphipods are legendary. The interactions of native and rapidly invading alien species are very complex and difficult to understand. The fluctuations in densities are considerable and sometimes new invaders replace earlier invaders. Haas et al. (2002) give an overview of changes in abundance of alien species in the Rhine. The crayfish, as the second dominant group, belongs to the Decapoda, whose major centre of distribution is in North America and there are only a few species in Europe. The economic importance of crayfish is, of course, the major incentive for introducing alien crayfish into Europe.

A comparison of alien crustaceans established in Switzerland and in neighbouring countries is not without flaws, because of gaps in knowledge. However, the 17 species listed here compare quite well with the 19 species recorded for Austria (Essl and Rabitsch, 2002). Geiter et al. (2002) list 26 species for Germany, but this includes species living in marine and brackish environments.

The origin of the alien crustaceans established in Switzerland is equally divided between North America (including three crayfish species), the Ponto–Caspian region (five of the seven amphipods) and Mediterranean parts of Europe. The Ponto–Caspian region is essentially the area of the Black and Caspian Seas and their adjacent rivers. Many species endemic to the Ponto–Caspian region have become established in Europe, the Baltic Sea and, more recently, the Great Lakes in North America. This extraordinary spread has been facilitated by the construction of numerous canals allowing species to disperse by active migration and, to a greater extent, with ship traffic (in ballast tanks and through hull-fouling). Many Ponto–Caspian crustaceans were also transplanted between water bodies as food for native fish to stimulate fish production within the former USSR.

Although the exact time and place of the first introductions of many species are not documented, the data available suggest that many of them have invaded Switzerland fairly recently. Thus, further spread and increase in species densities in the short or long term are very likely. Moreover, other species are expected to arrive via river systems.

With the exception of the crayfish species, almost all the crustacean invasions of Switzerland have been facilitated by the construction of canals and ship traffic. In most cases it is difficult to prove the exact pathways for the various species. Natural migration of some mobile species along rivers and canals is likely to be important over short distances. However, the rapid expansion of most species and some isolated records indicate spread by ship traffic, either in ballast tanks or on hulls. The crayfish species, however, were deliberately introduced as a food resource for human consumption. Additionally, escapees from aquaculture facilities have founded several populations. A third pathway is the importation of live crayfish for consumption. Crayfish are a delicacy and have to be added to boiling water alive. Thus, they are imported alive and some may have escaped. Moreover, some specimens escape from aquariums and garden ponds, or are released by their owners, who no longer want to keep them.

The impacts of the species, especially the six high-risk species, are detailed in the Fact Sheets and in Table 3.1. The three North American crayfish species are of greatest concern with regard to the survival of the native crayfish populations, because they act as a vector of the devastating crayfish plague. The two amphipod species *D. villosus* and *C. curvispinum* alter the invaded habitats by predation, competition and causing changes to the substrate. Demonstrating impacts of alien species on native biodiversity and ecosystems is always difficult owing to the complex interactions. In conclusion, species thought to be harmless may turn out to have some, as yet undetected, negative impacts. This is especially true for freshwater ecosystems. Many of the alien species occur in enormous abundance. This must have some impact on the ecosystem, since each individual uses some resources and is a resource for others. Rey and Ortlepp (2002) found that the biomass in the Rhine near Basel was dominated by alien species – 97% of the animal biomass and more than 90% of the individuals were of alien origin. Thus, the original character of the Rhine has vanished; in this area it is not the typical Rhine anymore. Most of the alien species have invaded this stretch of the Rhine within the past five years. This suggests that their distribution will further expand and their dominance in other areas will increase. The dominance of alien species in European (and other continental) inland waters is dramatic.

In most cases, eradication of established problematic species is not feasible. Control has limited success in open freshwater systems, such as rivers. Some species, in particular the crayfish, have economic value and intensive fishing could reduce their numbers. However, a reduction in the crayfish population might not be a sufficient goal, given the great threat they pose to native crayfish. One crayfish plague-infested alien crayfish could be enough to wipe out a healthy population of their European relatives. Migrating specimens of alien crayfish were observed even in low-density situations, so a reduction might not prevent their spread. Thus, prevention of further introductions of species into and within Switzerland should have highest priority to safeguard native biodiversity and ecosystems. North American crayfish species are of greatest concern. With respect to releases of problematic freshwater species (e.g. for fishing and from aquarium dumping) an awareness-raising campaign would be crucial to sensitize the public to the potential problems caused by alien species. Accidental arrival of new species with ship traffic can only be minimized by effective treatment of ballast water and ships' hulls.

Crayfish species other than those mentioned above must be regulated too. An Australian species, *Cherax destructor* Clark for example, has been found in Switzerland (Stucki and Jean-Richard, 2000) and is being kept as a pet in aquariums and garden ponds owing to its beautiful appearance. The release of pets is illegal, but the unfortunate fact is that it is used as a way of getting rid of unwanted individuals, and they are also capable of escaping from ponds.

Table 3.1: Established alien crustaceans in Switzerland.

Scientific name	Taxonomic group	Origin	Year	Pathway	Impact	Note
Daphnia parvula Fordyce	Cladocera	America	1972	Ship traffic	Change in food web?	First European record in the Bodensee (Lake Constance)
Cyclops vicinus Uljanin	Copepoda	Europe	1954	Fish releases?	Predator of native crustaceans	Found in the Bodensee.
Atyaephyra desmaresti (Millet)	Atyidae	Mediterranean	?	Expanding along canals, ship traffic?	No impact shown	Likely to expand further throughout Europe
Corophium curvispinum (Sars)	Corophiidae	Ponto–Caspian	1980s	Ballast water Also migration	Change of ecosystem by transferring hard substrate to muddy areas. Reduces available habitat for hard substrate species	Rapid colonization of the Rhine
Echinogammarus ischnus (Behning)	Gammaridae	Ponto–Caspian	1990s	Ship traffic Migration	Modifies substrate sediment. Alters energy flow between pelagic and benthic organisms. Additional prey for fish. Excludes competing species	Invader of a large portion of Europe
Echinogammarus trichiatus (Martynov)	Gammaridae	Ponto–Caspian	-	Ship traffic	Not known	Likely to reach Switzerland in the near future
Echinogammarus berilloni Catta	Gammaridae	South-western Europe	20^{th} century	Migration through canals	Not known	Probably still invading Europe
Dikerogammarus haemobaphes (Eichwald)	Gammaridae	Ponto–Caspian	1990s	Ship traffic Migration	Not known	Decreasing in Europe, because of the invasion of *D. villosus*
Dikerogammarus villosus (Sovinski)	Gammaridae	Ponto–Caspian	Late 1990s	Ship traffic	Predator of alien and native gammarids and other prey	Replacing earlier invaders

Table 3.1: Established alien crustaceans in Switzerland.

Scientific name	Taxonomic group	Origin	Year	Pathway	Impact	Note
Gammarus tigrinus Sexton	Gammaridae	North America	1990s	Ship traffic Migration	Changes in food web?	Introduced from North America in ballast water
Astacus leptodactylus Eschscholtz	Astacidae	South-eastern Europe	1980s	Release for fishing	Competition with native crayfish species	Important competitor for native crayfish species, but also vulnerable to the crayfish plague
Pacifastacus leniusculus (Dana)	Astacidae	North America	?	Release for fishing	Competition with native crayfish species Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Orconectes limosus (Rafinesque)	Cambaridae	North America	Before 1976	Release for fishing	Competition with native crayfish species. Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Procambarus clarkii Girard	Cambaridae	Southern North America	?	Release for fishing	Competition with native crayfish species. Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Proasellus coxalis (Dollfuss)	Asellidae	South-western Europe	Second half of 20th century	Ship traffic	Not known	Rhine, but not common
Proasellus meridianus (Racovitza)	Asellidae	South-western Europe	Second half of 20th century	Ship traffic	Not known	Rhine, near Basel, but not common
Jaera istri Veuille	Jaeridae	Ponto–Caspian	End of 1990s	Ship traffic	Not known, but very abundant	One of the species with the highest abundance – likely to increase further

References

Bernauer, D., Kappus, B. and W. Jansen (1996) Neozoen in Kraftwerksproben und Begleituntersuchungen am nördlichen Oberrhein. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse.* Ecomed Verlagsgesellschaft, Landsberg, pp. 87-95.

Eder, E. (2002) Krebstiere: Flusskrebse (Crustacea: Decapoda: Astacidae und Cambaridae). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich.* Umweltbundesamt, Wien, pp. 287-291.

Essl, F. and W. Rabitsch (eds) (2002) *Neobiota in Österreich*. Federal Environment Agency, 432 pp.

Frutiger, A. and R. Müller (2002) Der Rote Sumpfkrebs im Schübelweiher (Gemeinde Küsnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG.

Gaviria, S. (2002) Krebstiere: Wasserflöhe & Ruderfusskrebse (Crustacea: Cladocera und Copepoda). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich.* Umweltbundesamt, Wien, pp.263-268.

Geiter, O., Homma, S. and R. Kinzelbach (2002) *Bestandsaufnahme und Bewertung von Neozoen in Deutschland*. Umweltbundesamt, 308 pp.

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the Rhine river determines biodiversity and ecosystem function: an affair between amphipods and mussles. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Löffler, H. (1983) Aspects of the history and evolution of Alpine lakes in Austria. Hydrobiologia 100, 143-152.

Ojaveer, H., Leppäkoski, E., Olenin, S. and A. Ricciardi (2002) Ecological impact of ponto-caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 412-425.

Pöckl, M. (2002) Flohkrebse (Crustacea: Amphipoda: Corophiidae und Gammaridae). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 273-284.

Pöckl, M. and W. Rabitsch (2002) Ausgewählte aquatische Neozoen (Cnidaria, Plathelminthes, Kamptozoa, Annelida, Isopoda). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 228-239.

Reinhardt, F., Herle, M. Bastiansen, F. and B. Streit (2003) *Economic impact of the spread of alien species in Germany.* Federal Environmental Agency of Germany, 190 pp.

Rey, P. and J. Ortlepp (2002) Koordinierte biologische Untersuchungen am Hochrhein 2000; Makroinvertebraten. BUWAL Schriftenreihe Umwelt Nr. 345, Gewässerschutz, 98 pp.

Stucki, T. and P. Jean-Richard (2000) Verbreitung der Flusskrebse in der Schweiz. Mitteilungen zur Fischerei Nr. 65, 52 pp.

Tittizer, T. (1996) Vorkommen und Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den Bundeswasserstrassen. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse.* Ecomed Verlagsgesellschaft, Landsberg, pp. 49-86.

Tittizer, T., Schöll, F., Banning, M., Haybach, A. and M. Schleuter (2000) Aquatische Neozoen im Makrozoobenthos der Binnenwasserstrassen Deutschlands. Lauterbornia 39, 1-72.

Vorburger, C. and G. Ribi (1999) Aggression and competition for shelter between a native and an introduced crayfish in Europe. Freshwater Biology 42, 111-119.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 76-95.

Wittmann, K.J. (2002) Krebstiere: “Schwebgarnelen” und Süsswassergarnelen (Crustacea: Mysidacea: Mysidae, Decapoda: Atyidae). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, 269-272.

Fact Sheets

Astacus leptodactylus

Taxonomic status

Scientific name	*Astacus leptodactylus* (Eschscholtz)
Family	Astacidae
Taxonomic group	Decapoda
English name	Narrow-clawed crayfish
German name	Galizierkrebs
French name	Ecrevisse à pattes grêlles
Italian name	Gambero di fiume turco

Description and identification

Description	A typical freshwater crayfish with a total length of up to 18 cm. The colouration is brownish to yellowish.
Similar species	The crayfish species found in Swiss waters are rather difficult to identify and it can be done reliably only by an experienced person. The narrow-clawed crayfish is distinguished by two ridges behind the eye and the lack of red colouration on the claws.

Biology and ecology

Behaviour	The narrow-clawed crayfish is mainly nocturnal, hiding during the day in burrows, below stones and between tree roots at the edge of the water. The eggs are carried around on the lower side of the body until the young hatch. Generally, the young are guarded by the mother for another few days or weeks.
Food	Crayfish are omnivorous. Depending on the age of the crayfish and the habitat, they eat plankton, algae, plants, insect larvae, mussels, snails, carrion, fish and other crayfish.
Habitat	It prefers lakes and ponds.

Origin Its origin is south-eastern Europe and Asia.

Introduction and dispersal

History of introduction	The narrow-clawed crayfish was introduced to many European countries at the beginning of the 20th century, after the introduction of the disastrous crayfish plague (see Fact Sheet in the chapter on Fungi) had devastated crayfish fishing in Europe. It reached Switzerland probably in the 1980s.
Pathways of introduction	Stocking of water bodies that were depleted of native crayfish species during outbreaks of the crayfish plague.
Dispersal	Crayfish species have the ability to leave the water and migrate on land over short distances – perhaps up to several hundred metres.

Current status

Actual and potential distribution in CH	The narrow-clawed crayfish is widely distributed in the lakes and ponds of the Mittelland. Since this species is, as all European crayfish species, vulnerable to the crayfish plague, the populations crash where an outbreak of the disease happens.
Introduced distribution	It was widely stocked in many European countries as a food resource.

Impacts

Environmental impact	The narrow-clawed crayfish competes with the native crayfish species *Astacus astacus* (L.) and in some places with *Austrapotamobius torrentium* (Schrank).
Economic impact	The economic importance of this species is limited due to its

susceptibility to the crayfish plague.

Management options

Prevention of further expansion of its range is of highest priority. Eradication would only be feasible in small ponds and this would be detrimental to other species. Methods include use of pesticides and fishing activities, while a more rigorous method is the complete draining of the water body. Control with similar methods could be employed, but would have to be done continuously.

Information gaps

Effective prevention and control options.

References

Literature

Eder, E. (2002) Krebstiere: Flusskrebse (Crustacea: Decapoda: Astacidae und Cambaridae). In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 287-291.

Frutiger, A. and R. Müller (2002) Der Rote Sumpfkrebs im Schübelweiher (Gemeinde Küsnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG.

Stucki, T. and P. Jean-Richard (2000) Verbreitung der Flusskrebse in der Schweiz. Mitteilungen zur Fischerei Nr. 65, 52 pp.

Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 76-95.

Other sources

http://www.research-projects.unizh.ch/math/unit72101/area121/p1005.htm

http://www.eawag.ch/sumpfkrebs/SumpfkrebsBericht1997.pdf

http://www.wirbellose.de/arten.cgi?action=show&artNo=072

Corophium curvispinum

Taxonomic status

Scientific name	*Corophium curvispinum* (Sars)
Family	Corophiidae
Taxonomic group	Amphipoda
English name	
German name	Süsswasser-Schlickkrebs
French name	
Italian name	

Description and identification

Description	A dorso-ventrally compressed amphipod with massive second antennae. A large curved spine on the second antenna led to its specific name and is characteristic for this species. First antenna fairly long. Telson short. The maximum length is about 7 mm.
Similar species	Morphology and behaviour is characteristic.

Biology and ecology

Behaviour	*Corophium curvispinum* builds networks of mud tubes on hard substrate, in which it lives. It has about three generations per year, between March and October. Where it is abundant, it is a main prey item for some fish species.
Food	This amphipod is a filter feeder, feeding mainly on phytoplankton and detritus.
Habitat	It is a species of freshwater and brackish water due to its tolerance of saline conditions. It prefers lakes and slow-flowing rivers with a muddy or sandy bottom, where it builds its mud tubes on hard substrates such as stones, wood, plants, mussels, etc.

Origin It is of Ponto-Caspian origin.

Introduction and dispersal

History of introduction	*C. curvispinum* is one of the widely distributed amphipods of Ponto-Caspian origin. At the beginning of the 20th century it started the successful expansion of its natural range by using ship traffic in artificial canals. First it reached northern Germany, and then used the network of canals to invade most Central European waters.
Pathways of introduction	Long distance travel is by ship traffic, while invasions over shorter distances occur also by natural migration.
Dispersal	The natural migration of this and the other amphipod species is fairly well adapted to a rapid expansion of the range.

Current status

Actual and potential distribution in CH	In the Rhine near Basel, but it is likely to invade more lakes and rivers.
Introduced distribution	Wide distribution in Europe.

Impacts

Environmental impact	This species is known to cause ecosystem changes. It transforms hard substrate by fixing up to 4 cm of mud on stones, thus depleting habitats for other hard substrate species. A marked reduction in macroinvertebrate species richness and a substantial decrease in abundance of several macrozoobenthic taxa were observed concomitantly with the enormous increase in abundance

of *C. curvispinum* in the Lower Rhine. The proposed mechanisms underlying this change are competition for food and the transformation of the substrate that prevents settlement of other species adapted to hard substrates. This affects not only native species, but also other alien species, e.g. the zebra mussel (*Dreissena polymorpha* (Pallas)) (see Fact Sheet in the chapter on the Mollusca). In conclusion, this species harms native species, but its effects are very difficult to predict, owing to wide impacts on entire invaded ecosystems.

Economic impact — It is possible that it affects the fish community in a detrimental way for the fisheries sector.

Management options — Prevention of introduction with ballast water is the only option for managing this species.

Information gaps — Effective prevention.

References

Literature

Bernauer, D., Kappus, B. and W. Jansen (1996) Neozoen in Kraftwerksproben und Begleituntersuchungen am nördlichen Oberrhein. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 87-95.

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the Rhine river determines biodiversity and ecosystem function: an affair between amphipods and mussles. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Ojaveer, H., Leppäkoski, E., Olenin, S. and A. Ricciardi (2002) Ecological impact of ponto-caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 412-425.

Pöckl, M. (2002) Flohkrebse (Crustacea: Amphipoda: Corophiidae und Gammaridae). In: Essl, F. and W. Rabitsch. Neobiota in Österreich (eds) Umweltbundesamt, Wien, pp. 273-284.

Tittizer, T. (1996) Vorkommen und Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den Bundeswasserstrassen. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 49-86.

Van den Brink, F.W.B., Van der Velde, G. and A. Bij de Vaate (1993) Ecological aspects, explosive range extension and impact of a mass invader, *Corophium curvispinum* Sars, 1895 (Crustacea: Amphipoda), in the Lower Rhine (The Netherlands). Oecologia 93, 224-232.

Dikerogammarus villosus

Taxonomic status

Scientific name	*Dikerogammarus villosus* (Sovinski)
Family	Gammaridae
Taxonomic group	Amphipoda
English name	
German name	Grosser Höckerflohkrebs
French name	
Italian name	

Description and identification

Description	A typical carnivorous gammarid with strong mouthparts. It often has a neat pattern of markings and can grow to about 3 cm in length.
Similar species	Full-grown males are characterized by their enormous size and the neat light and dark pattern. The distinguishing characteristics are two dorsal extrusions on the first and second cephalothoracic segments.

Biology and ecology

Behaviour	*Dikerogammarus villosus* is a ferocious predator of other invertebrates. Given their huge size, attacks on small vertebrates or small early stages of larger vertebrates, e.g. eggs and larvae, cannot be ruled out. It disperses well by active swimming. It is found below stones, in crevices of human-made structures and between shells of the zebra mussel (*Dreissena polymorpha* (Pallas)) (see Fact Sheet in the chapter on Mollusca). The species can withstand variable salinities, temperatures and oxygen levels. This pre-adapts it for being carried in ballast water and for quick establishment. Densities of up to 2,500 individuals per square metre have been found.
Food	It is a ferocious predator. The species has shown the capability for completely displacing other gammarid species under laboratory conditions by predation. It is also suspected of attacking larger prey and injuring large numbers – maybe even vertebrates.
Habitat	*Dikerogammarus villosus* has become established in a wide variety of communities. It seems highly adaptable to different conditions due to its high ecological amplitudes.

Origin	It is of Ponto-Caspian origin.

Introduction and dispersal

History of introduction	*Dikerogammarus villosus* has undergone an explosive invasion of Europe, colonizing most of Central Europe in only a few years. It is also a potential threat to the North American Great Lakes, if it were to be accidentally introduced, as many other Ponto-Caspian amphipods have been before.
Pathways of introduction	The exceptionally rapid colonization must have been aided by ship traffic; most likely carried long distances in ballast water.
Dispersal	The natural migration of this species and the other amphipods is fairly well adapted to a rapid expansion of the range.

Current status

Actual and potential distribution in CH	In the Rhine near Basel, but it is likely to invade more lakes and rivers in the near future.

Introduced distribution	It acquired a wide distribution in Europe within a few yeas.

Impacts

Environmental impact	This species is a serious invader due to its enormous predatory pressure on other native (and alien) invertebrates. It is fairly large and strong and can overpower many different species. At the time of the *D. villosus* invasion, other gammarid species showed a significant decline in population density and finally disappeared from some areas. Some of the earlier invaders have been impacted, but also some native *Gammarus* spp. are declining in the Rhine where the new species has appeared. A negative impact on native vertebrates is possible.
Economic impact	It is possible that it affects the fish community, which is important for the fisheries sector.

Management options — Prevention of introduction with ballast water is the only option for managing this species.

Information gaps — Effective prevention.

References

Literature

Dick, J.T.A. and D. Platvoet (2000) Invading predatory crustacean *Dikerogammarus villosus* eliminates both native and exotic species. Proceedings of the Royal Society of London B 267, 977-983.

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the Rhine river determines biodiversity and ecosystem function: an affair between amphipods and mussles. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Ojaveer, H., Leppäkoski, E., Olenin, S. and A. Ricciardi (2002) Ecological impact of ponto-caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 412-425.

Pöckl, M. (2002) Flohkrebse (Crustacea: Amphipoda: Corophiidae und Gammaridae). In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 273-284.

Reinhardt, F., Herle, M. Bastiansen, F. and B. Streit (2003) Economic impact of the spread of alien species in Germany. Federal Environmental Agency of Germany, 190 pp.

Rey, P. and J. Ortlepp (2002) Koordinierte biologische Untersuchungen am Hochrhein 2000; Makroinvertebraten. BUWAL Schriftenreihe Umwelt Nr. 345, Gewässerschutz, 98 pp.

Tittizer, T. (1996) Vorkommen und Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den Bundeswasserstrassen. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 49-86.

Orconectes limosus

Taxonomic status

Scientific name	*Orconectes limosus* (Rafinesque)
Family	Cambaridae
Taxonomic group	Decapoda
English name	Spiny-cheeked crayfish
German name	Kamberkrebs
French name	Ecrevisse américaine
Italian name	

Description and identification

Description	The spiny-cheeked crayfish is a fairly small species of about 12 cm length. It is of brownish to greenish colouration with red-brown bands on the tail. Pincers are tipped with orange-red spicules, contrasting with dark blue to black colour on the balance of the claws. This species has a single postorbital ridge, and noticeable spines anterior to the thoracic furrow on its carapace.
Similar species	The crayfish species found in Swiss waters are rather difficult to identify and it can be done reliably only by an experienced person. This species is distinguished by the characteristics mentioned above and is recognized by the dark brown sutures on each abdominal segment.

Biology and ecology

Behaviour	The species is similar in its behaviour to the other crayfish species. However, unlike native species it seems to tolerate deoxygenated, eutrophic or polluted waters.
Food	Crayfish are omnivorous. Depending on the age of the crayfish and the habitat, they eat plankton, algae, plants, worms, insect larvae, mussels, snails, carrion and fish.
Habitat	It occurs in rivers, canals, lakes and ponds and prefers large, warm, slow-moving bodies of water of varying turbidity.

Origin The natural range encompasses the north-eastern USA and south-eastern Canada.

Introduction and dispersal

History of introduction	The first introduction of the spiny-cheeked crayfish into the European continent was the release of about 100 individuals into the river Oder or a fishpond in Germany in 1890. This was followed by several introductions in other countries. The incentive for the introductions was the dramatic decrease in native crayfish populations and harvest because of the expanding crayfish plague (see Fact Sheet in the chapter on Fungi), itself introduced to Europe. Subsequently this alien crayfish species has spread to the whole of Central and Western Europe. The first Swiss record is from 1976.
Pathways of introduction	Stocking of water bodies that were depleted of native crayfish species during outbreaks of the crayfish plague. It was soon recognized that this species is of low economic importance owing to its small size, narrow chelipeds, and meat of inferior quality. Thus, most of the subsequent introductions were probably not so much for human consumption and economic reasons, but by individuals emptying aquariums. The natural migration of this highly agile species is also of importance. This is supported by canals that

	now connect formerly isolated water bodies.
Dispersal	Crayfish species have the ability to leave the water and migrate on land over short distances – this species might wander for kilometres over land.

Current status

Actual and potential distribution in CH	This species is found in many water bodies north of the Alps and also in the Ticino. It is still expanding along the main watercourses, e.g. along the Aare. It can occur in high densities in favourable conditions.
Introduced distribution	It was widely stocked in many European countries as a food resource. Thus far, *O. limosus* has been introduced into water bodies in at least 15 European countries and it is still extending its range, especially in Central Europe. In several countries, e.g. Germany and Poland, it is currently the dominant freshwater crayfish species.

Impacts

Environmental impact	In Switzerland, the introduced spiny-cheeked crayfish may displace the native species *Austropotamobius pallipes* (Lereboullet) in some water bodies. It is not clear whether or not this species can impact native species by direct competition. However, it is tolerant to varying conditions and is highly adaptable. This, in combination with its role as a vector for the crayfish plague, makes it a species of high concern. The American species are resistant but act as a vector for the disease, which causes almost complete mortality in all European crayfish species (see Fact Sheet of the crayfish plague in the chapter on Fungi). It is expected that the spiny-cheeked crayfish will expand its range further and threaten remaining populations of native crayfish in Switzerland.
Economic impact	This species has a negative economic impact, since it is of little value for human consumption and is spreading the crayfish plague to native crayfish. Thus, it causes a decrease in the crayfish harvest. However, the costs cannot be estimated, because the losses suffered by fisheries and aquaculture from the crayfish plague are not known and other North American crayfish species act also as vectors, so that the contribution of this species is unclear.

Management options	Prevention of further expansion of its range is of highest priority. Introduction of North American crayfish species into the wild has to be prevented. Eradication would only be feasible in small ponds and this would often be detrimental to other species. Common methods include use of pesticides and fishing activities, while a more rigorous method is the complete drainage of the water body. Adult crayfish can be hand-collected or caught in baited traps. Control with similar methods could be employed, but would have to be done continuously.
Information gaps	Effective management of North American crayfish species in order to safeguard remnant populations of native crayfish.

References

Literature

Eder, E. (2002) Krebstiere: Flusskrebse (Crustacea: Decapoda: Astacidae und Cambaridae). In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 287-291.
Frutiger, A. and R. Müller (2002) Der Rote Sumpfkrebs im Schübelweiher (Gemeinde Küsnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG.

Stucki, T. and P. Jean-Richard (2000) Verbreitung der Flusskrebse in der Schweiz. Mitteilungen zur Fischerei Nr. 65, 52 pp.
Tittizer, T. (1996) Vorkommen und Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den Bundeswasserstrassen. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 49-86.
Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.
Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 76-95.

Pacifastacus leniusculus

Taxonomic status

Scientific name	*Pacifastacus leniusculus* (Dana)
Family	Astacidae
Taxonomic group	Decapoda
English name	Signal crayfish
German name	Signalkrebs
French name	Ecrevisse signal
Italian name	Gambero dal signale

Description and identification

Description	The signal crayfish is the largest of the species introduced into Europe from North America, commonly attaining a length of 17-18 cm. It is the fastest growing northern temperate zone crayfish species. The colouration is light brown. It has large and robust claws, which are smooth all over and coloured red underneath. The name-giving signal is a white spot at the base of the movable finger of the claw.
Similar species	The crayfish species found in Swiss waters are rather difficult to identify and it can be done reliably only by an experienced person. The signal crayfish can be distinguished by the combination of a white spot and red colour on the claws, the two ridges behind the eye, and the absence of spines behind these ridges.

Biology and ecology

Behaviour	The signal crayfish is the ecological homologue of the European *Astacus astacus* (L.) in North America. The morphology and life history are extremely similar. They have omnivorous food preferences, a nocturnal activity pattern, and favour the same habitat. During the day they hide in refuges. *P. leniusculus* burrows into sediments and is a strong climber. Therefore it escapes readily from captivity.
Food	Crayfish are omnivorous. Depending on the age of the crayfish and the habitat, they eat plankton, algae, plants, insect larvae, mussels, snails, carrion, fish and other crayfish.
Habitat	It prefers lakes and streams, primarily the littoral zone with stony bottoms or other substrates offering some refuges.

Origin	The natural range is the cool temperate regions of north-western USA and south-western Canada.

Introduction and dispersal

History of introduction	The signal crayfish is the North American ecological equivalent to the European species, see above. Native crayfish species have suffered and are under continuous threat in some regions from many factors, including diseases, pollution, over fishing and habitat destruction. By far the most devastating factor was the arrival of the North American crayfish plague (see Fact Sheet in the chapter on Fungi). The disappearing populations led to the breakdown of the fishing industry. Thus, the species were replaced by North American crayfish species that are resistant to the crayfish plague to restore the crayfish harvest. American crayfish species were both released into the wild to replace the disappearing native populations and cultured in captivity for human consumption, from where they readily escaped into the wild in many places. The first

	imports of North American species were around 1960 in Sweden, where breeding stations were established. The native *A. astacus* is extinct in Sweden.
Pathways of introduction	Stocking of water bodies that were depleted of native crayfish species during outbreaks of the crayfish plague. Escaped specimens from cultures for human consumption founded other populations. A third source of alien crayfish is aquarium releases, when the owners no longer want them; this is especially common for the more colourful alien species.
Dispersal	Crayfish species have the ability to leave the water and migrate on land over short distances – maybe up to several hundred metres.

Current status

Actual and potential distribution in CH	The signal crayfish has a very restricted range in Switzerland; scattered population are known in the south-western and northern parts. The species is a fairly recent invader, so that, bearing in mind the common lag phase in bioinvasions, and its high potential for spread, it is likely to increase its distribution in the long term.
Introduced distribution	It was widely stocked in many European countries as a food resource. Thus far, *P. leniusculus* has been introduced into water bodies in around 25 European countries and continued stockings are expanding the range of this economically important species.

Impacts

Environmental impact	The introduced signal crayfish has displaced at least two European species, *A. astacus*, and *Austropotamobius pallipes* (Lereboullet). Relative competitive abilities may determine the impact on native crayfish. The alien species has an advantage in aggressive interactions because it is the larger and faster growing species. However, its role as a vector of the crayfish plague overrides the importance of competition. The American species are resistant but act as a vector for the disease, which causes almost complete mortality in all European crayfish species (see Fact Sheet of the crayfish plague in the chapter on Fungi). It is expected that the signal crayfish will spread successfully and threaten remaining populations of native crayfish. The rare *A. torrentium* (Schrank) is of particular concern. Although the interactions between native and alien crayfish species are complex, it is indisputable that *P. leniusculus* and *A. astacus* cannot co-exist, as their ecological niches are too similar. The latter species is being replaced by the alien species, even in the absence of crayfish plague outbreaks.
Economic impact	The signal crayfish has turned out to be an economic success, while it is a disaster for the environment. It is very productive and has allowed countries whose stocks of native crayfish have been devastated by the crayfish plague to develop an alternative species for human consumption. However, at the same time the species spread the crayfish plague and in that way reduced the opportunity for using the native crayfish species for human consumption.

Management options	Prevention of further expansion of its range is of highest priority. Introduction of North American crayfish species into the wild has to be prevented. Eradication would only be feasible in small ponds and this would often be detrimental to other species. Common methods include use of pesticides and fishing activities, while a more rigorous method is the complete drainage of the water body. Adult crayfish can be hand-collected or caught in baited traps. Control with similar methods could be employed, but would have to be done continuously.
Information gaps	Effective management of North American crayfish species in order

to safeguard remnant populations of native crayfish.

References

Literature

Eder, E. (2002) Krebstiere: Flusskrebse (Crustacea: Decapoda: Astacidae und Cambaridae). In: Essl, F. and W. Rabitsch. (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 287-291.

Frutiger, A. and R. Müller (2002) Der Rote Sumpfkrebs im Schübelweiher (Gemeinde Küsnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG.

Stucki, T. and P. Jean-Richard (2000) Verbreitung der Flusskrebse in der Schweiz. Mitteilungen zur Fischerei Nr. 65, 52 pp.

Vorburger, C. and G. Ribi (1999) Aggression and competition for shelter between a native and an introduced crayfish in Europe. Freshwater Biology 42, 111-119.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 76-95.

Procambarus clarkii

Taxonomic status

Scientific name	*Procambarus clarkii* (Girard)
Family	Cambaridae
Taxonomic group	Decapoda
English name	Red swamp crayfish
German name	Roter Amerikanischer Flusskrebs
French name	Ecrevisse rouge de Louisiane
Italian name	Gambero rosso della Luisiana

Description and identification

Description	The red swamp crayfish is a small, slender freshwater crayfish of about 13 cm in length. Adult animals are of red and black colouration, as the common names imply. Claws are red when mature. This species has a single postorbital ridge with a spine.
Similar species	The crayfish species found in Swiss waters are rather difficult to identify and it can be done reliably only by an experienced person. However, the adults of this species, with their black and red colouration, are easily identifiable.

Biology and ecology

Behaviour	The species is similar in its behaviour to the other crayfish species. It has a high tolerance with respect to abiotic conditions and is apparently able to withstand the winter temperatures of Central Europe, although its native range is the southern part of North America and Central America. It is very mobile and capable of long-distance migration, including dispersal over land. Unlike other species, it is adapted to seasonally-flooded wetlands that may lack standing water for extensive periods. Thus, it is capable of tolerating sharp changes in environmental factors, e.g. temperature fluctuations and oxygen depletion.
Food	Crayfish are omnivorous. Depending on the age of the crayfish and the habitat, they eat plankton, algae, plants, worms, insect larvae, mussels, snails, carrion and fish.
Habitat	It is found in a wide variety of ecosystems. The natural preferred habitat is seasonally-flooded wetlands.

Origin	The origin of the species is the southern part of the USA and Mexico. This is a warm water species.

Introduction and dispersal

History of introduction	In 1973 the species was first introduced into Europe; it was released into rice fields in Spain. Commercial success encouraged illegal introductions, and the practice of selling live *P. clarkii* as food and as garden pond pets contributed to its expansion into natural waters in many other European countries.
Pathways of introduction	Initial releases were for stocking of water bodies that were depleted of native crayfish species during outbreaks of the crayfish plague. Subsequent illegal introductions occurred because of its commercial success. However, this very decorative species is a favourite pet for aquariums and garden ponds. Thus, escapes from captivity are probably another important pathway. Pet species are also often released “back into the wild” when no longer wanted by their owners.
Dispersal	Crayfish species have the ability to leave the water and migrate on

	land over short distances – this species might wander for kilometres over land. The red swamp crayfish is specifically adapted to changing environmental conditions, since its natural habitat includes seasonally flooded wetlands.

Current status

Actual and potential distribution in CH	The red swamp crayfish is the most restricted of the alien crayfish in Switzerland and is only found in a few lakes and ponds. However, owing to its high mobility, an expansion of its range is very likely.
Introduced distribution	This species is found in about 12 countries in Europe and is one of the dominant crayfish species in the world, commercially harvested in the USA, China and Spain.

Impacts

Environmental impact	In Switzerland, the introduced red swamp crayfish may displace native species in water bodies. It is not clear whether or not this species can impact native species by direct competition. However, it is tolerant to varying conditions and highly adaptable. This, in combination with its role as a vector of the crayfish plague, makes it a species of high concern. The American species are resistant but act as a vector for the disease, which causes almost complete mortality in all European crayfish species (see Fact Sheet of the crayfish plague in the chapter on Fungi). It is expected that the red swamp crayfish will expand its range further and threaten remaining populations of native crayfish in Switzerland.
Economic impact	This species is threatening the native crayfish species by vectoring the crayfish plague, thus decreasing crayfish harvest. However, the costs cannot be estimated, because the losses suffered by fisheries and aquaculture from crayfish plague are not known and other North American crayfish species act also as vectors. Thus, examining the contribution of single species to the overall effect is impossible.

Management options	Prevention of further expansion of its range is of highest priority. Introduction of North American crayfish species into the wild has to be prevented. Live importation of the species for human consumption or as pets is a cause for concern. Eradication would only be feasible in small ponds and this would often be detrimental to other species. Common methods include use of pesticides and fishing activities, while a more rigorous method is the complete drainage of the water body. Adult crayfish can be hand-collected or caught in baited traps. Control with similar methods could be employed, but would have to be done continuously.
Information gaps	Effective management of North American crayfish species in order to safeguard remnant populations of native crayfish.

References

Literature

Eder, E. (2002) Krebstiere: Flusskrebse (Crustacea: Decapoda: Astacidae und Cambaridae). In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 287-291.
Frutiger, A. and R. Müller (2002) Der Rote Sumpfkrebs im Schübelweiher (Gemeinde Küsnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG.
Stucki, T. and P. Jean-Richard (2000) Verbreitung der Flusskrebse in der Schweiz. Mitteilungen zur Fischerei Nr. 65, 52 pp.
Tittizer, T. (1996) Vorkommen und Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den Bundeswasserstrassen. In:

Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse. Ecomed Verlagsgesellschaft, Landsberg, pp. 49-86.

Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 76-95.

Other sources *http://members.aon.at/crayfish-hatchery/mergus.html*

4 Insects – Insecta

Prepared by Marc Kenis

Introduction

Insects probably represent the most numerous exotic organisms in Switzerland. A list of insects that are considered to be of exotic origin has been drawn up, with the help of specialists (see Tables 4.1–4.6). It includes 311 species of exotic origin that have certainly or probably been introduced into Switzerland or neighbouring countries by human activities. It does not include species that are spreading naturally into Switzerland, unless they were first introduced into neighbouring countries. This list is by no means complete, but it will be maintained and new records will be added when data become available. In collaboration with taxonomists for the various insect groups, we also intend to publish this list in peer-reviewed journals, with more details on the occurrence, distribution and biology of the exotic species. The two published lists of alien organisms in Austria and Germany (Essl and Rabitsch, 2002; Geiter et al., 2002) have been of great help in the construction of the Swiss list.

Many problems were encountered in drawing up the list, the main ones being detailed below.

- There is an obvious lack of information sources in Switzerland. Up-to-date, published checklists are available for a few insect groups only (e.g. Diptera, Orthoptera, Odonata). The 'Centre Suisse de Cartographie de la Faune' (CSCF) is maintaining incomplete lists with the input of Swiss taxonomists, and several lists of other important insect groups are in the process of being completed (e.g. Coleoptera, Lepidoptera, Aphidoidea, etc.). The CSCF and individual taxonomists were very cooperative in helping us check and complete the list of exotic insects; nevertheless, it has been a rather difficult task. For some groups, there is presently little expertise in Switzerland, and no recent checklist is available (e.g. most primitive orders and Mallophaga, which are therefore not included in the list, and also parts of the Hymenoptera, Heteroptera, etc.). Additionally, it must be noted that in the few checklists published, the origin of the species is often not clearly indicated. For future checklists, we suggest including the 'exotic character' and the area of origin in the data set.
- Many alien insects in Switzerland originate from the Mediterranean region. Some of these species, particularly Hemiptera, were evidently introduced with their host plants, which are often planted as ornamentals or crops in Switzerland. However, for other species, it is not clear whether they were introduced by human activities or arrived naturally (e.g. the Heteroptera *Arocatus longiceps* and *Deraeocoris flavilinea*). Some species undoubtedly migrated unaided from southern Europe to Switzerland, possibly because of global warming. This is, for example, the case for the dragonflies *Sympetrum meridionale* (Selys) and *Crocothemis erythraea* (Brullé). Likewise, many Lepidoptera species (e.g. *Helicoverpa armigera* (Hübner) and *Mythimna unipuncta* (Haworth), which used to be observed only occasionally in summer in southern Switzerland, are now overwintering in the country more frequently. Eastern European insect species are also increasingly observed in Switzerland. For most of them, it is not clear whether their introduction into Switzerland was natural or by human-mediated transport, and whether they are firmly established or not. In general, species whose establishment in Switzerland seems to be the result of a natural process were not included in our list. However, this phenomenon would merit further studies.
- High numbers of tropical or subtropical insects are found in Switzerland in houses, greenhouses and other confined environments. Many of them are important pests of greenhouse crops (e.g. several thrips and whiteflies) or stored products (e.g. various beetle and moth species). However, it is not always easy to determine whether these insects are firmly established, or regularly introduced from abroad with new plant material. Furthermore, some species that were thought to be confined to greenhouses are now found outdoors in natural environments. Examples include, among others, the scale insects *Icerya purchasi*, *Coccus hesperidum* and *Dynaspidiotus britannicus* (Kozar et al., 1994).
- Today, many insects, particularly those feeding on stored products and crops and occurring as ectoparasites of vertebrates are considered to be of cosmopolitan distribution and, therefore, it is often difficult to assess their exotic status and some will finally be concluded to be cryptogenic

species. Only insects that are suspected to be exotic, for any reason (e.g. because they feed only on an exotic plant, or because the genus is considered exotic) are included in the list.

Invasive alien insects are serious threats to agriculture, economies, the environment and human and animal health worldwide. In some regions, such as North America, South Africa and many oceanic islands, exotic insect pests are considered to be as important as native pests, if not more so. Traditionally, problems have been less severe in Central Europe. Only a few exotic insects are known to cause serious damage in Switzerland, usually as stored product pests or on agricultural crops. However, in recent years several pests of economic importance have invaded Europe, stimulating more interest in the issue of exotic insects. For example, the western corn rootworm, *Diabrotica virgifera* ssp. *virgifera* is seriously threatening European maize production, and the horse chestnut leaf miner, *Cameraria ohridella*, is causing much public concern because of its spectacular damage to urban trees in Central Europe.

Worldwide, environmental impacts have been studied less for alien insects than for other groups of invasive organisms such as plants or mammals. However, many insects are known to cause serious environmental damage in invaded habitats. Here again, most of these cases are from outside Europe. For example, the hemlock woolly adelgid, *Adelges tsugae* Annand, is threatening unique forest ecosystems in North America (Jenkins et al., 1999); the scale insect *Orthezia insignis* Browne was in the process of pushing the endemic gumwood tree *Commidendrum robustum* DC. in Saint Helena to the brink extinction when a successful biological control programme was implemented (Fowler, 2004). In Europe, there have been few similar examples. Recently, however, the Argentine ant *Linepithema humile* has been causing changes in invertebrate and plant communities in the Mediterranean region by predation and displacement of native species (Gómez and Oliveras, 2003). The horse chestnut leaf miner is an urban pest in Central Europe but, in the Balkans, it is threatening the few remaining indigenous horse chestnut populations. In general, most alien insects have not been the targets of serious environmental impact studies. Their interaction with the native fauna and flora has been rarely investigated, particularly if their habitat is of little economic concern. Environmental impacts may be direct (on a plant for a herbivore, or on a prey for a predator), but the invader may also have an indirect impact on co-occurring organisms, e.g. through sharing the same food webs. Among the over 300 recorded exotic insects in Switzerland, surely more than one has an important environmental impact within the newly invaded ecosystem? Investigations on the impact of invasive species should not be restricted to species of economic importance, but should also focus on abundant species in poorly studied ecosystems, in which important environmental impacts may have been overlooked.

The gaps in knowledge of the Swiss insect fauna, as explained at the beginning of this chapter, precludes any conclusive evaluation of its status, i.e. what percentage of the Swiss insect fauna is alien, the origins of the alien species, and the pathways by which they reached Switzerland. However, the fact that many species were apparently introduced with their host plants and food indicates that trade in commodities is a major pathway of insect introduction into Switzerland. Furthermore, it is certain that the majority of the alien insect fauna was accidentally introduced. Prevention of entry of pest species is addressed by quarantine regulations and interception; however, species of environmental concern are mostly not covered by these measures. Control of alien insect populations is also focussed on species of economic importance.

Coleoptera

(Advisor: Claude Besuchet, Muséum d'Histoire Naturelle, Genève)

There is no recent checklist of Coleoptera of Switzerland. However, Lucht (1987), in his catalogue of Coleoptera of Central Europe, includes distribution data for northern Switzerland. Furthermore, Claude Besuchet, Muséum d'Histoire Naturelle, Genève, is currently compiling a checklist for Switzerland, and he kindly helped us complete our list with his unpublished data.

Over 120 beetle species are known, or suspected, to be of exotic origin in Switzerland, which accounts for about 40% of the list of alien insects. Many of these exotic species are domestic pests, often feeding on stored products, construction material, etc. The main pests of stored products are found in the families Anobiidae, Bostrichidae, Bruchidae, Cucujidae, Curculionidae, Dermestidae, Mycetophagidae, Nitidulidae, Ptinidae, Silvanidae and Tenebrionidae. Most of them have been transported with their food and are now found worldwide. Their artificial cosmopolitan distribution renders the identification of their origin difficult. Some species, in particular many Dermestidae, may actually be native to Central Europe. Thus the inclusion of some species in the list is questionable.

Some of the stored product pests are of tropical origin and are strictly domestic in Switzerland, whereas others can also survive and reproduce under outdoor conditions. Many more species than those listed in this study are found associated with stored products in Switzerland. However, it is not always clear whether these species are established, or regularly introduced with imported goods. Our list includes only the species thought to be established, although, in several cases, the decision on whether to include them or not was rather subjective. For example, we did not include the coffee bean beetle, *Araecerus fasciculatus* De Geer, a species often found in imported coffee and cocoa beans in Swiss food factories, but not clearly established in the country.

Hoppe (1981) surveyed stored commodities in Switzerland and found the most destructive beetles to be the curculionids *Sitophilus granarius* and *S. orizae*, the silvanid *Oryzaephilus surinamensis* and the tenebrionids *Tribolium castaneum* and *T. confusum*, all considered to be of exotic origin.

Apart from stored product pests, few exotic beetles are recorded as agricultural pests in Switzerland. However, two important chrysomelid beetles are worth mentioning. The infamous Colorado potato beetle, *Leptinotarsa decemlineata* invaded Europe from North America in the 1920s and reached Switzerland in 1937. It is a major pest of potato in Europe and North America (see Fact Sheet). More recently, the western corn rootworm, *Diabrotica virgifera* ssp. *virgifera*, a Nearctic species, took the same road and arrived in Belgrade in 1992. Twelve years on, it has spread to more than 12 European countries, including Switzerland (see Fact Sheet). *D. virgifera virgifera* is considered the major pest of maize in North America and substantial economic damage has already been observed in Central and eastern Europe.

Some exotic beetles are damaging to forest and ornamental trees. Xylophagous insects are notorious for being easily introduced into new regions through the importation of timber or solid wood packing material. At least six Scolytidae in Switzerland are of alien origin. In particular, the Asian *Xylosandrus germanus* and the North American *Gnathotrichus materiarius* damage freshly cut logs and reduce timber quality. They both arrived in Switzerland in the 1980s (see Fact Sheet for *X. germanus*; Hirschheydt (1992) for *G. materiarius*). Other wood boring scolytids arrived in Switzerland very recently: *Tripodendron laeve* from East Asia or Scandinavia, *Xyleborinus alni* from East Asia, and *Xyleborus punctulatus* from Siberia (C. Besuchet, pers. comm.). Similarly, the cerambycids *Neoclytus acuminatus* and *Xylotrechus stebbingi*, xylophagous beetles from North America and the Himalayas, respectively, have recently been found in the Ticino (C. Besuchet, pers. comm.). Although these species have not yet caused economic or environmental damage in Switzerland, their introductions show that international movement of timber and timber products is an important introduction pathway for bark and wood boring beetles that may eventually lead to the establishment of serious forest pests. Among these potential introductions are the two Asian cerambycids *Anoplophora glabripennis* (Motschulsky) and *A. chinensis* (Forster). Both species are important pests in Asia, attacking and killing a whole range of tree species (see Fact Sheets for both species). They were both introduced into North America in the 1990s, where they are now the targets of large-scale eradication programmes. These species have been often intercepted at ports of entry into Europe and, in the last four years, field populations have been found at various sites in Europe (in Austria, Germany and France for *A. glabripennis*; in Italy and France for *A. chinensis*). Eradication programmes have been established but the population of *A. chinensis* in Italy, at least, is considered to be established. The potential damage these two species could cause in Europe is unclear, but it could be spectacular. *A. glabripennis* is usually introduced as eggs, larvae or pupae in solid wood packing material, i.e. crating, pallets or packing blocks from China. *A. chinensis* has been transported to North America, France and Italy in bonsai trees from Asia.

Not all introduced beetles in Switzerland are of economic importance. Many exotic species are found in decaying plant material, compost, litter, etc., in particular several fungus beetles (Latridiidae) and rove beetles (Staphylinidae), but also species in the families Hydrophilidae, Languridae, Merophysiidae, Orthoperidae, Ptiliidae, etc. Considering how little attention has been paid to these insects and their ecosystems, it is likely that many more exotic species remain unrecorded in Switzerland, and in Europe in general. Some of the recorded species are particularly abundant in their habitat, suggesting that direct or indirect interactions with the native fauna occur.

Finally, another invasive beetle worth mentioning in the multicoloured Asian ladybeetle, *Harmonia axyridis*. This coccinellid is a biological control agent widely used in greenhouses against aphids. It recently became established outdoors in several European countries. The first specimen was found in Basel in 2004 (Klausnitzer, 2004). It is also established since the late 1980s in North America, where it has become a human nuisance because of its habit of invading houses and buildings in large numbers.

Furthermore, it seems to decrease the diversity of native Coccinellidae, and it has also become a pest of fruit production, particularly in vineyards (see Fact Sheet).

Lepidoptera

(Advisors: Ladislaus Reser, Natur-Museum Luzern; Rudolf Bryner, Twann)

The Lepidoptera of Central Europe has been quite well studied, and the distribution of both native and exotic species is fairly well known compared with most other insect orders. In this group, the main difficulty in establishing a list of exotic species came from the high numbers of Mediterranean species that are occasionally observed in Switzerland. The exotic or invasive status of most of these species is unclear. For example, Rezbanyai-Reser (2000) lists Mediterranean Geometridae and Noctuidae which occasionally overwinter in the Ticino. Some species apparently became established only recently, such as the noctuids *Mythimna unipuncta* and *Acantholeucania loreyi* (Duponchel), perhaps as a result of climate change. Others, such as the well known noctuid pest *Spodoptera exigua* (Hübner), are occasional visitors that can overwinter in the warmest areas of the country. Many other southern or eastern European species, including migrant species, are occasionally recorded in Switzerland. In general, these Lepidoptera are not included in our list, because their introduction and establishment in Switzerland are natural phenomena and not mediated by human activity. A few species whose invasive status is in doubt are included in the list, such as the geometrid *Eupithecia sinuosaria*, a European species for which the spread through Central Europe has been particularly well studied (Rezbanyai-Reser et al., 1998). Similarly, *Caradrina ingrata* is a noctuid of eastern Mediterranean origin and is increasingly observed in urban areas, where it could have become established in warmer microclimates (Rezbanyai-Reser et al., 1997; Whitebread, 1997).

Many Lepidoptera of exotic origin are primary or secondary pests. Among the best-known exotic species are several leaf miners in the family Gracillariidae, which all invaded Europe in the last 30 years. Leaf miners are easily introduced into new areas because the mines on fresh or dead leaves are often inconspicuous and readily carried over long distances. In addition, several species pupate in or near the leaf mine, and these stages are less vulnerable to adverse conditions. The horse chestnut leaf miner, *Cameraria ohridella,* is a moth of unknown origin that was first found in Macedonia in 1984 and in Switzerland in 1998 (Kenis and Forster, 1998; see also Fact Sheet). In less than 20 years, it has invaded most of Europe. The rapid spread of the moth in Europe is explained by the transport of adults and dead leaves containing pupae in or on vehicles. It causes severe defoliation to horse chestnut (*Aesculus hippocastanum* L.) trees in urban areas in most European regions as well as to indigenous horse chestnut stands in the Balkans, where it represents a threat to the survival of the tree species in the wild. The North American species *Phyllonorycter robiniella* and *Parectopa robiniella* mine leaves of their original host, the North American black locust *Robinia pseudoacacia* L. (see Fact Sheet in the plants chapter). *Phyllonorycter platani*, a moth originating from the Balkans and Asia Minor, is commonly found on *Platanus* trees. *Phyllonorycter leucographella*, also of eastern Mediterranean origin, has spread all over Europe and feeds on *Pyracantha* and *Crataegus*. Another gracillariid, the eastern Asian *Caloptilia azaleella*, mines on *Rhododendron* in greenhouses. Ornamental Cupressaceae in Europe are attacked by another North American leaf miner, the yponomeutid *Argyresthia thuiella*.

The arctiid moth *Hyphantria cunea* is another interesting case of an invasive Lepidoptera. Originating from North America, *H. cunea* arrived in the 1940s in Hungary, from where it spread to most of Europe. It was first found in the Ticino in 1991 (Jermini et al., 1995; see also Fact Sheet). This polyphagous defoliator is considered a serious pest of forest and ornamental trees and shrubs in some eastern European countries and eastern Asia, where it was also introduced. *Cydia molesta* is an Asian species present in orchards in Switzerland where it feeds on various fruit trees. The noctuid *Helicoverpa armigera* is a cosmopolitan, polyphagous pest, probably of African origin, which occurs in Switzerland mainly in greenhouses. It is now also regularly found overwintering in the Tessin, where it probably arrived by itself. Another greenhouse pest of African origin is the banana moth, *Opogona sacchari*, which feeds on various woody and perennial ornamentals.

Several exotic moths are pests of stored products in Switzerland. Most of them have been introduced with commodities into most parts of the world. The pyralid *Plodia interpunctella* is a major pest of stored products in warehouses, grain elevators and food factories, as well as in private households. It feeds on grains, nuts and various other dried products. In Switzerland, it is particularly prevalent in chocolate factories, together with other pyralids, *Ephestia elutella* and *Cadra cautella* (Hoppe, 1981). The pyralids *E. kuehniella* and *Sitotroga cerealella* are also cosmopolitan species, found mainly in stored grains. These pests of stored products are usually well controlled in Switzerland and other developed countries, but their management makes extensive resource demands on the industry.

Hymenoptera

(Advisor: Bernhard Seifert, Staatliches Museum für Naturkunde, Görlitz, Germany (Formicidae))

Only two Symphyta in the Swiss fauna are known to be of exotic origin. The wood wasp *Sirex cyaneus* is a secondary forest pest. Larvae live in dead or dying trunks of *Abies,* mainly, but also *Larix* and *Pseudotsuga* (Schwenke, 1982). The insect originates from North America but invaded Europe a long time ago, without causing damage. It is interesting to note that a European congeneric species, *S. noctilio* F., in Europe nearly as harmless as *S. cyaneus*, has become a major introduced pest of pine plantations in Australia, New Zealand, South Africa and South America. The second exotic sawfly in Switzerland is the nematine tenthredinid *Nematus tibialis,* an American species established in Europe where it feeds on its original host, *Robinia pseudoacacia*.

Most Hymenoptera belong to the Apocrita, and of these the vast majority are parasitic insects. These are among the least known insects. There is no checklist of parasitic Hymenoptera for Switzerland, and new, undescribed species are found every year in Central Europe. Many European species are known to occur on other continents as well but, for most of them, it is impossible to know whether their wide distribution is the result of an introduction of exotic species into Europe, or vice versa. Only the few species deliberately introduced into Europe as part of biological control programmes are definitely exotic. For example, at least three alien parasitoid species have been introduced into Switzerland and have become permanently established. The aphelinid *Aphelinus mali* was released against the woolly aphid *Eriosoma lanigerum* as early as 1922 (Greathead, 1976). Another aphelinid wasp, *Encarsia perniciosi,* was introduced more recently against the San José scale *Quadraspidiotus perniciosus,* and the dryinid *Neodryinus typhlocybae* was released in the Ticino in 1998-99 to control the flatid planthopper *Metcalfa pruinosa* (Mani and Baroffio, 1997; Jermini et al., 2000). Other parasitoids were released in neighbouring countries and were subsequently recovered in Switzerland, such as *Aphytis proclia*, *Encarsia berlesei* and *E. lounhuryi*, all introduced in Italy to control scale insects (Greathead, 1976; Noyes, 2002). The encyrtid *Ooencyrtus kuvanae*, an Asian egg parasitoid of the gypsy moth, *Lymantria dispar* L., was released in many European countries. It is has not been recorded from Switzerland, but since it is present in all neighbouring countries, there is no doubt that it also occurs in Switzerland (Greathead, 1976; Noyes, 2002).

Other parasitic Hymenoptera of exotic origin are used as augmentative biological control agents in Swiss greenhouses. The most commonly used species, such as the whitefly parasitoid *Encarsia formosa*, are mentioned in our list because they have become part of greenhouse ecosystems although, in most cases, they cannot survive winter conditions outdoors.

Many exotic seed chalcids of the genus *Megastigmus* (Torymidae) have been accidentally introduced into Europe with seed trading, some of them having become pests in European seed orchards (Roques and Skrzypczynska, 2003). Only *M. spermothrophus*, the North American Douglas fir seed chalcid, is reported from Switzerland, but many other species are known from neighbouring countries and, thus, are probably present in Switzerland.

Two sphecid wasps have recently invaded Switzerland. The American *Isodontia mexicana* has been found in the Ticino and the Lemanic region since the early 1990s (Vernier, 1995, 2000). It feeds on crickets and, given its abundance, its impact on native ecosystems would merit further attention. *Sceliphron curvatum* is an Asian species which arrived in Europe in the 1970s. The first specimens were found recently in Switzerland (Gonseth et al., 2001). Its nests are commonly found in houses and other buildings.

Five exotic ant species are recorded for the Swiss fauna (Freitag et al., 2000; Neumeyer and Seifert, 2005). These are 'tramp' ants of tropical and subtropical origin but transported by human activities to most regions of the world. The most common is the Asian species *Monomorium pharaonis*, very abundant in buildings and often considered as an urban pest. *Hypoponera schauinslandi* is found in greenhouses and other heated buildings in Central Europe (Seifert, 2004). *Linepithema humile* is the famous Argentine ant, which has invaded a vast territory along the Mediterranean coast and has been occasionally recorded in Switzerland (e.g. Kutter, 1981). Neumeyer and Seifert (2005) state that it could soon become established in outdoor situations because of global warming. *Tapinoma melanocephalum* and *Paratrechina longicornis* have been observed in few occasions indoors in Switzerland and their establishment is not firmly established (Dorn et al., 1997; Freitag et al., 2000).

Another ant, *Lasius neglectus* Van Loon, Boomsma & Andrasfalvy, an Asian species, is rapidly invading Europe, causing some damage in urban areas (Seifert, 2000). It is not yet recorded from Switzerland, but its occurrence in neighbouring countries (France, Italy and Germany) suggests that it may be already present.

Finally, the chestnut gallwasp, *Dryocosmus kuriphilus* Yasumatsu (Hym.: Cynipidae), is worth mentioning as a potential threat for the European chestnut, *Castanea sativa*, in Switzerland and the rest of Europe. This Chinese species was found for the first time in Northern Italy in 2002 and is considered as the most serious insect pest of *Castanea* spp. worldwide (Bosio, 2004). Attacks of *Dryocosmus kuriphilus* reduce growth of young chestnuts and fruiting. Yield reductions of 50-70% are observed and severe infestations may result in the dead of the tree.

Diptera

(Advisors: Bernhard Merz, Muséum d'Histoire Naturelle, Genève; Jean-Paul Haenni, Muséum d'Histoire Naturelle, Neuchâtel; Gerhard Baechli, Zoologisches Museum, Zürich; Wolfgang Billen, Amt für Landwirtschaft, Lörrach, Germany)

Checklists of Swiss Diptera have been published recently (Merz et al., 1998, 2001). These do not contain information on the exotic or invasive status of the species but the authors (Drs. B. Merz, J.-P. Haenni and G. Baechli) were contacted and kindly reviewed the list to extract the species which are thought to be exotic.

Less than 20 dipteran species in Switzerland are of alien origin. Some are agricultural or horticultural pests. The Nearctic agromyzids *Liriomyza huidobrensis* and *L. trifolii* are pests of vegetables, mainly in greenhouses but occasionally found outdoors. Another agromyzid fly, *Napomyza gymnostoma*, was recently found in Switzerland (Eder and Bauer, 2003). *N. gymnostoma*, previously known as a harmless insect from some European countries, but not Switzerland, mysteriously became a serious pest of onions and leeks one or two decades ago in several Central and western European countries. Its origin is not known, although it may be a virulent ecotype of a European species that unexpectedly adapted itself to agricultural systems and crops. Its sudden pest status and spread may also be due to changes in pest control methods in leek and onion crops, or to global warming.

Two of the world's most serious fruit flies (Tephritidae), the olive fly *Bactrocera oleae* and the Mediterranean fruit fly, *Ceratitis capitata*, both originating from the Mediterranean region, are also established in Switzerland, where they have reached their climatic limit and, thus, cause little damage. Two North American tephritids have recently invaded the country. *Rhagoletis completa* feeds on walnut and is considered a pest in its native region. It was discovered in the Ticino in 1991 (Merz, 1991) and, since then, has spread rapidly to many regions north of the Alps (see Fact Sheet). Populations are increasing and severe damage has been observed in Switzerland and Italy. Another American species, *R. cingulata*, was found at the same time, in cherries (Merz, 1991, as *R. indifferens*). Until now, populations have remained very low and it does not seem to spread as quickly as *R. completa*.

The North American Drosophilidae *Chymomyza amoena* attacks various fruits of broadleaved trees, such as apple, walnut, plum, acorn, etc. It is present in high numbers in both urban and forest environments. Its spread and ecology in Switzerland have been studied in detail (e.g. Burla and Baechli, 1992; Band, 1995; Band et al., 1998, 1999). Another drosophilid, *Drosophila curvispina*, originating from east Asia, is present in the Ticino, Vaud and Valais (Bächli et al., 2002; Bächli, pers. comm.).

Other alien Diptera occurring in Switzerland are saprophagous or coprophagous. These species are often of cosmopolitan distribution. The calliphorid *Chrysomya albiceps* and the muscid *Hydrotaea aenescens* are found on human cadavers and other decaying matters. The black soldier fly, *Hermetia illucens* (Stratiomyidae), was found in very high numbers in composted plants in the Ticino (Sauter, 1989). In North America, this very common species is often associated with poultry houses and other farming or animal-rearing activities. Only one milichiid, *Desmometopa varipalpis*, is mentioned in our list as clearly exotic. However, the Milichiidae are small, often cosmopolitan and poorly known insects, and it is possible that other milichiid members of the Swiss fauna are also of exotic origin (B. Merz, pers. comm.)

Exotic mosquitos (Culicidae) represent a major threat to human health worldwide. The tiger mosquito, *Aedes albopictus*, was found in Switzerland for the first time in the Ticino in 2003 (see Fact Sheet). Besides causing human nuisance through its bites, *A. albopticus* is also a potential vector of various illnesses. In Asia, its region of origin, it is a natural vector of dengue fever and other arboviruses, as well as filaria for both human and domestic animals. In North America, it is a vector of the West Nile virus.

Hemiptera

(Advisors: Daniel Burckhardt, Naturhistorisches Museum Basel (Psyllina); Gerolf Lampel, Pensier, and Yves Gonseth, Centre Suisse de Cartographie de la Faune, Neuchâtel (Aphidina); Ralf Heckmann, Konstanz, Germany (Heteroptera))

This order probably encompasses the highest number of exotic pests worldwide. Small Hemiptera, particularly aphids, scales, whiteflies and psyllids, are very easily carried around the globe on plant material. Many are pests of worldwide distribution and it is sometimes difficult to assess their region of origin. Among the cosmopolitan species of doubtful origin and listed as exotic in Switzerland, for example, are the aphids *Myzus persicae*, *Aphis gossypii* and *Cinara cupressi*, the whitefly *Bemisia tabaci*, and the scales *Dynaspidiotus britannicus*, *Quadraspidiotus pyri* and *Planococcus citri*. Many other cosmopolitan species are not included in this list because they are supposed to be of European origin (e.g. the aphids *Acyrthosiphon pisum*, *Brevicoryne brassicae* and *Rhopalosiphum padi*), although their origin is unclear and the possibility that they entered Switzerland a long time ago cannot be ruled out.

Another problem, particularly prevalent in Hemiptera, is the high number of tropical or subtropical pest species introduced into greenhouses with their host plants. The most abundant species have been included in the list because there is no doubt that they have become established in Switzerland in indoor conditions. For example, the aphid *Aphis gossypii*, the whiteflies *Bemisia tabaci* and *Trialeurodes vaporarium* and the scale *Planococcus citri* are recurrent problems in protected crops and plants in Switzerland. Many other tropical and subtropical species are occasionally reported from greenhouses and indoor plants, but it is difficult to say whether their presence results from a permanent establishment or from regular introductions. In addition to those species included in our list, Kozar et al. (1994) mentions several species of scale insects that have been recovered from greenhouses and indoor plants in Switzerland. Interestingly, three of these scale species previously known only from greenhouses (*Diaspidiotus distinctus*, *Coccus hesperidum* and *Icerya purchasi*) are now found established in the field (Kozar et al., 1994). Other 'greenhouse' Hemiptera of exotic origin and not mentioned in our list are bug species of the genera *Orius* and *Xylocoris* (Anthocoridae), commonly used as biological control agents against thrips, spider mites or aphids.

Many hemipteran species in Switzerland have migrated from neighbouring countries, especially the Mediterranean region. In most cases these have probably been introduced with their host plant. For example, most Psyllidae and Triozidae, included in the list feed specifically on plants of Mediterranean origin which are used in Switzerland as ornamentals. However, other southern European species may have entered Switzerland independently. In particular, four true bugs, the lygaeids *Arocatus longiceps*, *Orsillus depressus* and *Oxycarenus lavaterae*, and the mirid *Deraeocoris flavilinea* are clearly expanding their range from southern to Central Europe (e.g. Adlbauer and Rabitsch, 2000; Rabitsch, 2002). Whether the spread is purely natural or not remains unclear.

Most of the known exotic Hemiptera included in the list are recognized as pests, feeding on crops, ornamentals and forest trees in Switzerland. It is likely that many other exotic Hemiptera remain undetected because they feed on non-commercial plants. Among aphids, one of the best-known cases of exotic pests in Europe is the grape phylloxera, *Viteus vitifoliae* which invaded Europe from North America in the 19th century, causing serious damage to vineyards and endangering the European wine industry. The problem was solved by grafting European cultivars on less susceptible American rootstocks; however, the level of damage has increased again in recent years, including in Switzerland. Other aphid species, such as *Myzus persicae*, *Macrosiphum euphorbiae* and *Aphis gossypii,* attack a wide range of vegetable crops, both indoors and outdoors. They are also vectors of serious viral diseases. The Russian wheat aphid, *Diuraphis noxia* (Kurdjumov), a serious pest of cereals, has not yet been reported from Switzerland, but has already invaded France, Italy and Austria (CABI, 2001; Lethmayer and Rabitsch, 2002). Orchard trees in Switzerland, in particular apple trees, can be severely damaged by the North American woolly aphid *Eriosoma lanigerum* and the Asian *Aphis spiraecola*. In forestry, the most serious exotic aphid is certainly the woolly aphid *Dreyfusia nordmannianae*, a pest of firs (*Abies*) of Caucasian origin, but other species such as *Gilletteella cooleyi* on *Pseudotsuga* and *Elatobium abietinum* on *Picea,* both from North America, may cause some concern to foresters.

Only two exotic whitefly species (Aleyrodidae) are known to occur in Switzerland, *Bemisia tabaci* and *Trialeurodes vaporarium*, but these are among the main pests of vegetables in greenhouses. Control is achieved using aphelinid parasitoids in the genera *Encarsia* and *Eretmocerus*.

A number of exotic scale insects are also known as pests in Switzerland, particularly on orchard and ornamental trees. The San José scale, *Quadraspidiotus perniciosus*, is an Asian species that has invaded nearly all continents, including Europe, where it is still expanding its range. It is already distributed in most parts of Switzerland, where it causes serious damage to orchards, particularly apple, peach and plum (see Fact Sheet). Another congeneric species, *Q. pyri*, also attacks fruit trees, but its origin remains uncertain, and it may be indigenous. In recent years, serious damage by scale insects has been observed on urban trees. The diaspidid *Pseudaulacaspis pentagona*, an insect of Asian origin and known to be polyphagous attacking mainly mulberry and peach trees, has caused severe damage to ornamental trees such as *Sophora*, *Aesculus* and *Catalpa* in Swiss cities (Mani et al., 1997). Similarly, the coccid *Pulvinaria regalis* (see Fact Sheet) is a polyphagous exotic species of uncertain origin that has recently caused heavy damage to *Tilia* and *Aesculus* in Zürich (Hippe and Frey, 1999).

Only seven species of Auchenorrhyncha are listed as exotic in Switzerland. However, some of them are of economic importance. *Metcalfa pruinosa*, a flatid planthopper of American origin, has recently invaded the Ticino through Italy (see Fact Sheet). This polyphagous species is found on many trees and shrubs, but also on crops such as soyabean. It can be particularly harmful to fruits such as grape, pear, apple, citrus and peach. It is expected that *M. pruinosa* will expand its distribution to most of Switzerland. Another North American species, the vine leafhopper *Scaphoideus titatus*, recently entered Switzerland. It does not cause direct damage to vine, but it transmits a severe mycoplasma disease, the 'flavescence dorée' (Günthart, 1987). Two other North American species are present in Switzerland, the cicadellid leafhopper *Graphocephala fennahi* on *Rhododendron*, and the membracid treehopper *Stictocephala bisonia*, a polyphagous species found mainly in orchards, but neither of them causes serious damage.

The only heteropteran bugs of non-European origin known to occur in Switzerland are the two North American lace bugs *Corythucha ciliata* and *Corythucha arcuata*. *C. ciliata* is a serious pest of *Platanus* in urban areas in Europe. Heavy infestations cause discolouration of leaves and premature leaf fall. It was first observed in Switzerland in 1983 and its distribution now covers most of western Switzerland (see Fact Sheet). *Corythucha arcuata* is a similar species, feeding on oak. It was first found in Italy in 2000 and in 2003 in Switzerland (Ticino) (see Fact Sheet). Similarly, another American bug, the coreid *Leptoglossus occidentalis* Heidemann, has recently been found in high numbers in northern Italy. It feeds on various conifer seeds and is considered a serious pest in seed orchards in North America (Villa et al., 2001).

Orthoptera

(Advisor, Hannes Bauer, Naturhistorisches Museum, Bern)

The Orthoptera of Switzerland and their distributions are listed in Thorens and Nadig (1997). Only two species established in the country are clearly exotic. The house cricket *Acheta domesticus* is a cosmopolitan species, probably of North African origin. In Central Europe, it lives mainly in buildings, although in summer it is also commonly found outdoors, particularly in the Valais. The house cricket is omnivorous, feeding mainly on refuse and, occasionally, on stored products.

The greenhouse camel cricket, *Tachycines asynomorus*, probably originates from east Asia, but is now found worldwide. It was introduced into Europe in the 19^{th} century. In Switzerland, it lives mainly in greenhouses, where it feeds on fruits, seedlings and insects. It is also occasionally found outdoors, e.g. in botanical gardens.

Some Mediterranean species such as the Egyptian grasshopper *Anacridium aegyptium* (L.) are occasionally caught in Switzerland. Specimens found in the Ticino may have migrated from the South, however, it seems that at least some catches in various regions may be related to the importation of food products. (Nadig and Thorens, 1991; Rezbanyai-Reser, 1993).

Dictyoptera

At least five exotic cockroach species are known to be established in Switzerland. Others may be introduced occasionally with imported goods. Unlike the native cockroaches, the exotic species are synanthropic, i.e. they are always found in association with humans. These cockroaches are of tropical and subtropical origin but they now occur worldwide. Some species, such as *Blatta orientalis* and *Periplaneta americana*, have been cosmopolitan for such a long time that their origin is uncertain. *B. orientalis*, *P. americana*, *P. australasiae* and *B. germanica* have been established in Switzerland for a long time, whereas *Supella longipalpa* is a recent introduction.

All these species are considered as serious urban pests. They are gregarious, nocturnal, and difficult to eradicate in houses. They can eat almost anything, e.g. human food and animal feed, bookbindings, wallpaper, excrement, leather products, etc. They can carry organisms causing human diseases, have a repulsive odour, and can cause allergic reaction and anxiety in some individuals. In Switzerland, the most problematic species are *B. germanica*, *S. longipalpa* and *B. orientalis*, whereas *Periplaneta* spp. are of minor importance (Landau et al., 1999).

Isoptera

There is no record of establishment of exotic termites in Switzerland. However, in recent years, subterranean termites of the genus *Reticulitermes* have invaded new areas (see Fact Sheet). The North American *R. flavipes* (Kollar) is introduced in some German and Austrian cities. The southern European *R. grassei* Clément occurs now in southern England and *R. santonensis* de Feytaud, a species of uncertain origin (and perhaps synonymous with *R. flavipes*) has spread from south-western to northern France. These termites undoubtedly have the potential to invade the warmest areas in Switzerland. They live in colonies in the soil, mainly in urban areas. They are particularly harmful to wooden elements in building but can also attack living trees. The spread of subterranean termites in France is causing major concern. New regulations have been set up to limit the spread.

Thysanoptera

Many exotic thrips species are found, regularly or occasionally, in Switzerland in greenhouses. However, it is not always clear whether they are firmly established in the country. At least four species are considered permanently established, mainly in greenhouses. Three of them, *Frankliniella intonsa*, *F. occidentalis* and *Heliothrips haemorrhoidalis* are polyphagous, cosmopolitan pests on ornamentals, vegetables, and fruits. *F. occidentalis*, the western flower thrips, is among the most destructive greenhouse pests in Switzerland (Ebener et al., 1989; Schmidt and Frey, 1995). It is also a vector of various viruses. The pest status of *F. occidentalis* is relatively recent. It occurs naturally in North America on wild flowers and emerged as a greenhouse pest in the Netherlands in 1983. Since then, it has spread all around the world (CABI, 2001). In Switzerland, *F. intonsa* is particularly associated with strawberry crops (Linder et al., 1998).

The gladiolus thrips, *Thrips simplex*, originates from South Africa and was introduced in many regions with gladiolus corms. It reproduces only on gladiolus corms and leaves but adults are found on many other plants (CABI, 2001). In Switzerland, it does not survive outdoors.

Psocoptera

(Advisor: Yves Gonseth, Centre Suisse de Cartographie de la Faune, Neuchâtel)

Psocoptera, or psocids, are rather poorly known insects. Most species live in woodlands, but some are domestic, i.e. they inhabit houses, warehouses, etc., feeding on organic matter. The domestic species can become a nuisance, although they rarely cause economic damage. Partial European and Swiss lists of Psocoptera exist, but the origin of the species is often unclear. Lienhard (1994) lists 29 species that are totally, essentially or occasionally domestic in Switzerland. Most of them are not, or very rarely, found in the field, suggesting that they are not indigenous. We have included in our list the species that Lienhard (1994) mentions as exclusively or essentially domestic in Switzerland, keeping in mind that some of them might be indigenous but poorly known in their natural habitat.

Three species of the genus *Dorypteryx* are most likely of exotic origin. Their spread in Europe is illustrated in Lienhard (1994). *D. domestica*, described from Zimbabwe in 1958, was first found in Switzerland in 1973. From there, it has spread rapidly to most European countries where it has become one of the most frequent domestic species. *D. longipennis*, a species of unknown origin, was first found in Luxembourg in 1988. It reached Switzerland in 1992 and is now spreading very rapidly. *D. pallida* is an older introduction. It was first described from North America, and found in Germany in 1890. Its spread seems to be slower than that of the other two species. Other species that are most probably exotic include *Liposcelis mendax*, *Ectopsocus pumilis* and *E. richardsi*, which have been found associated with an importation of dry mushrooms from Asia. Whether these rare species are established in Switzerland is unclear. Other species are found outdoors in the Mediterranean regions but only indoors in Switzerland, e.g. *Trogium pulsatorium* and *Ectopsocus vachoni*.

Ectoparasites

Ectoparasitic insects of vertebrates include mainly Siphonaptera (fleas – on birds and mammals), Anoplura (sucking lice – on mammals) and Mallophaga (biting lice – on birds and mammals). Undoubtedly, several of the ectoparasites present in Switzerland are allochtonous, having arrived in the region with their hosts. However, these insects are rather poorly studied, particularly in Switzerland, and their origin is often unclear. In their work on the Siphonaptera of France and the western Mediterranean region, Beaucournu and Launay (1990) provided data for Switzerland. At least two fleas appear to be definitely exotic in the country. The cat flea, *Ctenocephalides felis felis,* has a cosmopolitan distribution but is probably not of European origin (Beaucournu and Launay, 1990). The rabbit flea, *Spilopsylus cuniculi,* is a vector of myxomatosis and probably originates, like its host, from the Iberian Peninsula, while the disease was introduced into Europe from South America. Some other fleas present in Switzerland are of doubtful origin and are not included in the list. For example, the human flea *Pulex irritans* L., which feeds on many carnivores, is now cosmopolitan but belongs to a Nearctic genus. However, its arrival in Europe was probably in the distant past. Büttiker and Mahnert (1978) listed 25 Anoplura for Switzerland. Only one, *Haemodipsus ventricosus*, is very likely to be of exotic origin because it seems to be restricted to rabbits. Sucking lice of doubtful origin include the cosmopolitan rat louse, *Polyplax spinulosa* (Burmeister), and the dog sucking louse, *Linognathus setosus* (v. Olfers). There is no recent list of Mallophaga for Switzerland. Mey (1988) provides a list of mammalian Mallophaga in Europe, but data for Switzerland are scarce. Three South American species, *Gyropus ovalis* Burmeister, *Gliricola porcelli* (Schrank) and *Trimenopon hispidum* (Burmeister), are found on guinea pigs in neighbouring countries and, thus, are probably present in Switzerland. Similarly, it is possible that the Nearctic *Trichodectes octomaculatus* Paine and *Pitrufquenia coypus* Marelli, parasites on raccoons and coypus, respectively, in Central Europe, are present in Switzerland with their host.

References

Adlbauer, K. and W. Rabitsch (2000) *Orsillus depressus* (Mulsant & Rey 1952) in Österreich und Liechtenstein (Het., Lygaeidae). Heteropteron 8, 19-22.

Bächli, G., Vilela, C.R. and F. Haring (2002) Four new species of West Palaearctic Drosophilidae (Diptera). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 75, 299-333.

Band, H.T. (1995) Is *Chymomyza amoena* (Loew) (Diptera: Drosophilidae) a versatile, colonizing species? Mitteilungen der Schweizerischen Entomologischen Gesellschaft 68, 23-33.

Band, H., Bächli, G. and R.N. Band (1999) Nearctic *Chymomyza amoena* (Loew) (Diptera: Drosophilidae) remains a domestic species in Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 72, 75-82.

Band, H., Band, R. N. and G. Bächli (1998) Further studies on Nearctic *Chymomyza amoena* (Loew) (Diptera, Drosophilidae) in Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 71, 395-405.

Barbalat, S. and B. Wermelinger (1996) Première capture *d'Agrilus guerini* Lac. (Col. Buprestidae) en Suisse. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 69, 201-202.

Barbey, S. (1996) La protection phytosanitaire des conifères et arbustes d'ornement. Revue Horticole Suisse 69, 120-122.

Beaucournu, J.-C. and Launay, H. (1990) Les puces (Sipohnaptera) de France et du Bassin méditerranéan occidental. Faune de France 76.

Blattner, S. (1959) *Sedina buettneri* Hering, neu für die Schweiz. Mitteilungen der Entomologischen Gesellschaft Basel 9, 107-109.

Bonavia, M. and M. Jermini (1998) La cicadelle *Metcalfa pruinosa* Say au Tessin. Distribution actuelle, dynamique des populations et perspective de lutte. Revue Suisse de Viticulture, Arboriculure et Horticulture 30, 169-172.

Bosio, G. (2004) Pericolo cinese per il castagno italiano. Informatore Agrario 60, 71-72.

Burckhardt, D. and J. Freuler (2000) Jumping plant-lice (Hemiptera, Psylloidea) from sticky traps in carrot fields in Valais, Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 73, 191-209.

Burla, H. and G. Bächli (1992) *Chymomyza amoena* (Diptera: Drosophilidae) reared from chestnuts, acorns and fruit collected in the Canton Ticino, Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 65, 25-32.

Büttiker, W. and Mahnert, V. (1978) Vorläufige Liste der Anoplura (Insecta der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 51, 299-306

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Dorn, K., Landau, I. and D. Cherix (1997) Einschleppung von *Tapinoma melanocephalum* (Formicidae) in der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 70, 242-243.

Ebener, T., Freuler, J. and G. Meylan (1989) *Frankliniella occidentalis* Pergande: 'le cas en Suisse romande'. Revue Horticole Suisse 62, 326-343.

Eder, R. and R. Bauer (2003) La mouche mineuse du poireau est arrivée en Suisse. Der Gemüsebau/le Maraîcher 7/2003, 24-25.

Essl, F. and W. Rabitsch (eds) (2002) *Neobiota in Österreich.* Umweltbundesamt, Wien.

Fischer, S. (1993) Les mineuses (Lepidoptera, Yponomeutidae), insectes ravageurs des Cupressacees d'ornement en Suisse. Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 25, 383-387.

Forster, B. (2002) Auswirkungen eingewanderter oder eingeschleppter Insekten auf die Wald- und Parkbäume der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 75, 135-136

Fowler, S.V. (2004) Biological control of an exotic scale, *Orthezia insignis* Browne (Homoptera: Ortheziidae), saves the endemic gumwood tree *Commidendrum robustum* (Roxb.) DC. (Asteraceae) on the island of St. Helena. Biological Control 29, 367-374.

Freitag A., Dorn, K. and D. Cherix (2000) First occurrence of the crazy ant *Paratrechina longicornis* (Latreille) (Hym., Formicidae: Formicinae) in Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 73, 301-303.

Geiter, O., Homma, S. and R. Kinzelbach (2002) Bestandsaufnahme und Bewertung von Noezoen in Deutschland. Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit. Forschungsbericht 296 89 901/'1 UBA-FB 000215.

Giacalone, I. and G. Lampel (1996) Pucerons (Homoptera, Aphidina) de la région insubrique tessinoise d'origine subméditerranéenne, méditerranéenne, est-européenne, asiatique et américaine. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 69, 229-260.

Giacalone, I., Dioli, P. and N. Patocchi (2002) Monitoraggi faunistici alle Bolle di Magadino (Svizzera meridionale) Eterotteri acquatici e terrestri (Insecta, Heteroptera: Gerromorpha, Nepomorpha e Geocorisae). Bollettino della Società Ticinese di Scienze Naturali 90, 81-92.

Gómez, C. and J. Oliveras (2003) Can the Argentine ant (*Linepithema humile* Mayr) replace native ants in myrmecorchory? Acta Oecologica 24, 47-53.

Greathead, D.J. (ed) (1976) A review of biological control in western and southern Europe. Commonwealth Institute of Biological Control. Technical Communication No 7.

Grimm, K. (1986): Neu für die Schweiz: Sclerocona acutellus EV. - Mitteilungen der Entomologischen Gesellschaft Basel 36, 171-172

Günthart, H. (1987) Für die Schweiz neue und wenig gesammelte Zikaden-Arten (Hom., Auchenorrhyncha). 2. Ergänzung. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 60, 83-105.

Günthart, H., R. Mühlethaler and P. Lauterer (2004) Für die Schweiz neue Zikadenarten und Ergänzungen zu bereits bekannten Arten (Hemiptera Auchenorrhyncha). Mitteilungen der Entomologischen Gesellschaft Basel 54, 150-160.

Günther, H. and G. Schuster (1990) Checklist of the bugs of central Europe (Heteroptera). Deutsche Entomologische Zeitschrift 37, 361-396.

Hächler, M., Jermini, M. and R. Brunetti (1998) Deux nouvelles noctuelles, ravageurs des cultures de tomate sous abri au Tessin et en Suisse romande. Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 30, 281-285

Hättenschwiler, P. (2000) *Typhonia beatricis* sp. n., eine möglicherweise aus dem östlichen Mittelmeerraum eingeschleppte Psychide (Lepidoptera, Psychidae) - Mitteilungen der Entomologischen Gesellschaft Basel 50, 2-17.

Eichhorn, O. (1967) On methods of differentiating the species of the harmful white woolly aphids (Genus *Dreyfusia* CB. = *Adelges* AN.) on fir, and the consequences for forest protection Technical Bulletin of the Commonwealth Institute of Biological Control 8, 53-82.

Hippe, C. and J.E. Frey (1999) Biology of the horse chestnut scale, *Pulvinaria regalis* Canard (Hemiptera: Coccoidea: Coccidae), in Switzerland. Entomologica 33, 305-309.

Hirschheydt, J.V. (1992) Der Amerikanische Nutzholzborkenkäfer *Gnathotrichus materiarius* (Fitch) hat die Schweiz erreicht. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 65, 33-37.

Höhn, H., Höpli, H., Graf, B., Meier, J. and H. Kull (2003) Die grüne Zitrusblattlaus - auch im Schweizer Obstbau. Obst- und Weinbau 139, 9-11.

Hoppe, T. (1981) Vorratsschädlinge in der Schweiz: Vorkommen und Resistenz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 54, 3-13.

Jenkins, J.C., Aber, J.D. and C.D. Canham (1999) Hemlock woolly adelgid impacts on community structure and N cycling rates in eastern hemlock forests. Canadian Journal of Forest Research 29, 630-645.

Jermini, M., Bonavia, M., Brunetti, R., Mauri, G. and V. Cavalli (1995) *Metcalfa pruinosa* Say, *Hyphantria cunea* (Drury) et *Dichelomyia oenophila* Haimah, trois curiosités entomologiques ou trois nouveaux problèmes phytosanitaires pour le Tessin et la Suisse? Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 27, 57-63.

Jermini, M., Brunetti, R. and M. Bonavia (2000) Introduzione di *Neodryinus typhlocybae* per il contenimento biologico di *Metcalfa pruinosa*: Prime esperienze in Svizzera. Sherwood - Foreste ed Alberi Oggi, Supplemento 55, 18-20.

Kenis, M. and B. Forster (1998) Die Rosskastanien-Miniermotte: neu in der Schweiz. Der Gartenbau 39, 16-17.

Karsholt O. and J. Razowski (1996) *The Lepidoptera of Europe: a distributional checklist*. Stenstrup, Denmark: Apollo Books.

Klausnitzer, B. (2004) Harmonia axyridis (Pallas, 1773) in Basel-Stadt (Coleoptera, Coccinellidae). Mitteilungen der Entomologischen Gesellschaft Basel 54, 115-122.

Kosztarab, M. and F. Kozár (1988) *Scale insects of Central Europe*. Budapest, Hungary: Akadémiai Kiadó.

Kozar F., Guignard, E., Bachmann, F., Mani, E. and C. Hippe (1994) The scale insect and whitefly species of Switzerland (Homoptera: Coccoidea and Aleyroidea). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 67, 151-161.

Kutter, H. (1981) *Iridomyrmex humilis* (Hym., Formicidae), Gattung und Art neu für die Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 54, 171-172.

Lampel, G. (1974) Für die Schweiz neue Blattlaus-Arten (Homoptera, Aphidina) I Mitteilungen der Schweizerischen Entomologischen Gesellschaft 47, 273-306.

Lampel,. G. and W. Meier (2003) Hemiptera: Sternorrhyncha - Aphidina Volume 1. Fauna Helvetica 8.

Lienhard, C. (1994) Staubläuse (Psocoptera) - ungebetene Gäste in Haus und Vorrat. Mitteilungen der Entomologischen Gesellschaft Basel 44, 122-160

Linder, C., Antonin, P., Mittaz, C. and R. Terrettaz (1998) Les thrips des fraisiers en Suisse romande. Especes, dynamique des populations, nuisibilite. Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 30, 161-166.

Liston, A.D. (1981) A provisional list of Swiss sawflies. Deutsche Entomologische Zeitschrift N.F. 28, 165-181.

Lethmayer, C. and W. Rabitsch (2002) Pflanzenläuse (Sternorrhyncha). In: Essl, F. & Rabitsch, W. (eds) *Neobiota in Österreich.* Umweltbundesamt, Wien, pp. 316-323.

Lucht, W.H. (1987) *Die Käfer Mitteleuropas. Katalog*. Goeke & Evers, Krefeld.

Mani, E. and C. Baroffio (1997) Biologische Bekämpfung der San-José- Schildlaus im Kanton Zug mit der Schlupfwespe *Encarsia perniciosi*. Schweizer Zeitschrift für Obst- und Weinbau 133, 392-394.

Mani E., Merz, B., Brunetti, R., Schaub, L., Jermini, M. and F. Schwaller (1994) Zum Auftreten der beiden amerikanischen Fruchtfliegenarten *Rhagoletis completa* Cresson und *Rhagoletis indifferens* Curran in der Schweiz (Diptera: Tephritidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 67, 177-182.

Mani E., Kozar, F., Schwaller F. and C. Hippe (1997) Auftreten und Biologie der Maulbeerschildlaus *Pseudaulacasois pentagona* (Targioni-Tozzetti) in der Schweiz (Homoptera: Diaspididae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 70, 399-408.

Mario, B., Jacques, D., Luigi C. and B. Roberto (2001) Update of monitoring data of *Diabrotica virgifera virgifera* in Switzerland in 2001. XXI IWGO Conference, VIII Diabrotica Subgroup Meeting, Legnaro – Padua – Venice – Italy, Oct. 27 – Nov. 3, 2001. Proceedings, pp. 169-173.

Meier, F., R. Engesser, R., B. Forster, B. and O. Odermatt (2004) Forstschutz-Überblick 2003. Report. Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, Birmensdorf. 22 pp

Meier, W. Ergänzungen zur Blattlausfauna der Schweiz I (Homoptera, Aphididae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 45, 1-30.

Meier, W. Ergänzungen zur Blattlausfauna der Schweiz II (Homoptera, Aphididae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 48, 405-435.

Merz, B. (1991) *Rhagoletis completa* Cresson und *Rhagoletis indifferens* Curran, zwei wirtschaftlich bedeutende nordamerikanische Fruchtfliegen, neu für Europa (Diptera: Tephritidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 64, 55-47.

Merz, B., Bächli, G., Haenni, J.-P. and Y. Gonseth (eds) (1998) Diptera. Checklist. Fauna Helvetica 1, 266-267.

Merz, B., Baechli, G. and J.P. Haenni (2001) Erster Nachtrag zur Checkliste der Diptera der Schweiz. 2001 Mitteilungen der Entomologischen Gesellschaft Basel 51, 110-140.

Mey, E. (1988) Uebersicht über die Säugtiere-Mallophagen Europas. Angewandte Parasitologie 29, 113-126

Nadig, A. and P. Thorens (1991) Liste faunistique commentée des Orthoptères de Suisse (Insecta, Orthoptera, Saltatoria). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 64, 281-291.

Neuenschwander, P. (1984) Erster Nachweis der Olivenfliege *Dacus oleae* (Gmel.) (Dipt. Tephritidae) in der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 57, 286

Neumeyer, R. and B. Seifert (2005) Kommentierte Liste der frei lebenden Ameisen (Hymenoptera: Formicidae) in der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 78, 1-17.

Noyes, J.S. (2001) Interactive catalogue of world Chalcidoidea 2001. CD-ROM Taxapad, Vancouver, Canada.

Prescher, S., Moretti, M. and P. Duelli (2002) Scuttle flies (Diptera, Phoridae) in *Castanea sativa* forests in the southern Alps (Ticino, Switzerland), with thirteen species new to Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 75, 289-298.

Pschorn-Walcher, H. and A. Taeger (1995) Blattwespen (Hymenoptera: Symphyta) aus Zeltfallen-Fängen im Kanton Jura. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 68, 373-385.

Rabitsch, W. (2002) *Deraeocoris flavilinea* (A. Costa, 1862) erstmals in Österreich festgestellt (Heteroptera, Miridae). Beiträge zur Entomofaunistik 3, 181-183.

Rezbanyai-Reser, L. (1983) Über *Caradrina*-Arten, insbesondere über *C. ingrata* Staudinger, 1897, eine für die Schweiz und für Mitteleuropa neue mediterrane Art (Lep., Noctuidae). Entomologische Berichte Luzern 10, 99-109.

Rezbanyai-Reser, L. (1984) Ueber *Heliothis armigera* Hbn. ihr Wanderflugjahr 1983, sowie Angaben über ihr Erscheinen in der Schweiz in früheren Jahren (Lep. Noctuidae). Mitteilungen der Entomologischen Gesellschaft Basel 34, 71-91.

Rezbanyai-Reser, L. (1991) *Hyphantria cunea* Drury, 1773, und *Noctua tirrenica* Biebinger, Speidel & Hanigk, 1983, im Südtessin, neu für die Schweiz (Lep.: Arctiidae, Noctuidae). Entomologische Berichte Luzern 26, 94-96, 135-152.

Rezbanyai-Reser, L. (1993) Erneut ein Heuschrecken-Fremdling, die Aegyptische Knarrschrecke, *Anacridium aegyptium*, bei Luzern, Zentralschweiz, gefunden (Saltatoria). Entomologische Berichte Luzern 29, 67-68.

Rezbanyai-Reser, L. (2000) Zur Nachtgrossfalterfauna der Magadino-Ebene, 196-210m, Kanton Tessin, 1980-1995 (Lepidoptera: "Macroheterocera"). Entomologische Berichte Luzern 43, 17-179.

Rezbanyai-Reser, L., Schäffer, E. and M. Hächler (1997) *Platyperigea ingrata* (Staudinger, 1897) zum ersten Mal in der Zentralschweiz, sowie weitere Fundangaben aus der Südwestschweiz (Lepidoptera: Noctuidae). Mitteilungen der Entomologischen Gesellschaft Basel 47, 2-8.

Rezbanyai-Reser, L., Blöchlinger, H., Hoppe, H., Schäffer, E. and J. Schmid (1998) Zur Weiterverbreitung von *Eupithecia sinuosaria* (Eversmann, 1848) in der Schweiz (Lepidoptera, Geometridae). Atalanta 28, 309-314.

Rognes K. (1997) Additions to the Swiss fauna of blowflies with an analysis of the systematic position of *Calliphora stylifera* (Pokorny, 1889) including a description of the female (Diptera, Calliphoridae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 70, 63-76.

Roques, A. and M. Skrzypczynska (2003) Seed-infesting chalcids of the genus *Megastigmus* Dalman, 1820 (Hymenoptera: Torymidae) native and introduced to the West Palearctic region: taxonomy, host specificity and distribution. Journal of Natural History 37, 127-238.

Sauter, W. (1983) Die Schmetterlinge der Schweiz. 8. Nachtrag : Microlepidopteren. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 56, 107-124.

Sauter, W. (1989) Interessante neue Insektenfunde aus der Schweiz (Dipt., Lep.) Mitteilungen der Schweizerischen Entomologischen Gesellschaft 62, 147-149.

Schaefer, H.A. (1949) Beiträge zur Kenntnis der Psylliden der Schweiz. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 22, 1-96.

Schmidt, M.E. and J.E. Frey (1995) Monitoring of the western flower thrips *Frankliniella occidentalis* in greenhouses. Mededelingen Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, Universiteit Gent 60, 847-850.

Schwenke, W. (ed) (1972) *Die Forstschädlinge Europas, I. Band. Würmer, Schnecken, Spinnentier, Tausendfüssler und Hemimetabole Insecten.* Paul Parey, Hamburg and Berlin.

Schwenke, W. (ed) (1982) *Die Forstschädlinge Europas, 4. Band. Hautflüger und Zweiflüger.* Paul Parey, Hamburg and Berlin.

Seifert, B. (2000) Rapid range expansion in *Lasius neglectus* (Hymenoptera: Formicidae) – an Asian invader swamps Europe. Mitteilungen aus dem Museum für Naturkunde in Berlin. Deutsche Entomologische Zeitschrift 47, 173-179.

Seifert, B. (2004) *Hypoponera punctatissima* (Roger) and *H. schauinslandi* (Emery) – tow morphologically and biologically distinct species (Hymenoptera: Formicidae). Abhandlungen und Berichte des Naturkundemuseums Görlitz 75, 61-81.

Skuhrava, M. and V. Skuhravy (1997) Gall midges (Diptera: Cecidomyiidae) of Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 70, 133-176.

Stary, P. (1995) Natural enemy spectrum of *Aphis spiraephaga* (Hom., Aphididae), an exotic immigrant aphid in Central Europe. Entomophaga 40, 29-34.

Thorens, P. and A. Nadig (1997) *Atlas de distribution des orthopteres de Suisse: sauterelles, grillons, criquets (Orthoptera), mante religieuse (Mantodea).* Centre Suisse de Cartographie de la Faune, Neuchâtel.

Vernier, R. (1995) *Isodontia mexicana* (Sauss.), un Sphecini américain naturalisé en Suisse (Hymenoptera, Sphecidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 68, 169-177.

Vernier, R. (2000) *Isodontia mexicana* (Sauss.) (Hymenoptera, Sphecidae) est apparu dans le Bassin lémanique. Bulletin Roman d'Entomologie 18, 143-145.

Villa, M., Tescari, G. and S.J. Taylor (2001) Nuovi dati sulla presenza in Italia di *Leptoglossus occidentalis* (Heteroptera Coreidae). Bolletino della Societa Entomologica Italiana 133, 103-112.

Watson, G.W., Voegtlin, D.J. Murphy, S.T. and R.G. Foottit (1999) Biogeography of the *Cinara cupressi* complex (Hemiptera: Aphididae) on Cupressaceae, with description of a pest species introduced into Africa. Bulletin of Entomological Research 89, 271-283.

Whitebread, S. (1997) *Platyperigea ingrata* (Staudinger, 1897): Die Raupe als unerwünschter Gast im Hause (Lepidoptera: Noctuidae). Mitteilungen der Entomologischen Gesellschaft Basel 47, 9-11.

Fact Sheets

Aedes albopictus

Taxonomic status

Scientific name	*Aedes albopictus* (Skuse)
Synonyms	
Taxonomic position	Diptera: Culicidae
English name	Asian tiger mosquito
German name	Tigermücke
French name	Moustique tigre
Italian name	Zanzara tigre

Description and identification

Description	The adult is covered with shiny black scales with distinct silver-white bands on the palpus and tarsi. Its most distinctive characteristic is the band of silver scales forming a discrete stripe on the dorsal surface of the thorax and head.
Similar species	Many native *Aedes* species occur in Switzerland.

Biology and ecology

Life cycle	*A. albopictus* is a multivoltine species. In temperate countries, it overwinters as diapausing eggs, which are laid at the surface of water, mainly in artificial containers (tyres, cups, buckets, etc.). Larval and pupal development in water last 5-10 days and 2-3 days, respectively.
Habitat	Immature stages are found in water in artificial and natural containers.

Origin Probably South-east Asia.

Introduction and dispersal

History of introduction	*A. albopictus* has been recently introduced into North and South America, Nigeria, Australia, the Pacific Islands, Albania and Italy, where it was first found in Genoa in 1990. In Switzerland, it was observed for the first time in southern Ticino in August 2003.
Pathways of introduction	It is supposed that *A. albopictus* was introduced into Europe and North America in used tyres containing eggs and larvae in rainwater.
Dispersal	*A. albopictus* adults are not strong flyers. Thus, the main mode of dispersal is probably through the transportation of larvae and eggs in water-filled tyres, containers, etc.

Current status

Actual and potential distribution in CH	Its distribution in Switzerland is probably still restricted to southern Ticino. Most of Switzerland may be too cold for *A.albopictus*, but warm areas such as the Ticino and the Lac de Genève are more at risk.
Distribution in Europe	It is established in Italy and Albania. It was also recently observed in other European countries such as France and Belgium but its establishment there is not confirmed.

Impacts

Environmental impact	In North America, it has been shown that *A. albopictus* is able to displace other species, but similar studies have not been carried out in Europe yet (Rohdain, 1996). It is also a potential disease vector for wild and domestic vertebrates.
Economic impact	In Europe*, A. albopictus* is mainly a human nuisance through its

aggressive daytime biting behaviour. In South-east Asia, it is a natural vector of dengue fever and other arboviruses, as well as filaria affecting both humans and domestic animals. In North America, it is a recognized vector of the West Nile virus disease. In Europe, the mosquito could become a vector for transmission to humans and animals of various indigenous and exotic diseases such as *Dirofilaria* and arboviruses (Mitchell, 1995; Guillet and Nathan, 1999).

Management options

The easiest and safest control strategy is to remove potential mosquito breeding habitats (i.e. all containers that may accumulate rainwater) during the mosquito breeding season. Insecticides are used in other parts of the world where *A. albopictus* transmits severe illnesses, but their use is not yet justified in Europe.

Information gaps

The potential distribution of the mosquito and its role and threat as a disease vector in Europe are unclear.

References

Literature

Guillet, P. and M. Nathan (1999) *Aedes albopictus*, une menace pour la France? Médecine Tropicale 59, 49-52.

Mitchell, C.J. (1995) Geographic spread of *Aedes albopictus* and potential for involvement in arbovirus cycles in the Mediterranean basin. Journal of Vector Ecology 20, 44-58.

Rodhain, F. (1996) Problèmes posés par l'expansion d'*Aedes albopictus*. Bulletin de la Société de Pathologie Exotique 89, 137-141.

Anoplophora glabripennis

Taxonomic status

Scientific name	*Anoplophora glabripennis* (Motschulsky)
Synonyms	
Taxonomic position	Coleoptera: Cerambycidae
English name	Asian long-horn beetle
German name	Asiatischer Laubholz-Bockkäfer
French name	Longicorne asiatique
Italian name	

Description and identification

Description	Adults are typical Cerambycidae, about 2.5 cm (male) to 3.5 cm (female) long. Antennae are 2.5 times the body length in males and 1.3 times in females, with 11 segments, each with a whitish-blue base. The adult is black with irregular white spots on the elytra. Larvae are of typical cerambycid shape, cream-white, up to 5 cm long when mature. Characteristic damage includes entry and exit wounds, sometimes with sap flowing out of the trunks and branches, and sawdust piled up at the bases of trees.
Similar species	There used to be some confusion in the taxonomy of this genus until the recent revisions by Lingafelter and Hoebeke (2002). Several *Anoplophora* spp. with uncertain taxonomic status occur in Asia, particularly in the *glabripennis* group. Other important pests such as *A. chinensis* (Forster) (= *malasiaca (Thomson)*) could be confused with *A. glabripennis*.

Biology and ecology

Life cycle	There can be one or two overlapping generations per year, depending on the climate and feeding conditions. Adults fly from May to October, with a peak of activity in June-July. They live for about 1 month, and females lay about 32 eggs, singly under the bark in oviposition slits chewed out by the female. Eggs hatch after about 2 weeks and the larvae feed first in the cambium, then in the sapwood, where they pupate (EPPO, 2003).
Host plant	*A. glabripennis* has a very wide host range. Many broadleaf genera are attacked. In China, its main hosts are *Populus* spp. and *Salix* spp., whereas in North America, it was mainly found on *Acer* spp. and *Aesculus hippocastanum* L. However, it can also attack and develop on *Alnus*, *Betula*, *Fraxinus*, *Malus*, *Morus*, *Platanus*, *Robinia*, *Rosa*, *Ulmus*, etc.
Habitat	Due to its wide host range, the beetle can invade urban, rural and forest landscapes.

Origin China, Korea

Introduction and dispersal

History of introduction	Introduced at various locations in North America in the last 8 years. Infestations were observed in Austria and France in 2001 and 2003, respectively (Cocquempot et al., 2003). In was also discovered in southern Germany in 2004.
Pathways of introduction	The beetle was probably introduced into Europe and North America as eggs, larvae or pupae in solid wood packing material, i.e. crating, pallets or packing blocks from China.
Dispersal	Adults spread slowly, about 300 m per year. Spread through

infested material transported by trade is more critical.

Current status

Actual and potential distribution in CH	Not yet observed in Switzerland. If introduced into Switzerland, *A. glabripennis* could probably spread to most regions and environments.
Distribution in Europe	It is not yet clear whether recently found populations in Austria and France have been eradicated (Krehan, 2002; Cocquempot et al., 2003). It is frequently intercepted during phytosanitary inspections in Europe (e.g. France, UK, Germany).

Impacts

Damage on plant	*A. glabripennis* can attack healthy as well as stressed trees. Several generations can develop on a single tree, which eventually dies.
Environmental impact	The environmental impact of the beetle has never been studied in China, where it is not mentioned as a serious pest in natural forests. However, in newly invaded regions, the damage on native trees is expected to be more significant than in its native range.
Economic impact	*A. glabripennis* is one of the most important forest pests in China, where the beetle has damaged about 45% of the poplar plantations. Over 50 million trees were felled [see below] between 1991 and 1993 in one province alone (Ningxia), resulting in losses of US$ 37 million. In the USA, suppressing a 1996 infestation in New York State cost more than US$ 4 milllion (EPPO, 2003) and, if established in North American hardwood forests, the US Department of Agriculture (USDA) predicts estimated annual losses of US$ 128 million.

Management options In China, identification and removal of infested trees remains the only widely used method. Other methods include the use of less susceptible hybrids, the direct application of insecticides, the use of trap trees or the use of insect-pathogenic nematodes. In North America and in Austria, where established populations have been detected, large eradication programmes have been carried out. In the USA, over 5,000 and 1,500 trees have been felled in New York and Chicago, respectively (Smith et al., 2002), and about 1,000 trees in Austria (Krehan, 2002). The result of these eradication programmes is still uncertain. Many biological control options are presently being studied (see Smith et al., 2002, for a review).

Information gaps The potential ecological impact of the beetle in a newly invaded region remains unclear. Biological control options still have to be studied.

References

Literature

Cocquempot, C., Prost and D. Carmignac (2003) Interceptions et introductions en France de longicornes asiatiques: cas des *Anoplophora glabripennis* (Motschulsky) et *chinensis* (Forster) (Coleoptera Cerambycidae). Bulletin Mensuel de la Société Linnéenne de Lyon 72, 273-278.

EPPO (2003) *Anoplophora glabripennis*. EPPO data sheets on Quarantine Pests http://www.eppo.org/QUARANTINE/Data_sheets/anolgl/dsanolgl.html

Krehan, H. (2002) Asian longhorned beetle in Austria: Critical comments on phytosanitary measures and regulations. In: S.L.C. Fosbroke and K.W. Gottschalk (eds), Proceedings US Department of Agriculture Interagency Research Forum on

Gypsy Moth and other Invasive Species. Annapolis, MD, pp. 5-6.

Lingafelter, S.W. and E.R. Hoebeke (2002) Revision of Anoplophora (Coleoptera: Cerambycidae). The Entomological Society of Washington, Washington, DC, 238 pp.

Smith, M.T., Z.Q. Yang, F. Hérard, R. Fuester, L. Bauer, L. Solter, M. Keena, and V. D'Amico (2002) Biological control of *Anoplophora glabripennis* (Motsch.): A synthesis of current research programs, In: S.L.C. Fosbroke and K.W. Gottschalk (eds), Proceedings US Department of Agriculture Interagency Research Forum on Gypsy Moth and other Invasive Species. Annapolis, MD, pp. 87-91.

Anoplophora chinensis

Taxonomic status

Scientific name	*Anoplophora chinensis* (Forster)
Synonyms	*Anoplophora malasiaca* (Thomson)
Taxonomic position	Coleoptera: Cerambycidae
English name	Citrus longhorn beetle, white-spotted longicorn beetle
German name	
French name	Capricorne à points blancs
Italian name	

Description and identification

Description	Adults are typical Cerambycidae, about 2.5 cm (male) to 3.5 cm (female) long. Antennae are 2 times the body length in males and 1.2 times in females. The adult is black with irregular white spots on the elytra. Larvae are of typical cerambycid shape, cream-white, up to 4.5 cm long when mature. The piles of frass ejected from galleries and accumulating at the base of an attacked tree are usually conspicuous and give a good indication of infestation.
Similar species	*A. chinensis* and *A. malasiaca* have recently been synonymized by Lingafelter and Hoebeke (2002), who also provided identification characters for congeneric species such as the Asian longhorn beetle *A. glabripennis* (Motschulsky).

Biology and ecology

Life cycle	The life cycle can take 1 or 2 years. The adults are present from May to August and live about 1 month. Eggs are laid singly under the bark of the trunk or branches. Each female lays about 70 eggs. Larvae feed first under the bark and then enter the wood, where they pupate (CABI/EPPO, 1997; CABI, 2001).
Host plant	*A. chinensis* is very polyphagous, having been recorded feeding on at least 68 species of forest and orchard trees, including *Acer*, *Alnus*, *Casuarina*, *Citrus*, *Litchi*, *Melia*, *Morus*, *Populus*, *Salix*, etc.
Habitat	Due to its wide host range, the beetle can invade urban, rural and forest landscapes, as well as orchards.

Origin China, Korea, Japan, Malaysia, Myanmar, Viet Nam

Introduction and dispersal

History of introduction	Recently introduced into USA (eradication programmes on-going, e.g. in Florida and Oregon), northern Italy (Colombo and Limonta, 2001) and France (Cocquempot et al., 2003).
Pathways of introduction	The beetle was introduced into the USA, Italy and France on bonsai trees. It can also travel as eggs, larvae or pupae in solid wood packing material, i.e. crating, pallets or packing blocks from China.
Dispersal	Adults can fly, but probably spread slowly. Transport of infested material by trade is more critical.

Current status

Actual and potential distribution in CH	Not yet in Switzerland. *A. chinensis* could probably spread to most regions and environments in Switzerland, but damage is more likely in the warmer areas in the Ticino, the Valais and the Lac de Genève area.
Distribution in Europe	Presently restricted to Italy and France, where it was recently introduced.

Impacts

Damage on plant	*A. chinensis* can attack healthy as well as stressed trees. Attacked trees are weakened and more susceptible to disease and wind damage. Trees are often killed. Adults can also damage trees by feeding on leaves, petioles and bark.
Environmental impact	The environmental impact of the beetle has never been studied in Asia.
Economic impact	*A. chinensis* can cause serious damage to fruit, ornamental and amenity trees in Asia. Damage is particularly serious in citrus orchards.

Management options

Various management options have been used and proposed, such as insecticide treatments (both aerial treatment and tree injection), protecting trunks with wire mesh, cutting and burning of heavily infested branches, biological control with *Beauveria* and nematodes, etc. (see CABI/EPPO, 1997 and CABI, 2001 for reviews).

Information gaps

The environmental impact of the beetle remains unclear. Biological control options still have to be studied.

References

Literature

Cocquempot, C., Prost, M. and D. Carmignac (2003) Interceptions et introductions en France de longicornes asiatiques: cas des *Anoplophora glabripennis* (Motschulsky) et *chinensis* (Forster) (Coleoptera Cerambycidae). Bulletin Mensuel de la Société Linnéenne de Lyon 72, 273-278.

Colombo, M. and L. Limonta (2001) *Anoplophora malasiaca* Thomson (Coleoptera Cerambycidae Lamiinae Lamiini) in Europe. Bollettino di Zoologia Agraria e di Bachicoltura 33, 65-68.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G. , Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

Lingafelter, S.W. and E.R. Hoebeke (2002) Revision of *Anoplophora* (Coleoptera: Cerambycidae). The Entomological Society of Washington, Washington, DC, 238 pp.

Cameraria ohridella

Taxonomic status

Scientific name	*Cameraria ohridella* Deschka and Dimic
Taxonomic position	Lepidoptera: Gracillariidae
English name	Horse chestnut leaf miner
German name	Rosskastanien-Miniermotte
French name	Mineuse du marronnier
Italian name	Minatrice fogliare dell'ippocastano

Description and identification

Description	All developmental stages are described in Deschka and Dimic (1986). The adult is a small moth, about 4-5 mm long. Forewings are light brown with white stripes, margined with black. Hindwings are fringed. Antennae are almost as long as the forewings, the legs are white with darker rings. Eggs are found on the upper side of leaves and are about 0.3 mm long, oval, and relatively flat. Six larval instars cause a characteristic blotch mine on the upper side of horse chestnut leaves. The brown pupa is found in a white pupal chamber in the mine.
Similar species	This is the only species of the genus *Cameraria* in Europe. To distinguish *C. ohridella* from other Gracillariidae, see Deschka and Dimic (1986). There is no other leaf miner on horse chestnut in Europe.

Biology and ecology

Life cycle	Adult moths emerge in spring from overwintering pupae and mate on the bark of the trunk. Eggs are laid on the upper epidermis of the leaves. Egg development lasts 2-3 weeks. There are usually 6 larval instars. The first instar is sap feeding and the next 3 feed on leaf tissue. The last 2 instars (spinning stages) spin a cocoon in the mine, in which pupation occurs. In Central Europe, larval and pupal developments last about 3 and 2 weeks, respectively. There are 2-4 generations per year, depending on the climate. Pupae overwinter in dead leaves. Biology in central Europe is described in Pschorn-Walcher (1994) and Freise and Heitland (2004).
Food	Larvae feed mainly on the horse chestnut (*Aesculus hippocastanum* L. and some other *Aesculus* spp., but can also develop on some maple species such as *Acer pseudoplatanus* L. and *A. platanoides* L.
Habitat	*C. ohridella* is found everywhere horse chestnut occurs, i.e. mainly in urban areas but also occasionally in forests.

Origin The origin of *C. ohridella* is unknown. It was first found in Macedonia in 1984 and, since its main host tree, *Aesculus hippocastanum*, originates from the Balkans, the moth may come from this region. However, several indications suggest that it possibly comes from another continent, i.e. Asia or North America. Its original host tree may be an *Aesculus* sp. (several species occur in Asia and North America), but another tree genus cannot be ruled out, since it can develop on some *Acer* spp. in Europe.

Introduction and dispersal

History of introduction: It is not known how the moth was introduced into Europe, if indeed it is not native. From Macedonia, it spread rapidly to the rest of

	Europe. *C. ohridella* was first observed in 1998 in Bern and Zürich (Kenis and Forster, 1998), but probably entered Switzerland several years before.
Pathways of introduction	The fast spread of the moth in Europe is explained by the movement of adults entering vehicles, and pupae in dead leaves being spread e.g. by car, train and truck.
Dispersal	Males and females can fly and are easily dispersed by wind. Males are attracted by a sex pheromone emitted by females. However, the main dispersal mechanism in Europe is probably human-mediated transport (Gilbert et al., 2004).

Current status

Actual and potential distribution in CH	It is now present in most regions in Switzerland, but it has not yet reached all towns and villages. All regions where horse chestnut is planted are at risk.
Distribution in Europe	Albania, Austria, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Luxembourg, Macedonia, Netherlands, Poland, Romania, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Ukraine, UK.

Impacts

Damage on plant	The damage is produced by the larvae that mine leaves of horse chestnut. In the regions where the moth is present, nearly all horse chestnut trees are attacked, and most become brown and lose their leaves in summer. Heavy defoliation is observed nearly every year. The endemic forests of horse chestnut in the Balkans are equally threatened. The real impact on trees is not yet clear. So far, trees are surviving but recent observations suggest that the pest affects fruit production and seedling survival in natural stands.
Environmental impact	The environmental impact of *C. ohridella* is unclear. In Switzerland, horse chestnut is not a native tree but in the Balkans the few endemic horse chestnut forests are endangered. In addition, high populations of *C. ohridella* greatly increase the populations of generalist natural enemies (parasitoids and predators), which, in turn, may affect the populations of native leaf miners.
Economic impact	The pest is causing much concern in Europe where horse chestnut is an important ornamental tree in streets, parks and gardens. Horse chestnut is no longer planted in Europe, and attacked trees are being cut on a massive scale and replaced by other tree species.

Management options	Current control methods are based on the use of chemicals and removal of dead leaves. Diflubenzuron is effective when aerial applications are made during the oviposition period of the first generation, but applications are expensive, have to be repeated every year, and are not always popular with the public. The most common control practice is the destruction or composting of dead leaves containing pupae in autumn. However, this method is time consuming and is only effective when all leaves in a given area are destroyed. Other control options such as biological control and pheromone-based mass trapping or mating disruption are presently being studied.
Information gaps	The region of origin of the moth has not yet been ascertained. Locating the area of origin would allow the development of a classical biological control programme. The environmental impact on the native fauna sharing the same natural enemy complex should be investigated. These indirect effects of invasive alien species are not well studied and understood. Alternative control methods should be further studied.

References

Literature

Deschka, G. and N. Dimic (1986) *Cameraria ohridella* sp. n. (Lep., Lithocolletidae) aus Mazedonien, Jugoslawien. Acta Entomologica Jugoslavica 22, 11-23.

Freise, J. F. and W. Heitland (2004) Bionomics of the horse-chestnut leaf miner *Cameraria ohridella* Deschka & Dimic 1986, a pest on *Aesculus hippocastanum* in Europe (Insecta: Lepidoptera: Gracillariidae). Senckenbergiana biologica 84, 1-20.

Gilbert, M., Grégoire, J.-C., Freise, J. F. and Heitland, W. 2004. Long-distance dispersal and human population density allow the prediction of invasive patterns in the horse chestnut leafminer *Cameraria ohridella*. *Journal of Animal Ecology* **73**, 459-468.

Kenis, M. and B. Forster (1998) Die Rosskastanien-Miniermotte: neu in der Schweiz. Der Gartenbau 39, 16-17.

Pschorn-Walcher, H. (1994) Freiland-Biologie der eingeschleppten Rosskastanien-Miniermotte *Cameraria ohridella* Deschka and Dimic (Lep., Gracillariidae) im Wienerwald. Linzer Biologische Beiträge 26, 633-642.

Corythucha arcuata

Taxonomic status

Scientific name	*Corythucha arcuata* (Say)
Synonyms	
Order: Family	Heteroptera: Tingidae
English name	Oak lace bug
German name	Eichennetzwanze
French name	Punaise réticulée du chène
Italian name	Tingide americana della quercia

Description and identification

Description	Adults are a flattened, small and, greyish tingid bugs (about 3 mm long), with broad, transparent, lacelike wing covers. Nymphs are black and covered with spines. Infested leaves have chlorotic flecks on the upper side.
Similar species	*C. arcuata* is similar to sycamore lace bug, *Corythucha ciliata* (Say) (see Fact Sheet) but can be easily distinguished by the difference in the pigmentation of the hemielytras.

Biology and ecology

Life cycle	Adults overwinter, usually in bark crevices. They lay eggs on the underside of leaves. There are 5 nymphal instars, which feed on leaves. A full cycle from egg to adult may be completed in 30 to 45 days. There are 2-4 generations per year (Connel and Beacher, 1947).
Host plant	Mainly oak (*Quercus* spp.). Also found on *Castanea americana* (Michx.), and occasionally on *Acer*, *Malus* and *Rosa* species.
Habitat	Forests, urban and rural areas.

Origin North America

Introduction and dispersal

History of introduction	Found in 2000 in Italy (Lombardia, Piemonte) and in Switzerland in 2003 (Ticino).
Pathways/ manner of introduction	It was probably introduced on oak plants or branches.
Dispersal	Adults can fly and can be spread by wind.

Current status

Actual and potential distribution in CH	Present in southern Ticino since 2003 (Meier et al., 2004). Its potential distribution probably matches that of oak species.
Distribution in Europe	Present in Italy in Lombardia and Piemonte, where it now covers an area of 7,000 km^2 (Bernardinelli, 2000; Bernardinelli and Zandigiacomo, 2000).

Impacts

Damage on plant	Adults and nymphs feed directly on leaves, causing discolouration of the upper surface, a reduction in photosynthesis and premature leaf fall.
Environmental impact	The environmental impact is not clear and probably fairly low in North America. However, it is difficult to predict what its impact will be on native oaks in Europe, in the absence of its natural enemies.
Economic impact	The economic impact is low in North America, but it may be much higher in Europe or any other region of introduction, since oaks are

very important forest and amenity trees. A closely related species, the American sycamore lace bug, *C. ciliata*, is a serious pest of *Platanus* spp. in Europe, suggesting that *C. arcuata* has the potential to become harmful as well.

Management options

In North America, natural enemies usually provide sufficient control, and chemical control options are rarely necessary. This indicates the potential for classical biological control.

Information gaps

Due to its low importance in North America, relatively little is known about the ecology of this species. Its potential host range and damage in Europe is totally unknown.

References

Literature

Bernardinelli, I. (2000) Distribution of *Corythucha arcuata* (Say) in northern Italy (Heteroptera, Tingidae). REDIA 83, 157-162.

Bernardinelli, I. and P. Zandigiacomo (2000) Prima segnalazione di *Corythucha arcuata* (Say) (Heteroptera, Tingidae) in Europa. Informatore Fitopatologico 50 (12), 47-49.

Connel, W.A. and J.H. Beacher (1947) Life history and control of the oak lace bug. Delaware Agriculture Experimental Station Bulletin 265, 28 pp.

Meier, F., R. Engesser, R., B. Forster, B. and O. Odermatt (2004) Forstschutz-Überblick 2003. Report. Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, Birmensdorf. 22 pp

Corythucha ciliata

Taxonomic status

Scientific name	*Corythucha ciliata* (Say)
Synonyms	
Taxonomic position	Heteroptera: Tingidae
English name	Sycamore lace bug
German name	Platanennetzwanze
French name	Tigre du platane
Italian name	Tingide americana del platano

Description and identification

Description	Adults are flattened, small, whitish tingid bugs (about 3 mm long), with broad, transparent, lacelike wing covers. Nymphs are black and covered with spines. Infested leaves have chlorotic flecks on the upper side (Drake and Ruhoff, 1965). It is the only tingid feeding on *Platanus* spp.
Similar species	*C. ciliata* is similar to another recently introduced species, the oak lace bug, *C. arcuata* (Say) (see Fact Sheet) but it can be easily distinguished by the difference in the pigmentation of the hemielytras pigmentation and by its larger size.

Biology and ecology

Life cycle	*C. ciliata* overwinters as adults, under loose bark or in nearby cracks and crevices. Eggs are laid on the underside of leaves. Females can lay up to 282 eggs. There are 5 nymphal instars, which feed on leaves. A full cycle from egg to adult may be completed in about 45 days. There are several generations per year (d'Aguilar et al., 1977; Maceljski, 1986).
Host plant	Mainly *Platanus* spp. Occasionally reported on other host plants, such as *Broussonetia*, *Carya*, *Chamaedaphne* or *Fraxinus* (Drake and Ruhoff, 1965).
Habitat	Urban and rural areas.

Origin North America

Introduction and dispersal

History of introduction	It was first found in Italy in 1964, from where it spread to most of southern and Central Europe. It was first observed in Switzerland in Basel in 1983 (Wicki, 1983). It has also been introduced into Russia, east Asia and Chile.
Pathways of introduction	Probably on *Platanus* plants and branches.
Dispersal	Adults are good flyers, and are easily dispersed by wind. However, its main mode of spread within Europe is probably by human-mediated transport.

Current status

Actual and potential distribution in CH	It is already widespread in Basel and western Switzerland (Barbey, 1996). Its potential distribution in Switzerland follows that of *Platanus* spp.
Distribution in Europe	It is found in Italy, France, Spain, Switzerland, Germany, Hungary, former Yugoslavia, Romania and Bulgaria. It is still spreading further North, perhaps accelerated by global warming.

Impacts

Damage on plant	*C. ciliata* adults and nymphs feed on the undersides of leaves, causing desiccation of leaves, which may drop prematurely. Weakened trees and young trees are especially susceptible. Successive attacks may lead to tree death, particularly when other factors are involved, e.g. environmental stress or diseases.
Environmental impact	The environmental impact in Switzerland is likely to be low, since its main hosts, *Platanus* spp., are urban, exotic trees.
Economic impact	*C. ciliata* is a serious pest of *Platanus* spp. in public places in Europe, particularly in southern Europe. *C. ciliata* is a social nuisance and the damage is mainly aesthetic but, in conjunction with other factors such as diseases (e.g. canker stain of plane) or environmental stress, tree survival may be affected.

Management options Insecticidal treatments are available, either as foliar application or trunk injection, but their use is costly and often difficult in urban areas.

Information gaps

References

Literature

Barbey, S. (1996) La protection phytosanitaire des conifères et arbustes d'ornement. Revue Horticole Suisse 69, 120-122.

d'Aguilar, J., R. Pralavorio, J.M. Rabasse, and R. Mouton (1977) Introduction en France du tigre du platane: *Corythucha ciliata* (Say) (Het. Tingidae). Bulletin de la Société Entomologique de France 82, 1-6.

Drake, C.J. and F.A. Ruhoff (1965) Lacebugs of the world: A catalog (Hemiptera: Tingidae). Smithsonian Institution, Washington, DC, United States National Museum Bulletin 213, 634 pp.

Maceljski, M. (1986) Current status of *Corythuca* [sic] *ciliata* in Europe. Bulletin OEPP/EPPO Bulletin 16, 621-624.

Wicki, C. (1983) Basler Platanen von einer neu aufgetretenen Platanen-Netzwanze befallen. Gärtnermeister 29/83, 688 pp.

Diabrotica virgifera ssp. virgifera

Taxonomic status

Scientific name	*Diabrotica virgifera* ssp. *virgifera* LeConte
Taxonomic status	Coleoptera: Chrysomelidae
English name	Western corn rootworm
German name	Westlicher Maiswurzelbohrer
French name	Chrysomèle des racines du maïs
Italian name	Diabrotica del mais

Description and identification

Description	Adults are elongate, c. 5.1 mm long (range 4.4-6.8 mm), yellowish green, with parallel yellow humeral plicae and distinct piceous elytral vittae; lateral margin widest medially. The pronotum is shiny and yellow. The elytra are straw yellow, each with 1 humeral and 1 sutural vitta ending near the apex; humeral plicae are distinct. There are 3 discal sulci. Punctuations are distinct. The scutellum is buff. The head is shiny; the vertex is amber; the labrum and clypeus are piceous. Antennae are 4.2 mm long. Segment 3 is 1.5 times longer than segment 2. Segments 2 and 3 combined equal the length of segment 4. The sterna are straw yellow, the episternites tawny and piceous on sutures. Legs are yellow to tawny, with the outer edge of femora piceous. The abdomen is yellow. Adults lay tiny, oval, white eggs that are less than 0.1 mm long. The embryonic stage at diapause is flattened oval and c. 50 µm long, consisting of undifferentiated cells representing the embryonic primordium and the amnion. Larvae are slender, white to pale yellow, with a yellowish-brown head, and about 10 mm long when in the third instar. Pupae are naked and white, and are found in earthen cells in soil near plant roots.
Similar species	This is the only species of the genus *Diabrotica* in Europe. To distinguish *D. virgifera* ssp. *virgifera* from other American *Diabrotica*, see the identification key on the EPPO website.

Biology and ecology

Life cycle	*D. virgifera* ssp*. virgifera* is univoltine. The eggs overwinter in the soil and begin to develop in spring when soil temperatures reach 10-11°C. The larvae develop in and on the roots, the young larvae feeding on fine rootlets and the older ones invading the root core. There are 3 instars before the larvae fully mature. Pupation takes place in the soil. The emerging adults move to the maize plant, feeding on the leaves, silks and pollen, and are prevalent until autumn. About 2 weeks after mating, the females begin laying eggs in the soil, usually at the base of maize plants and in the top 15 cm of soil.
Food	*D. virgifera* ssp*. virgifera* attack mainly maize; larvae feed on the roots and adults feed on the leaves and silk. Other Poaceae may occasionally serve as host plants for the larvae, while the adults may also feed on other Poaceae, Asteraceae, Fabaceae and Cucurbitaceae.
Habitat	*D. virgifera* ssp*. virgifera* is found mainly in maize fields.

Origin	The natural distribution of *D. virgifera* ssp*. virgifera* is in Mexico and Central America. It became an important pest of maize in North America after the wide distribution of maize as a staple crop.

Introduction and dispersal

History of introduction	The beetle was first detected in July 1992 in the locality of Surcin near the Belgrade International Airport. The origin of this introduction remains unknown. In 2000, *D. virgifera* ssp. *virgifera* was reported for the first time in Switzerland, near the airport of Lugano/Agno, in the Ticino.
Pathways of introduction	The origin and pathway of the first introduction near Belgrade remains unknown. There is no very obvious means of intercontinental dispersal by trade, since it would not be expected that the insects would be carried by consignments of seed or grain. However, an introduction is possible by transportation of maize cobs or green maize. Well-established populations of *D. virgifera* ssp*. virgifera* in north-western Italy would serve as a source for re-introduction into Switzerland (Bertossa et al., 2001).
Dispersal	While the larvae move relatively little, the adults fly to maize fields and can migrate over short and longer distances, moving with weather features such as cold fronts (Grant & Seevers, 1989).

Current status

Actual and potential distribution in CH	It has entered Switzerland in the Ticino from Italy (Bertossa et al., 2001). In 2003 the first beetles were recorded north of the Alps. Since then it has been found in at least 4 places in Switzerland north of the Alps. The first records were along the motorway from the Ticino to the north, thus transportation of adults in cars is highly likely. In the long term, all regions with maize fields are at risk.
Distribution in Europe	Austria, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, France, Hungary, Italy, Romania, Slovakia, Switzerland, Ukraine, Serbia-Montenegro and Slovenia.

Impacts

Damage on plant	Newly hatched larvae feed primarily on root hairs and outer tissues of roots. As the larvae grow and their food requirements increase, they burrow into roots. Larval damage is usually most severe after the secondary root system is well established and brace roots are developing. Root tips appear brown and often tunnelled into and chewed back to the base of the plant. Larvae may be found tunnelling in larger roots and occasionally in the rootcrown. Larvae may burrow through plants near the base, causing stunting or death of the growing point and frequently causing tillering. Larval feeding can continue into maize brace roots and onto lower leaf sheaths. As root feeding starts shortly after plant emergence, early symptoms are expressed as drought or nutrient deficiencies. Plant lodging occurs later in plant development. Sites of larval damage are often pathways for infection by disease pathogens, resulting in root rots. Adult beetles cause noticeable damage by feeding principally on pollen, silk and young kernels. Silk clipping near the husk during anthesis can cause reduced seed set in maize, which may only be observed at the time of harvest.
Environmental impact	The environmental impact of *D. virgifera* ssp*. virgifera* is unclear.
Economic impact	One adult beetle per maize plant meets the economic threshold necessary to control *D. virgifera* ssp*. virgifera* in the following year (Stamm, 1985, Turpin et al., 1972). The costs of soil insecticides used to control larval damage to maize roots, aerial sprays to reduce adult damage to maize silk, and crop losses, approach US$ 1 billion annually in North America (Metcalf, 1986). *D. virgifera* ssp*. virgifera* can also transmit and spread maize chlorotic mottle machlomovirus (Jensen, 1985). In Europe, economic damage has been seen on maize in Serbia, Croatia, Hungary and Romania, as

well as in Italy in Lombardia. Until 2002, no economic damage was observed in Switzerland.

Management options

See Levine and Oloumi-Sadeghi (1991) for a review of integrated pest management strategies for *D. virgifera* ssp*. virgifera*, i.e. crop rotation, tillage and soil environment, planting and harvesting dates, host-plant resistance, biological control, control of larvae and adults with insecticides, etc. Present IPM tactics depend on monitoring pest populations, use of economic thresholds and integration of the different control methods. Monitoring adults in one season gives a reasonably good forecast of damage in the following season (Levine Gray, 1994). Many different types of traps are available (Hesler Sutter, 1993). A rotation strategy has been effective (Nelson et al., 1994). In North America where this pest is a major problem for maize, preventive applications of soil insecticides are widely used as a management strategy in fields where maize is cultivated continuously. Generally, granular soil insecticides such as terbufos or isofenphos are applied at planting (Sutter et al., 1990). In October 2004 an EU Directive was released on emergency measures to prevent the spread of the beetle within the Community, i.e. Directive 2003/766/EC: *http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_275/l_27520031025en00490050.pdf*

Information gaps

Since the capacity for natural and artificial spread of *D. virgifera* ssp*. virgifera* is enormous, it is difficult to propose measures to prevent spread in Europe. At the present time, it is essential to monitor the behaviour of the pest and its rate of local spread. Methods for local eradication should be investigated, and their potential for future application assessed. Changes in maize-growing practices may have to be considered. The main aim at present must be to contain *D. virgifera* ssp*. virgifera* and to reduce its impact as much as possible. However, as the current management methods depend so much on soil insecticides, alternative control methods should be further studied, i.e. effective biological control agents.

References

Literature

Bertossa, M., Jacques, D., Luigi, C. and B. Roberto (2001) Update of monitoring data of *Diabrotica virgifera virgifera* in Switzerland in 2001. XXI IWGO Conference, VIII Diabrotica Subgroup Meeting, Legnaro - Padua - Venice - Italy, Oct. 27 - Nov. 3, 2001. Proceedings, pp. 169-173.

Grant, R.H. and K.P. Seevers (1989) Local and long-range movement of adult western corn rootworm (Coleoptera: Chrysomelidae) as evidenced by washup along southern Lake Michigan shores. Environmental Entomology 18, 266-272.

Hesler, L.S. and G.R. Sutter (1993) Effect of trap color, volatile attractants, and type of toxic bait dispenser on captures of adult corn rootworm beetles (Coleoptera: Chrysomelidae). Environmental Entomology 22, 743-750.

Jensen, S.G. (1985) Laboratory transmission of maize chlorotic mottle virus by three species of corn rootworm. Plant Diseases 69, 864-868.

Krysan, J.L. and R.F. Smith (1987) Systematics of the *virgifera* species group of *Diabrotica* (Coleoptera: Chrysomelidae: Galerucinae). Entomography 5, 375-484.

Kuhlmann, U. and W.A.C.M. van der Burgt (1998) Possibilities for biological control of the western corn rootworm, *Diabrotica virgifera virgifera* Le Conte, in Central Europe. Biocontrol News and Information 19 (2), 59N-68N.

Levine, E. and M.E. Gray (1994) Use of cucurbitacin vial traps to predict corn rootworm (Coleoptera: Chrysomelidae) larval injury in a subsequent crop of corn. Journal of Entomological Science 29, 590-600.
Levine, E. and H. Oloumi-Sadeghi (1991) Management of diabroticite rootworms in corn. Annual Review of Entomology 36, 229-255.
Metcalf, R.L. (1986) Foreword. In: Methods for the study of pest *Diabrotica*. Krysan, J.L. and T.A. Miller (eds) Springer-Verlag, New York, USA.
Nelson, S.D., Dwyer, L.M., Fox, C.A. and J.L.B. Culley (1994) Effects of a new rootworm (Coleoptera: Chrysomelidae) infestation on continuous and rotated corn under four tillage systems. Journal of Sustainable Agriculture 4, 31-37.
Sutter, G.R., Fisher, J.R., Elliott, N.C. and T.F. Branson (1990) Effect of insecticide treatments on root lodging and yields of maize in controlled infestations of western corn rootworms (Coleoptera: Chrysomelidae). Journal of Economic Entomology 83, 2414-2420.
Stamm, D.E., Mayo, Z.B., Campbell, J.B., Witkovski, J., Andersen, L.W. and R. Kozub (1985) Western corn rootworm beetle counts as a mean of making larval control recommendations in Nebraska. Journal of Economic Entomology 78, 794-798.
Turpin, F.T., Dumenil, L.C. and D.C. Peters (1972) Edaphic and agronomic characters that affect potential for rootworm damage to corn in Iowa. Journal of Economic Entomology 65 (6): 1615-1619.

Further information: *http://www.eppo.org/QUARANTINE/Diabrotica_virgifera/diabrotica_virgifera.html*

Harmonia axyridis

Taxonomic status

Scientific name	*Harmonia axyridis* (Pallas)
Synonyms	
Taxonomic position	Coleoptera: Coccinellidae
English name	Multicoloured Asian ladybeetle or ladybird
German name	Asiatische Marienkäfer
French name	Coccinelle asiatique multicolore
Italian name	

Description

Description	The adult is a large (4.9-8.2 mm) oval beetle. It exists in various colour morphs, ranging from pale-yellow to black, and with 0 to 19 black or red spots on the elytra, which displays a wide transverse keel at the apex. The head, antennae and mouthparts are usually straw yellow. The pronotum is yellowish with black markings in the centre. These markings can be four black spots, two curved lines, a black M-shaped mark, or a solid black trapezoid. Larvae are elongate, somewhat flattened, and adorned with strong tubercles and spines. The mature larva is mostly black to dark bluish-grey, with prominent bright yellow-orange patch on the sides of abdominal segments 1 to 5. (Adriaens *et al.* 2003; Koch, 2003; Klausnitzer, 2004).
Similar species	Because coloration and maculation are so variable, *H. axyridis* can easily be mistaken for several native species. It can be distinguished from most Central European species by its large size. The few large Central European species do not have the typical keel on the apex of the elytra (Klausnitzer, 2004)

Biology and ecology

Life cycle	The life cycle, population dynamics and other bio-ecological traits are reviewed by Koch (2003). The beetle is generally considered bivoltine, but up to four or five generations per year have been reported. Adults typically live one to three months, but may survive up to three years. In summer, the life cycle from egg to adult lasts about a month. *H. axyridis* has a very high fecundity. Up to 3,800 eggs per female have been reported, with a daily oviposition rate of about 25 eggs. There are four larval stages. In autumn, adults aggregate at overwintering sites, on or in buildings, cliffs, etc.
Prey	*H. axyridis* is very polyphagous. It preys mainly on aphids, and other tree-dwelling hemipterans (e.g. psyllids and scale insects), but can also feed on eggs and larvae of other insects such as Lepidoptera, Coleoptera and Diptera (Koch, 2003)
Habitat	Because of its large prey-range, *H. axyridis* occurs in a wide variety of natural, semi-natural and anthropogenic habitats.

Origin East Asia (China, Japan, Korea, Eastern Russia)

Local dispersal

History of Introduction	In Europe, *H. axyridis* has been used for biological control against aphids in greenhouses and field crops since 1982, but naturalized populations have been observed only recently (e.g. Germany, 2000; Belgium, 2001; the Netherlands, 2002). In North America, where releases have been carried out intentionally, the first established population was reported in 1988.

Pathways of introduction	It is believed that naturalized populations in Europe result from specimens released for biological control. However, in America, the argument has been made that established populations may have originated from accidental introductions (Koch, 2003).
Dispersal	*H. axyridis* has strong dispersal capacities, allowing it to undertake long-range migrations for overwintering.

Current status

Actual and potential distribution in CH	Only one specimen was found in the botanical garden of Basel, in summer 2004 (Klausnitzer, 2004). It is not known whether the species is already established in Switzerland. However, the beetle is spreading fast in Germany, and has also probably established in France and Italy, which suggests that Switzerland will soon be invaded. Its wide distribution in Asia and North America (from south-eastern USA to eastern Canada) suggests that most regions and environments in Switzerland are suitable for establishment.
Distribution in Europe	Expanding populations are observed in Belgium, the Netherlands, and Germany. Naturalized populations have also been reported in Greece, France, Italy and UK and a single specimen was found in Switzerland (Adriaens et al., 2003; Klausnitzer, 2004; ISSG web site). *H. axyridis* is still used as a biological control agent in greenhouses and field crops in many European countries.

Impacts

Environmental impact	*H. axyridis* is a voracious species that feeds not only on pests but also on beneficials such as other coccinellids, lacewings, hoverflies and butterfly eggs and larvae, etc. Studies in North America showed that it is able to out-compete and displace native aphidophagous species through predation, competition for food and other mechanisms (Koch, 2003; Alyokhin and Sewell, 2004).
Economic impact	In North America, the beetle has become a human nuisance because it aggregates in high numbers in houses and building for overwintering. It is also considered a pest for the fruit industry because it aggregates on fruits, particularly grapes, which may alter wine quality. In its native range, *H. axyridis* is seen as a very efficient aphid predator. Even in North America it is still often considered beneficial to growers and agriculturalists. For example, its presence has significantly benefited the pecan industry by nearly eliminating pecan aphids (Koch et al., 2003; ISSG, website).

Management options	Management options proposed in North America focus mainly on the control of aggregated beetles in houses and buildings. Physical, chemical and mechanical control methods are described by the ISSG website. There are no control methods presently used to limit the impact of the beetle on the native fauna. In the long term, if serious non-target effects are demonstrated in Europe, the importation of specific natural enemies (e.g. parasitoids or pathogens) from its native range may be considered.
Information gaps	The present and potential ecological and economic impacts on the native fauna in Europe are unknown. Even in North America, where the beetle has been intensively studied in the last ten years, the impact of the beetle on non-target organisms and pest populations remains a matter of debate (Brown, 2003; Koch, 2003). Comparative population studies should be carried out in Europe, North America and Asia to better understand the population dynamics and natural mortality factors in its native and invasive ranges.

References

Literature

Adriaens, T., E. Branquart, E. and D. Maes (2003) The multicoloured Asian ladybird *Harmonia axyridis* Pallas (Coleoptera: Coccinellidae), a threat for native aphid predators in Belgium? Belgian Journal of Zoology 133, 195-196.

Alyokhin, A. and G. Sewell (2004) Changes in a lady beetle community following the establishment of three alien species. Biological invasions 6, 463-471.

Brown M.W. (2003) Intraguild responses of aphid predators on apple to the invasion of an exotic species, *Harmonia axyridis*. BioControl 48, 141-153.

ISSG (website) Invasive species specialist group. Web page for *Harmonia axyridis*: *http://www.issg.org/database/species/ecology.asp?si=668&fr=1&sts*=

Klausnitzer, B. (2004) *Harmonia axyridis* (Pallas, 1773) in Basel-Stadt (Coleoptera, Coccinellidae). Mitteilungen der Entomologischen Gesellschaft Basel 54, 115-122.

Koch R.L. (2003) The Multicolored Asian Lady Beetle, *Harmonia Axyridis*: A Review of Its Biology, Uses in Biological Control, and Non-target Impacts. 16pp. Journal of Insect Science 3, 32 Available online: insectscience.org/3.32.

Hyphantria cunea

Taxonomic status

Scientific name	*Hyphantria cunea* (Drury)
Synonyms	*Hyphantria textor* Harr.
Taxonomic position	Lepidoptera: Arctiidae
English name	Fall webworm, American white moth
German name	Weisser amerikanischer Bärenspinner
French name	Ecaille fileuse
Italian name	Ifantria americana, Falena tessitrice

Description

Description	Adults have a wingspan of 25-30 mm. Wings are white, with a small black spot on the hind wing and, often, several black spots arranged in a number of rows on the forewing. Larvae are brownish-grey, up to 40 mm long, and have 12 small warts surmounted by characteristic tufts of hair. Their silk nests enclosing a number of leaves are characteristic.
Similar species	No congeneric species occur in Europe.

Biology and ecology

Life cycle	In Central Europe, there are usually 2 generations per year. Pupae overwinter in the bark cracks or in the soil. Adults fly in April-May and lay eggs in groups, usually on the underside of leaves. Larvae usually have 7 instars, but up to 11 can be observed. Early instars are gregarious and build colonial silk nests enclosing leaves, in which they live to the fifth to sixth instars when they become solitary and disperse. Then, they pupate in refuges and emerge for a second generation, which flies in July-August (CABI/EPPO, 1997).
Host plants	*H. cunea* is very polyphagous. Over 250 host plants have been recorded. The most favourable for development are in the genera *Morus*, *Acer, Populus, Platanus, Malus* and *Prunus*. Other cultivated plants such as grapevine, maize or soyabean can be attacked.
Habitat	Because of its polyphagy, *H. cunea* can invade most habitats.

Origin North America

Local dispersal

History of Introduction	It arrived in the 1940s in Hungary, from where it spread to the whole of Europe. First found in southern Ticino in 1991 (Jermini et al., 1995). Also introduced into eastern Asia.
Pathways of introduction	The pathway of introduction into Europe is unknown.
Dispersal	Adults are good flyers. Furthermore, *H. cunea* can spread with vehicles, packing material, host plant material, etc.

Current status

Actual and potential distribution in CH	Until now, it has been restricted to the southern half of the Ticino. All lowland areas in Switzerland are probably suitable for establishment. However, *H. cunea* seems unable to establish in the northern half of Europe, probably because of climatic constraints, and it is a serious pest only in Bulgaria, Romania, Hungary, former Yugoslavia, Russia and northern Italy. Therefore, the Ticino and the Valais are probably more at risk than the other Cantons.
Distribution in Europe	Austria, Bulgaria, Croatia, Czech Republic, France, Hungary, Italy,

Moldova, Poland, Romania, Russia, Slovakia, Slovenia, Switzerland, Turkey, Ukraine, former Yugoslavia.

Impacts

Damage on plant — Trees/plants are often totally defoliated by the late-instar larvae, particularly in the second generation.

Environmental impact — Environmental impacts are unknown, but are likely, given high polyphagy and impact on individual plants.

Economic impact — *H. cunea* is a threat to orchards, ornamentals and forest trees in some regions in Central and eastern Europe, as well as in eastern Asia. Its colonial habit is particularly damaging to ornamentals. As yet, no serious damage has been observed in Switzerland.

Management options — Mechanical (nest destruction) and chemical control methods are used. *Bacillus thuringiensis* is effective and should be used in preference to chemical insecticides (Giovanni et al., 1986).

Information gaps — The potential distribution and damage in Switzerland is unclear, since population levels and damage vary considerably within the areas of introduction. A possible extension of its distribution within Europe related to climate change is possible. If populations increase in Switzerland, environmental impacts should be studied.

References

Literature

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G. , Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

de Giovanni, G., Oliva, G. and A. Montermini (1986) Strategie di difesa dall'ifantria americana. Informatore Fitopatologico 36, 11-15.

Jermini, M., Bonavia, M., Brunetti, R., Mauri, G. and V. Cavalli (1995) *Metcalfa pruinosa* Say, *Hyphantria cunea* (Drury) et *Dichelomyia oenophila* Haimah, trois curiosités entomologiques ou trois nouveaux problèmes phytosanitaires pour le Tessin et la Suisse? Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 27, 57-63.

Leptinotarsa decemlineata

Taxonomic status

Scientific name	*Leptinotarsa decemlineata* (Say)
Synonyms	*Chrysomela decemlineata* Say; *Doryphora decemlineata* (Rogers)
Order: Family	Coleoptera: Chrysomelidae
English name	Colorado potato beetle
German name	Kartoffelkäfer
French name	Doryphore de la pomme de terre
Italian name	Dorifora delle patate

Description and identification

Description	Adults are stout, oval, strongly convex and hard-backed beetles, and about 1 cm in length. They are yellowish brown with 5 black stripes on each elytra and about a dozen small black spots on the top of the head and thorax. Larvae have a fat abdomen, strongly convex. Young instars are red-orange, mature instars are pale orange. Head and legs are black.
Similar species	No similar species occur on Solanaceae in Europe. The genus has been revised by Jacques (1988).

Biology and ecology

Life cycle	Adults overwinter in the soil, and emerge in spring. After reaching the nearest suitable plant, they feed and mate. Females lay batches of 20-80 eggs on the lower leaf surface. Each female lays up to 2,000 eggs within a period of several weeks. There are 5 larval instars, which feed on leaves, petioles and stems. Mature larvae pupate in a cell in the soil. Young adults emerge some weeks later and feed on leaves. Then they may start another generation or enter the soil for hibernation. The number of generations varies from 1 to 3, depending on the climate (Grison, 1963; Hare, 1990).
Host plants	The main host plant is potato, but other cultivated and wild solanaceous plants, such as tomatoes and aubergines are also attacked.
Habitat	Mainly cultivated fields.

Origin North America, from wild Solanaceae.

Introduction and dispersal

History of introduction	First found in Bordeaux in 1922, from where it spread to most of Europe. First observed in Switzerland in 1937. Also introduced in various Asian, African and North and Central American countries (CABI/EPPO, 1997).
Pathways of introduction	The pathway of introduction into Europe is unknown. It was discovered in 1922, probably several years after its introduction.
Dispersal	Adults fly and spread over large areas by wind-borne migration. Adults and larvae can also be transported on potato plants and tubers, or on fresh vegetables grown on land harbouring overwintering beetles.

Current status

Actual and potential distribution in CH	The beetle is widespread in the lowlands and has probably already reached its limit of distribution.
Distribution in Europe	Most of Europe has been invaded, except the UK and Scandinavia where it has been occasionally found, but has not established.

Impacts

Damage on plant — Adults and larvae feed on host plants and can cause complete defoliation.

Environmental impact — Adults and larvae feed on wild Solanaceae, but the impact on these plants has never been studied.

Economic impact — *L. decemlineata* is a major pest of potato in Europe and North America. Considerable yield losses have been observed in Europe (up to 50% in some countries (CABI/EPPO, 1997)). Damage has also been observed on other crops such as tomato and aubergine [eggplant]. In recent years, however, damage levels have decreased in Europe, mainly because effective plant protection products are available and the routine control of the beetle has become incorporated into the established pattern of potato cultivation. In the USA, however, infestations remain very high, mainly because of the development of resistance to the major insecticides. The cost of controlling infestations in the eastern USA averages between US$138 and $368 per hectare (CABI, 2001).

Management options — Insecticides remain the most common control method throughout Europe and North America. However, in recent years, *L. decemlineata* has become resistant to many chemical insecticides, particularly in North America. Alternative means of control have been extensively searched. Nematodes, fungi, bacteria, protozoa and iridoviruses have been used, with varyingious degrees of success. *Bacillus thuringiensis* ssp. *tenebrionis* is now commonly used. Biological control methods using natural enemies were also tested and implemented locally. Other control methods include cultural practices, such as crop rotation and manipulation of planting dates, or the development of resistant cultivars and transgenic plants. For reviews of management options see Hare (1990) and CABI (2001).

Information gaps — *L. decemlineata* has been and is still one of the most studied agricultural pests in the world.

References

Literature

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G., Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

Grison, P. (1963) Le doryphore de la pomme de terre.: pp. 640-738 In: Balachowsky, A.S. (ed) Entomologie appliquée à l'agriculture. Tome 1. Coléoptères (Second volume). Masson et Cie, Paris France.

Hare, J.D. (1990) Ecology and management of the Colorado potato beetle. Annual Review of Entomology 35, 81-100.

Jacques, R.L. (1988) The potato beetles. The genus *Leptinotarsa* in North America (Coleoptera: Chrysomelidae). Flora and Fauna Handbook No. 3. E.J. Brill, New York, USA.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Metcalfa pruinosa

Taxonomic status

Scientific name	*Metcalfa pruinosa* Say
Synonyms	*Ormenis pruinosa* (Say)
Taxonomic position	Flatidae
English name	Citrus planthopper
German name	Bläulingszikade
French name	Cicadelle Metcalfa pruinosa
Italian name	Metcalfa pruinosa

Description and identification

Description	Detailed descriptions of adult and nymphs are found in Metcalf and Brunner (1948), and Lucchi and Santini (1993), respectively. Adults are about 7 mm long, dark blue-black in colour and covered with a waxy pubescence. They hold their wings flat against the sides of their bodies, and jump when disturbed. Nymphs are ivory white, strongly dorsoventrally compressed and look like small fluffy masses of cotton because of white waxy secretions they deposit around themselves and on the plant.
Similar species	There is no congeneric species in Europe.

Biology and ecology

Life cycle	*M. pruinosa* is a univoltine insect. Eggs overwinter under tree bark and in woody tissue. Eggs hatch from May to July. There are 5 nymphal stages, which last about 45 days in northern Italy. Nymphs feed on leaves and young stems, and surround themselves with long, waxy filaments. Adults are present from July to October.
Food	*M. pruinosa* is a very polyphagous species, feeding on over 200 herbaceous and woody plants in Italy (CABI, 2001). Even in its restricted distribution in Switzerland, 28 species belonging to 19 families have been reported as host plants (Bonavia and Jermini, 1998).
Habitat	Its polyphagy allows the planthopper to be present in most habitats. It is particularly abundant on ornamental bushes and trees.

Origin The origin of *M. pruinosa* is unclear. It occurs in North America (but is missing in the north-west and northern Prairies) and the Caribbean Islands. It was synonymized with *M. farinosa* (Walker), a South American species, suggesting that it may come from this continent, but this synonymy is now considered to be inaccurate (CABI, 2001).

Introduction and dispersal

History of introduction	Introduced into Italy in the late 1970s. In Switzerland, it was first found in Coldrerio, southern Ticino in 1993.
Pathways of introduction	The pathway by which *M. pruinosa* was introduced into Italy is unknown, but it was probably carried on a plant from America.
Dispersal	*M. pruinosa* is transported over long distances through horticultural activities and on vehicles that park along the roadsides near food plants. Local invasion of the surrounding area follows and is facilitated by the presence of uninterrupted belts of host trees and shrubs (Pantaleoni, 1989). Adults can fly.

Current status

Actual and potential distribution in CH	It is still restricted to the Ticino, where it is expanding its area of distribution (Jermini et al., 2000). The two main areas of occurrence are the Mendrisiotto, and the region of Bellinzona. Given its host range and its wide distribution in North America, *M. pruinosa* is probably capable of invading most of Switzerland, with the exception of high elevations.
Distribution in Europe	Italy, France, Slovenia, Croatia, Spain and Switzerland.

Impacts

Damage on plant	The damage depends on the host plant. High infestations can cause stunting of shoots and growth reduction. On soyabean, outbreak levels caused chlorosis and necrosis of the leaves, smearing of leaves and stalks with wax and sooty mould, withering of shoot tips and malformation and shrivelling of seeds (Ciampolini et al., 1987). Nymphs and, especially, adults produce high quantities of honeydew on which mould develops.
Environmental impact	The environmental impact of *M. pruinosa* is largely unknown. However, given the high infestation levels and the wide host range, it is suspected that *M. pruinosa* may have both a direct impact on sensitive host plants, and an indirect impact through competition with the native fauna and interference with their natural enemy complex. High infestation levels on ornamentals in gardens and urban areas often result in an abusive and incorrect use of insecticides with detrimental effects on the environment (Gervanesi and Colombo, 1997).
Economic impact	The economic impact on fruits (grape, pear, apple, citrus, peach, etc.) is mainly due to the mould developing on honeydew, which renders them unfit for sale. High infestations on soyabean in northern Italy led to 30-40% crop losses (Ciampolini et al., 1987).

Management options

Chemical insecticides are effective against *M. pruinosa*, but their use is problematic. Several treatments are required because of a protracted hatching period. Furthermore, since this insect is highly polyphagous, it is found in refuges along orchards and commercial fields, from where it can continuously invade the crop. Because of its wide occurrence honeybees and other pollinators, which could be affected by insecticidal treatments, commonly use its honeydew. Soap solutions cause almost all of the young stages of the pest to fall to the ground, but in the absence of insecticide treatments, the colonies reform 8-10 days later. In Europe, its natural enemy complex is limited. A North American dryinid parasitoid, *Neodryinus typhlocybae* Ashmead has been introduced into Italy, France and Slovenia, and the first results are promising (Frilli et al., 2001). The same parasitoid has been released in the Ticino (Jermini et al., 2000), but its establishment needs to be monitored.

Information gaps

The spread of *M. pruinosa* within Switzerland should be monitored, as well as the level of economic and environmental damage. The potential economic impact can be assessed by comparison with Italy, but the environmental impact is unknown and may be larger than expected. The establishment and impact of the parasitoid introduced in the Ticino should be assessed.

References

Literature

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Ciampolini, M., Grossi, A. and G. Zottarelli (1987) Danni alla soia per attachi di *Metcalfa pruinosa*. Informatore Agrario 43, 101-

103.
Frilli, F., Villani, A. and P. Zandigiacomo (2001) *Neodryinus typhlocybae* (Ashmead) antagonista di *Metcalfa pruinosa* (Say). Risultati di liberazioni pluriennali effettuate in Friuli-Venezia Giulia. Entomologica 35, 27-38.

Gervanesi, E. and Colombo, M. (1997) *Metcalfa pruinosa* nei vivai, nell'ambitourbano e in apicoltura. Informatore Agrario 7, 95-98.

Jermini, M., Brunetti, R. and M. Bonavia (2000). Introduzione di *Neodryinus typhlocybae* per il contenimento biologico di *Metcalfa pruinosa*: Prime esperienze in Svizzera. Sherwood - Foreste ed Alberi Oggi, Supplemento 55, 18-20.

Bonavia, M. and M. Jermini (1998) La cicadelle *Metcalfa pruinosa* Say au Tessin. Distribution actuelle, dynamique des populations et perspective de lutte. Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 30, 169-172.

Lucchi, A. and L. Santini (1993) Note morfo-biologiche sugli stadi preimmaginali di Metcalfa pruinosa (Say) (Homoptera, Flatidae). Frustula Entomologica 16, 175-185.

Metcalf, Z.P. and S.C. Bruner (1948) Cuban Flatidae with new species from adjacent regions. Annals of the Entomological Society of America 41, 63-118.

Pantaleoni, R.A. (1989) Modalità d'invasione di un nuovo areale in *Metcalfa pruinosa* (Say, 1830) (Auchenorrhyncha Flatidae). Bollettino dell'Istituto di Entomologia 'Guido Grandi' della Universita degli Studi di Bologna 43, 1-7.

Frilli, F., Villani, A. and P. Zandigiacomo (2001) *Neodryinus typhlocybae* (Ashmead) antagonista di *Metcalfa pruinosa* (Say). Risultati di liberazioni pluriennali effettuate in Friuli-Venezia Giulia. Entomologica 35, 27-38.

Pulvinaria regalis

Taxonomic status

Scientific name	*Pulvinaria regalis* Canard
Synonyms	
Taxonomic position	Hemiptera: Coccidae
English name	Horse chestnut scale
German name	Wollige Napfschildlaus
French name	Cochenille pulvinaire
Italian name	

Description and identification

Description and similar species	The adult scales are dark brown, flattish, round and about 4 mm in diameter. They are found on the edge of white egg masses on the bark of trunks and branches. The nymphs on the foliage are pale yellow and oval in shape. At outbreak density, *P. regalis* can be recognized by their white egg masses covering the trunk and the main branches in spring and in summer. However, other scales feed on the same trees in Europe, and some of them may produce similar egg masses. In particular, two other closely related species, probably of Asian origin, occur in Switzerland on similar ornamental trees: *Eupulvinaria hydrangeae* (Steinweden) and *Chloropulvinaria floccifera* (Westwood). Jansen (2000) compares the morphology and biology of the three species.

Biology and ecology

Life cycle	The scale is univoltine. Crawlers hatch in May and June and move to leaves of the host tree. Nymphs feed on leaves until September/October and then migrate to twigs where they overwinter in the third instar. In spring, newly emerged females first feed, then move to the main branches and the trunk to lay eggs (Hippe and Frey, 1999).
Host plant	*P. regalis* feeds on at least 61 plant species belonging to 24 families (Schmitz, 1997). Heavy infestations occur mainly on *Aesculus*, *Tilia* and *Acer*.
Habitat	Mainly ornamental trees in urban and suburban areas or along roads.

Origin	Unknown, probably from the Far East, but so far found only in Europe.

Introduction and dispersal

History of introduction	First found in London in 1964. Subsequently observed in France, Belgium, the Netherlands, Germany, Ireland and Switzerland, where it was first observed in 1992 (Hippe and Frey, 1999).
Pathways of introduction	Unknown, probably on host plants from the region of origin.
Dispersal	Crawlers can be transported by wind. Host plant transportation is probably another important mode of dispersal.

Current status

Actual and potential distribution in CH	The scale was observed in the Valais in 1992 and produced severe outbreaks on *Aesculus* and *Tilia* in Zürich in 1997. *P. regalis* is probably fairly widespread in Switzerland. It has the potential to invade most of Switzerland.
Distribution in Europe	UK, Ireland, France, Belgium, the Netherlands, Germany and Switzerland.

Impacts

Damage on plant — *P. regalis* does not kill the trees, but outbreaks have a considerable impact on the growth, particularly of young trees (Speight, 1991).

Environmental impact — The occurrence and incidence of the scale in natural habitats is unclear, and its interaction with the native fauna is not known.

Economical impact — Besides growth reduction, the scale also causes aesthetic damage to ornamental trees. Additionally, it produces high quantities of honeydew that may become a nuisance in urban areas.

Management options — The use of insecticides is possible, but difficult in urban areas. In spring, egg masses on trunks and branches can be washed off with water using a high-pressure cleaner. On small plants, mature scales and their eggs can be scraped or wiped from the stems.

Information gaps — The distribution in Switzerland is unknown, as is the occurrence and incidence of the scale in natural environments, such as forests, in Europe.

References

Literature

Hippe, C. and J.E. Frey (1999) Biology of the horse chestnut scale, *Pulvinaria regalis* Canard (Hemiptera: Coccoidea: Coccidae), in Switzerland. Entomologica 33, 305-309.

Jansen, M.G.M. (2000) The species of *Pulvinaria* in the Netherlands (Hemiptera: Coccidae). Entomologische Berichten 60, 1-11.

Schmitz, G. (1997) Zum Wirtspflanzenspektrum von *Pulvinaria regalis* Canard (Hom., Coccidae). Gesunde Pflanzen 49, 43-46.

Speight, M.R. The impact of leaf-feeding by nymphs of the horse chestnut scale, *Pulvinaria regalis* Canard (Hom.: Coccidae), on young host trees. Journal of Applied Entomology 112, 389-399.

Quadraspidiotus perniciosus

Taxonomic status

Scientific name	*Quadraspidiotus perniciosus* (Comstock)
Synonyms	*Diaspidiotus perniciosus* (Comstock)
Taxonomic status	Homoptera: Diaspididae
English name	San José scale
German name	San José Schildlaus
French name	Pou de San José
Italian name	Pidochio di San José

Description and identification

Description and similar species	Diaspididae are difficult to identify. Determination requires microscopic observation. The female is circular, grey and about 2 mm in diameter. The male has only forewings present. The larvae are variable, depending on stage and sex, and can be white to black, round to elongate, fixed scales or little mobile yellow organisms. All stages of development and symptoms are described in CABI/EPPO (1997) and CABI (2001). Kosztarab and Kozár (1988) provide descriptions and keys for all scales in Central Europe, including *Q. perniciosus* and congeneric species.

Biology and ecology

Life cycle	The number of generations depends on climatic conditions. In Switzerland, there are usually 2 complete generations and 1 partial generation per year. The winter is usually spent in the first larval stage. Development starts in early spring. Males have 2 larval instars, a prepupal and a pupal stage. Females become adult after the second moult and gradually increase in size. Males are winged and fly, but lack mouthparts, whereas females remain stationary and feed. Females are viviparous and produce larvae 30-40 days after copulation. The first instar crawls to find new host tissues. Then, it attaches itself and secretes a waxy substance which forms the scale cover (CABI/EPPO, 1997).
Host plant	*Q. perniciosus* is a highly polyphagous species. The main hosts are apples, peaches, pears, plums and *Rubus*, but it can attack many other deciduous trees and shrubs (see lists in CABI/EPPO, 1997, and CABI, 2001).
Habitat	Due to its polyphagy, *Q. perniciosus* can invade most habitats.

Origin Eastern Asia

Introduction and dispersal

History of introduction	It was first introduced into California in the 19th century, from where it spread to the whole North American continent. It is also present in many Asian, African and South American countries, as well as in New Zealand and Australia. It was first discovered in Hungary and Italy in 1928, and in Switzerland in 1946. The spread of the scale in Europe and Switzerland is described in Mani et al. (1995).
Pathways of introduction	International spread probably occurs through human-mediated transport of planting material of trees and shrubs, or fruits.
Dispersal	The crawling first instar larvae are the main dispersal stage and can be carried a few kilometres by wind. Adult males, but not females, can also be carried by wind.

Current status

Actual and Potential distribution in CH	It is already distributed in large parts of Switzerland (Mani et al., 1995). *Q. perniciosus* has the potential to invade most Swiss regions and habitats, except at high elevation.
Distribution in Europe	It is present in most European countries, although in many of them it has not yet reached its potential distribution. See CABI/EPPO (1997) and CABI (2001) for a complete distribution range.

Impacts

Damage on plant	Various young host plant tissues are affected. Attacks occur on wood mainly, but also on leaves and fruits. The insect injects toxic saliva, causing localized discolouration. It can kill a young tree in 2-3 years in the absence of control. Older trees are weakened and growth is reduced, as well as fruit production and quality.
Environmental impact	Little is known of the environmental impact of *Q. perniciosus*. However, since its host range includes many wild trees and shrub species and, given its small size, it is likely that its impact on economically unimportant plants is underestimated. High population levels may also exert an influence on populations of native scales through the sharing of natural enemies.
Economic impact	*Q. perniciosus* is the main orchard pest in California and other North American regions. It is also considered a serious orchard pest in several European countries. It kills young trees, and reduces growth and fruit quality and marketability. In its region of origin, the pest causes little damage.

Management options

Mineral oil can be applied in winter against overwintering stages, and pesticides during the growing season. Sex pheromone traps are used to monitor the timing and level of attack. Biological control with the aphelinid wasp *Encarsia perniciosi* (Tower) has been carried out in various regions, including Switzerland (Mani and Baroffio, 1997) with varying degrees of success.

Information gaps

Little is known of its abundance and impact on non-commercial host plants.

References

Literature

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G., Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Kosztarab, M. and F. Kozár (1988) Scale insects of Central Europe.Akadémiai Kiadó, Budapest, Hungary.

Mani, E. and C. Baroffio (1997) Biologische Bekämpfung der San-José-Schildlaus im Kanton Zug mit der Schlupfwespe *Encarsia perniciosi*. Schweizerische Zeitschrift für Obst- und Weinbau 133, 392-394.

Mani, E., Schwaller, F., Baroffio, C. and C. Hippe (1995) Die San-José-Schildlaus in der deutschen Schweiz: Wo stehen wir heute? Schweizerische Zeitschrift für Obst- und Weinbau 131, 264-267.

Reticulitermes spp.

Taxonomic status

Scientific name	*Reticulitermes* spp.
Synonyms	
Taxonomic position	Isoptera: Rhinotermitidae
English name	Subterranean termite
German name	Bodentermite
French name	Termite souterrain
Italian name	termite sotterranea

Description and identification

Description and similar species

The genus *Reticulitermes* is represented by several species in Europe, America and Asia. One species, *R. flavipes* (Kollar) is of North American origin and has been introduced into some cities in Germany and Austria (Sellenschlo, 1988). A complex of closely related species with uncertain taxonomic status occurs in southern Europe. A recent work (Clément et al., 2001) recognized 6 species: *R. santonensis* de Feytaud (perhaps synonymous with *R. flavipes*) in western France, *R. grassei* Clément in south-western France, north-western and southern Spain and Portugal, *R. banyulensis* Clément in north-eastern Spain, the central area of the Iberian Peninsula and south-western France, *R. lucifugus* (Rossi) in Italy and south-eastern France, *R. balkanensis* Clément in the Balkans and *Reticulitermes* sp. nov. in northern Italy and south-eastern France. Clement et al. (2001) provide characters to separate these species.

Biology and ecology

Life cycle

In common with all termites, *Reticulitermes* spp. are social, living in colonies in the soil. These colonies contain various castes: workers, soldiers, alate reproductives and replacement reproductives. The latter are particularly numerous in *Reticulitermes* spp. and allow the species to build up colonies of millions of individuals. Nests are built in the ground, usually in a humid environment. Workers bore into wood in contact with the ground to feed the colony. Dry wood (e.g. building structures) as well as living trees or other sources of cellulose can be attacked. For additional information on the biology and ecology of termites, see Pearce (1997).

Habitat

Mainly urban areas.

Origin

R. flavipes originates in eastern North America. The other species mentioned above are native in southern Europe, but there are indications suggesting that *R. santonensis* is an introduced species, perhaps synonymous with the North American *R. flavipes* (Vieau, 2001).

Introduction and dispersal

History of introduction

The North American species *R. flavipes* has been introduced into Germany and Austria. The southern European species are expanding their range further north, in particular *R. santonensis*, which has now reached northern France, and *R. grassei*, which is established in southern England.

Pathways of introduction

Long-distance transportation is due to human activities (e.g. transportation of demolition waste, construction timbers, packing

	cases, etc.).
Dispersal	The alates swarm to build new colonies.

Current status

Actual and Potential distribution in CH	Termites are not yet established in Switzerland. The potential distribution includes most regions at low altitude, but warmer regions such as the Ticino and the Valais, or the urban areas around the Lac de Genève and Basel are particularly at risk.
Distribution in Europe	Subterranean termites are still restricted to Mediterranean countries (see Clement et al., 2001 for an exact distribution), except *R. flavipes* which is established in Germany and Austria, and*R. grassei* which is established in southern England. The southern European species are expanding their range further north, in particular *R. santonensis* (perhaps in fact the introduced *R. flavipes*), which has now reached northern France.

Impacts

Damage on plant	Termites are particularly harmful to wooden elements in buildings but can also attack living trees, as observed with street trees in Paris recently (Lohou, 1997).
Environmental impact	In nature, indigenous termites are beneficial, by recycling dead trees and other wood material. The impact of *Reticulitermes* spp. on the soil fauna and flora in newly invaded areas in Europe has not been studied.
Economic impact	Termites, including *Reticultermes* spp., have huge economic impacts worldwide. In the USA, subterranean termites are believed to cause more than US$2 billion in damage each year. In France, the recent spread of the southern *Reticulitermes* spp. has caused major concern. New regulations were set up to limit the spread.

Management options

Management options are numerous and include both prevention and control methods. Building chemical or physical barriers can achieve prevention before and after construction (e.g. chemical wood treatment or steel mesh). Preventing moisture in the soil and in construction structures is an alternative strategy. Curative methods include termiticide injections, baits, trapping methods, etc. The potential of biological control agents such as the entomophagous fungus *Metarhizium anisopliae* is presently being investigated. Details of management methods for termites can be found in Pearce (1997) and Kard (2003).

Information gaps

References

Literature

Clément, J. L., Bagnères, A.G., Uva, P., Wilfert, l., Quintana, A., Reinhard, J. and S. Dronnet (2001) Biosystematics of *Reticulitermes* termites in Europe: morphological, chemical and molecular data. Insectes Sociaux 48, 202-215.

Kard, B.M. (2003) Integrated pest management of subterranean termites (Isoptera). Journal of Entomological Science 38, 200-224.

Lohou, C., Burban, G., Clément, J.L., Jequel, M. and J.L. Leca (1997) Protection des arbres d'alignement contre les termites souterrains. L'expérience menée à Paris. Phytoma 49, 42-44.

Pearce, M.J. (1997) Termites. Biology and Pest management. CAB Intenational, Wallingford, UK, 172 pp.

Sellenschlo, U. (1988) Termiten in Hamburg. Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz 61, pp. 105-108.

Vieau, F. (2001) Comparison of the spatial distribution and reproductive cycle of *Reticulitermes santonensis* Feytaud and *Reticulitermes lucifugus grassei* Clément (Isoptera, Rhinotermitidae) suggests that they represent introduced and native species, respectively. Insectes Sociaux 48, 57-62.

Rhagoletis completa

Taxonomic status

Scientific name	*Rhagoletis completa* Cresson
Synonyms	
Order: Family	Diptera: Tephritidae
English name	Walnut husk fly
German name	Amerikanische Walnuss-Fruchtfliege
French name	Mouche des brous du noyer
Italian name	Mosca delle noci

Description and identification

Description	Adults are yellow-orange flies with black stripes on wings, 4-8 mm long. The wing venation is characteristic. White and Elson-Harris (1992) provide a complete description of adults and larvae, as well as keys to the genus *Rhagoletis* and to the tephritid species of economic importance. Foote et al. (1993) provide a full key to North American *Rhagoletis* species.
Similar species	Many congeneric species exist in Europe, but none of these attacks walnut. Another North American species, *R.cingulata* (Loew) (previously identified as *R. indifferens* Curran), a pest of cherry, was found at the same time in the Ticino in Switzerland (Merz, 1991) but, so far population levels have remained very low, and it does not seem to spread like *R. completa*. This species, however, is potentially more harmful than *R. completa*, because of the economic importance of cherry trees and because of its ability to attack native *Prunus* spp.

Biology and ecology

Life cycle	*R. completa* overwinters in its puparium in the soil. Adults fly in summer, and can live up to 40 days. Eggs are laid under the skin of the host fruit and hatch after 3-7 days. Larvae feed for 2-5 weeks, usually in the mesocarp. There is only 1 generation per year.
Host plant	Mainly *Juglans* spp. (walnuts), but occasionally attacks on peach (*Prunus persica* (L.) are observed. In Switzerland, damage was found on *Juglans regia* L.
Habitat	Linked to the habitat of its main hosts, *Juglans* spp.

Origin North America

Introduction and dispersal

History of introduction	First found in Switzerland and Italy in the 1980s (Merz, 1991; Ciampolini and Trematerra, 1992). Since then, also collected in Slovenia.
Pathways of introduction	The pathway of introduction into Italy and/or Switzerland is unknown, but transport of larvae-infested fruit was probably responsible. There is also a risk that puparia can be transported in soil or packaging with plants that have already fruited.
Dispersal	Adults can fly, but only a short distance. The main mode of dispersal is probably human-mediated transport.

Current status

Actual and potential distribution in CH	The fly is now widespread in the Ticino (Mani et al., 1994) and is present in several areas north of the Alps, including VS, GR, UR, ZH, etc. (FAW, web site). It could probably survive in most of Switzerland, except in high elevation regions.

Distribution in Europe — Italy, Switzerland and Slovenia

Impacts

Damage on plant — Attacked fruits are pitted by oviposition punctures around which discolouration usually occurs. Larvae usually feed on the mesocarp, but at high density larvae also damage the pericarp and the nut itself.

Environmental impact — The environmental impact is not known, but it is likely to be low in Switzerland, since its main host, *J. regia*, is also an exotic species. Furthermore, in most cases, the nut itself is not damaged. However, populations are increasing in Switzerland and Italy, which may lead to unexpected consequences, i.e. the adoption of new host trees (the European walnut *J. regia* has already been adopted in Europe whereas it is rarely attacked in North America), and indirect environmental effects through the incorporation of *R. completa* into natural food webs.

Economic impact — Walnuts attacked by the fly become unfit for sale, because of the discolouration of the nut. It is a major pest of walnut in the USA. Since its introduction into Switzerand and Italy, its populations are increasing, and severe damage has been observed in both countries, with up to 100% of harvested walnuts infested in some orchards (Romani, 1998).

Management options — Control methods are discussed in CABI/EPPO (1997). Various chemical treatments are effective against *R. completa*, but no pesticide is registered against this pest in Switzerland. Attacked fruits should be removed and destroyed before the larva emerges. Covering the soil under trees could prevent the larvae from entering the soil and pupating. Yellow sticky traps baited with ammonia can be used as a monitoring method, but are not efficient as a control method.

Information gaps — Populations are increasing in Switzerland, while the potential level of damage is not known.

References

Literature

CABI/EPPO (1997) Quarantine Pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G., Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

Ciampolini, M. and P. Trematerra (1992) Diffusa presenza di mosca delle noci (*Rhagoletis completa* Cresson) nel nord Italia. Informatore Agrario 48 (48), 52-56.

FAW (website) http://www.faw.ch/Foren/steinobstforum/nuss.html

Mani E., Merz, B., Brunetti, R., Schaub, L., Jermini, M. and F. Schwaller (1994) Zum Auftreten der beiden amerikanischen Fruchtfliegenarten *Rhagoletis completa* Cresson und *Rhagoletis indifferens* Curran in der Schweiz (Diptera: Tephritidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 67, 177-182.

Merz, B. (1991) *Rhagoletis completa* Cresson und *Rhagoletis indifferens* Curran, zwei wirtschaftlich bedeutende nordamerikanische Fruchtfliegen, neu für Europa (Diptera: Tephritidae). Mitteilungen der Schweizerischen Entomologischen Gesellschaft 64, 55-47.

Romani, M. (1998) Gravi attacchi di *Rhagoletis completa* nei noceti lombardi. Informatore Fitopatologico 48 (11), 13-16.

Xylosandrus germanus

Taxonomic status

Scientific name	*Xylosandrus germanus* (Blandford)
Taxonomic position	Scolytidae
English name	Ambrosia beetle
German name	Schwarzer Nutzholzborkenkäfer
French name	Bostryche noir du Japon
Italian name	

Description and identification

Description	*Xylosandrus germanus* is a small scolytid beetle. Females are black, 2-2.5 mm long. Males are brown, 1-1.8 mm long. Males are rarely found. An easy identification character is the typical bore dust (white 'sticks' up to 2 cm long) found on the infested trees in summer.
Similar species	Only one other congeneric species, *X. morigerus* Blandford occurs in Europe, on Orchidaceae in greenhouses. The most similar species found in sapwood is another ambrosia beetle, *Xyleborus dispar* (F.). The species can be easily separated by the shape of the declivity of the elytra (sharp in *Xylosandrus germanus*, smooth in *Xyleborus dispar*), and by the typical bore dust of *Xylosandrus germanus*.

Biology and ecology

Life cycle	Females fly from May to summer. They bore a gallery in trunks, usually of freshly cut trees, and lay eggs in a brood chamber situated 2-3 cm deep in the wood. Larvae bore lateral galleries. Adults and larvae feed on an 'ambrosia' fungus introduced into the gallery by the female. Pupation occurs in the wood, as well as mating. Males die soon after mating and females overwinter in galleries. In Central Europe, only 1 generation per year is observed but 2 generations per year are reported from North America.
Food	*X. germanus* is highly polyphagous. Most broadleaf species are susceptible as well as spruce (*Picea*), fir (*Abies*) and pine (*Pinus*). Most attacks occur on freshly felled trees.
Habitat	Forests

Origin Eastern Asia (Japan, Korea, China, Viet Nam)

Introduction and dispersal

History of introduction	First introduced into North America (USA, Canada) in the 1930s. It was first found in Germany in 1952, from where it spread to France, Switzerland, Austria, Belgium and Italy. The first record in Switzerland was from Basel in 1984.
Pathways of introduction	Probably by timber importation.
Dispersal	Females fly to new infestation sites, but the main mode of spread is probably wood transportation.

Current status

Actual and potential distribution in CH	Present in most regions, with the possible exception of the Lemanic region and the Valais. Rare above 1,200 m above sea level. Especially prevalent in the Central Plateau and northern Jura. All regions below 1,200 m altitude are at risk.
Distribution in Europe	Germany, France, Switzerland, Austria, Belgium and Italy.

Impacts

Damage on plant: The beetle mainly attacks freshly cut logs, both with and without bark. Living trees are rarely attacked in Switzerland, but in the USA damage is frequently observed on living black walnut trees (*Juglans nigra* L.) and other broadleaf trees. Associations were reported between *X. germanus* and fungi, causing dieback and resprouting from the base of the tree. A similar association was observed in Italy on European walnut (*J. regia* L.), where *X. germanus* was recently found.

Environmental impact: Environmental impacts of *X. germanus* have never been studied.

Economic impact: Galleries in the wood reduce timber quality, although *X. germanus* does not bore as deeply as other wood-boring scolytids, such as *Trypodendron lineatum* (Olivier). In 1995 alone, about 20,000 m^3 of round timber were attacked by *X. germanus* in Switzerland, causing an economic loss of about SFR 1 million.

Management options

X. germanus is fairly resistant to the insecticides used to protect logs against other wood-boring insects. Bark removal is not very effective because the beetle can also attack debarked logs. Rapid removal of timber from the forest (just-in-time felling) is the best prevention method. Wet storage can also prevent beetle attack. Infested timber storage sites should not be used for storage the following year.

Information gaps

The environmental impacts are unknown, in particular ecological interactions with other bark and wood-boring beetles. In addition little is known in Europe of the level of attack on living trees and its possible association with tree diseases.

References

Literature

Graf, E. and P. Manser (2000) Beitrag zum eingeschleppten Schwarzen Nutzholzborkenkäfer *Xylosandrus germanus*. Biologie und Schadenpotential an im Wald gelagertem Rundholz im Vergleich zu *Xyloterus lineatus* und *Hylecoetus dermestoides*. Schweizerische Zeitschrift für Forstwesen 151, 271-281.

Jansen, E. and B. Forster (1991) Der Schwarze Nutzholzborkenkäfer (*Xylosandrus germanus*) - Ein eingeschleppter Lagerholz-Schädling. PBMD-Bulletin August 1991, 6 pp.

Maksymov, J.K. (1987) Erstmaliger Massenbefall des Schwarzen Nutzholzborkenkäfers, *Xylosandrus germanus* Blandf., in der Schweiz. Schweizerische Zeitschrift für Forstwesen 138, 215-227.

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
COLEOPTERA			
Anobiidae			
Lasioderma serricorne (F.)	Stored products, especially tobacco	Tropics and subtropics	C.Besuchet, pers. comm.
Stegobium paniceum (L.)	Stored products, very polyphagous	Cosmopolitan	Lucht, 1987
Oligomerus ptilinoides (Wollaston)	Feeds on wood products	Mediterranean region, possibly native	C. Besuchet, pers. comm.
Anthicidae			
Stricticomus tobias Marseul	Feeds on rotten plant tissue	Asia Minor, Central Asia, India	C. Besuchet, pers. comm.
Apionidae			
Alocentron curvirostre (Gyllenhal)	In stems of *Alcea rosea* L.	Asia, Middle East	C. Besuchet, pers. comm.
Aspidapion validum (Germar)	In fruits of *Alcea rosea*	Asia, Middle East	C. Besuchet, pers. comm.
Rhopalapion longirostre (Olivier)	In seeds of *Alcea rosea*	Asia, Middle East	C. Besuchet, pers. comm.
Bostrichidae			
Rhyzoperta dominica (F.)	Stored products, mainly cereals	Tropics and subtropics	C. Besuchet, pers. comm.
Bruchidae			
Acanthoscelides obtectus (Say)	In leguminous seeds, mainly beans	South and Central America	Lucht, 1987
Acanthoscelides pallidipennis (Motschulsky)	In seeds of *Amorpha fruticosa*	North America	C. Besuchet, pers. comm.
Bruchus pisorum (L.)	In peas	North America or Near East	Lucht, 1987
Callosobruchus chinensis (L.)	In leguminous seeds	East Asia	C. Besuchet, pers. comm.

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Buprestidae			
Agrilus guerini Lacordaire	Xylophagous, on *Salix*	Eastern Europe, Russia?	Barbalat and Wermelinger, 1996
Carabidae			
Perigona nigriceps (Dejean)	Predator, in various environments	South Asia	Lucht, 1987
Cerambycidae			
Gracilia minuta (F.)	Xylophagous, polyphagous, often found in wicker	Mediterranean region	Lucht, 1987
Nathrius brevipennis (Mulsant)	Xylophagous, polyphagous, often found in wicker	Mediterranean region	Lucht, 1987
Neoclytus acuminatus (F)	Xylophagous, on *Fraxinus*, Ticino	North America	C. Besuchet, pers. comm.
Phymatodes lividus (Rossi)	Xylophagous, on broadleaved trees	Mediterranean region	C. Besuchet, pers. comm.
Xylotrechus stebbingi Gahan	Xylophagous, polyphagous, on aspen in Ticino	Himalayas	C. Besuchet, pers. comm.
Cerylonidae			
Murmidius ovalis (Beck)	Stored products, especially mouldy cereals, hay, etc.	Cosmopolitan	C. Besuchet, pers. comm.
Chrysomelidae			
Diabrotica virgifera virgifera LeConte	Pest on Maize, root feeder, Ticino	Mexico, Central America	Mario et al., 2001
Leptinotarsa decemlineata (Say)	Defoliator, pest on Solanaceae	North America	Lucht, 1987
Cleridae			
Korynetes caeruleus (De Geer)	Predator on anobiids in wood	Cosmopolitan	Lucht, 1987
Necrobia ruficollis (F.)	Domestic, insect predator	Cosmopolitan	Lucht, 1987
Necrobia rufipes (De Geer)	Domestic, in stored products, also predator	Tropics, subtropics	Lucht, 1987
Necrobia violacea (L.)	Mainly domestic, also on cadavers	Cosmopolitan	Lucht, 1987

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Tarsostenus univittatus (Rossi)	Predator in wood, found in Genève only	Cosmopolitan	C. Besuchet, pers. comm.
Coccinellidae			
Harmonia axyridis (Pallas)	Polyphagous predator (perhaps not yet established)	East Asia	Klausnitzer, 2004
Rodolia cardinalis (Mulsant)	Predator of scale insects, released and established in Ticino	Australia	C. Besuchet, pers. comm.
Colydiidae			
Myrmecoxenus vaporariorum Guerin-Meneville	In greenhouses, manure, compost, etc.	Unclear	Lucht, 1987
Cryptophagidae			
Atomaria lewisi Reitter	In decaying plant material	East Asia	Lucht, 1987
Caenoscelis subdeplanata Brisout de Barneville	In decaying wood and plant material	North America	C. Besuchet, pers. comm.
Cucujidae			
Cryptolestes ferrugineus (Stephens)	Stored products, mainly cereal grains	Cosmopolitan	Lucht, 1987
Cryptolestes spartii (Curtis)	Stored products	Cosmopolitan	C. Besuchet, pers. comm.
Cryptolestes turcicus (Grouvelle)	Domestic, on plant products	Perhaps Turkey	C. Besuchet, pers. comm.
Curculionidae			
Pentarthrum huttoni Wollaston	Decaying wood	South-western Europe (native?)	C. Besuchet, pers. comm.
Sitophilus granarius (L.)	Stored products	India	Lucht, 1987
Sitophilus oryzae (L.)	Stored products	Asia	Lucht, 1987
Sitophilus zeamais Motschulsky	Stored products	Asia	C. Besuchet, pers. comm.

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Dermestidae			
Anthrenus festivus Rosenhauer	Domestic	Mediterranean region	C. Besuchet, pers. comm.
Anthrenus flavipes LeConte	Domestic, feeds on furnitures, fabrics, etc.	Cosmopolitan (Mediterranean region?)	C. Besuchet, pers. comm.
Attagenus brunneus Faldermann	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus quadrimaculatus Kraatz	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus rossi Ganglbauer	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus smirnovi Zhantiev	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus unicolor (Brahm)	Domestic, feeds mainly on fabrics	Africa	Lucht, 1987
Dermester ater DeGeer	Domestic, on animal products, fabrics, etc.	Cosmopolitan (southern Europe?)	C. Besuchet, pers. comm.
Dermestes maculatus DeGeer	Domestic, on animal products	Cosmopolitan (North America?)	Lucht, 1987
Dermestes peruvianus La Porte de C.	Domestic, on animal products, fabrics, etc.	Central and South America	C. Besuchet, pers. comm.
Reesa vespulae (Milliron)	Domestic and in museum collections	North America	C. Besuchet, pers. comm.
Trogoderma angustum (Solier)	Domestic and in museum collections	South America	C. Besuchet, pers. comm.
Trogoderma glabrum Herbst	Domestic and in nests of solitary wasps	Cosmopolitan (native?)	Lucht, 1987
Trogoderma granarium Everts	Stored products, especially cereals	India	C. Besuchet, pers. comm.
Trogoderma versicolor (Creutzer)	Domestic and in museum collections	Cosmopolitan	Lucht, 1987
Histeridae			
Carcinops pumilio Erichson	Predator on Diptera	Cosmopolitan	Lucht, 1987

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Hydrophilidae			
Cercyon laminatus Sharp	In various humid environments	East Asia	Lucht, 1987
Cryptopleurum subtile Sharp	In various humid environments	East Asia	Lucht, 1987
Languriidae			
Cryptophilus integer (Heer)	On decaying plant material	Cosmopolitan	Lucht, 1987
Latridiidae			
Adistemia watsoni (Wollaston)	Feeds on fungus, found in herbarium	Cosmopolitan	Lucht, 1987
Corticaria ferruginea Marsham	On fungus, on decaying plant material	Cosmopolitan	C. Besuchet, pers. comm.
Corticaria fulva (Comolli)	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Corticaria pubescens Gyllenhal	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Corticaria serrata Paykull	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Dienerella filum (Aubé)	On fungus, on decaying plant material	Central America	Lucht, 1987
Lathridius minutus (L.)	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Migneauxia orientalis Reitter	On fungus, on decaying plant material	Mediterranean region	C. Besuchet, pers. comm.
Stephostetus (= *Aridius*) *bifasciatus* (Reitter)	Feeds on fungus in various environments	Australia	C. Besuchet, pers. comm.
Stephostetus nodifer (Westwood)	Feeds on fungus in various environments	New Zealand	Lucht, 1987
Thes bergrothi (Reitter)	On fungus, on decaying plant material	North-eastern Europe	C. Besuchet, pers. comm.
Lyctidae			
Lyctus africanus Lesne	Domestic, in wood	Africa	C. Besuchet, pers. comm.
Lyctus brunneus (Stephens)	Domestic, in tropical wood	South-east Asia	Lucht, 1987

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Lyctus cavicollis Le Conte	Domestic, in wood	North America	C. Besuchet, pers. comm.
Merophysiidae			
Holoparamecus caularum (Aubé)	On fungus, on decaying plant material	Cosmopolitan	C. Besuchet, pers. comm.
Mycetophagidae			
Berginus tamarisci Wollaston	Found on pine trees in Switzerland	Canary Islands	C. Besuchet, pers. comm.
Litargus balteatus Le Conte	On fungus, on decaying plants, e.g. cereals	North America	C. Besuchet, pers. comm.
Typhaea stercorea (L.)	On fungus, on decaying plants, e.g. cereals	North America	Lucht, 1987
Nitidulidae			
Carpophilus dimidiatus (F.)	On stored products and cultivated fields, mainly cereals	North America	C. Besuchet, pers. comm.
Carpophilus hemipterus (L.)	Feeds on fruits, dry fruits, cereals	Cosmopolitan	Lucht, 1987
Carpophilus marginellus Motschulsky	Mainly domestic, on cereals	South-east Asia	C. Besuchet, pers. comm.
Carpophilus quadrisignatus Erichson	Feeds on dry fruits	Probably America	C. Besuchet, pers. comm.
Glischrochilus fasciatus (Olivier)	Feeds on vegetables, fruits, etc.	North America	C. Besuchet, pers. comm.
Glischrochilus quadrisignatus (Say)	Feeds on vegetables, fruits, etc.	North and Central America	C. Besuchet, pers. comm.
Urophorus rubripennis (Heer)	Under oak bark and on Apiaceae	Perhaps Mediterranean region	C. Besuchet, pers. comm.
Orthoperidae			
Orthoperus aequalis Sharp	In compost, in Ticino	Hawaii	C. Besuchet, pers. comm.
Ostomidae			
Tenebroides mauritanicus (L.)	On stored products, especially cereals	Africa	Lucht, 1987

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Ptiliidae			
Acrotrichis insularis (Maeklin)	In organic matters, from Vaud and Weissenstein	North America	C. Besuchet, pers. comm.
Acrotrichis sanctaehelenae Johnson	In organic matters, Ticino	St Helena, Africa?	C. Besuchet, pers. comm.
Ptilodactylidae			
Ptilodactyla exotica Chapin	Domestic, indoor plants	North America	C. Besuchet, pers. comm.
Ptinidae			
Gibbium psylloides (Czempinski)	Domestic, on stored products	Cosmopolitan	Lucht, 1987
Niptus hololeucus (Faldermann)	Domestic, feeds on fabrics	Asia Minor, southern Russia	Lucht, 1987
Ptinus tectus Boieldieu	Domestic, on stored products	Australia, New Zealand	Lucht, 1987
Epauloecus (=Tipnus) unicolor (Piller & Mitt.)	In barns, cowshed, animal burrows, etc	Cosmopolitan	Lucht, 1987
Scolytidae			
Gnathotrichus materiarius (Fitch)	Xylophagous, on conifers	North America	Hirschheydt, 1992
Phloeosinus aubei (Perris)	Xylophagous, on Cupressaceae	Mediterranean region	Lucht, 1987
Tripodendron laeve Eggers	Xylophagous, on *Picea*	East Asia, Scandinavia	C. Besuchet, pers. comm.
Xyleborinus alni (Niisima)	Xylophagous, on broadleaved trees	East Asia	C. Besuchet, pers. comm.
Xyleborus punctulatus Kurentzov	Xylophagous, on broadleaved trees	Siberia	C. Besuchet, pers. comm.
Xylosandrus germanus (Blandford)	Xylophagous, polyphagous	East Asia	Lucht, 1987
Silvanidae			
Ahasverus advena (Waltl)	Feeds on fungus on rotten stored products	South America	Lucht, 1987

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Oryzaephilus mercator (Fauvel)	On stored products, polyphagous	Tropics	C. Besuchet, pers. comm.
Oryzaephilus surinamensis (L.)	On stored products, polyphagous	Cosmopolitan	Lucht, 1987
Staphylinidae			
Acrotona pseudotenera (Cameron)	Mouldy hay	East Asia	C. Besuchet, pers. comm.
Carpelimus zealandicus (Sharp)	Sandy banks	New Zealand	C. Besuchet, pers. comm.
Edaphus beszedesi Reitter	Compost, rotting plant material	Pehaps Mediterranean region	Lucht, 1987
Leptoplectus remyi Jeannel	Unclear, found in Ticino	Asia	C. Besuchet, pers. comm.
Lithocharis nigriceps (Kraatz)	Compost, rotting plant material	Asia	Lucht, 1987
Micropeplus marietti Jaquelin Du Val	Waste land, fallow land	Southern Europe, Caucasus	C. Besuchet, pers. comm.
Oligota parva Kraatz	Domestic, in compost	South America	Lucht, 1987
Oxytelus migrator (Fauvel)	In compost, stable litter, etc.	South East Asia	C. Besuchet, pers. comm.
Paraphloeostiba gayndahensis MacLeay	Fermenting plant matters	Australia	C. Besuchet, pers. comm.
Philonthus parcus Sharp	In compost, stable litter, fermenting plant material, etc.	East Asia	C. Besuchet, pers. comm.
Philonthus rectangulus Sharp	In decomposing matters	East Asia	Lucht, 1987
Philonthus spinipes Sharp	In stable litter, cadavers, etc.	East Asia	C. Besuchet, pers. comm.
Thecturota marchii (Dodero)	Waste land, compost	Southern Europe	Lucht, 1987
Trichiusa immigrata Lohse	In compost and manure	North America	C. Besuchet, pers. comm.
Tenebrionidae			
Alphitobius diaperinus (Panzer)	In stored products, polyphagous	Tropics	C. Besuchet, pers. comm.
Alphitophagus bifasciatus (Say)	Mainly domestic, In rotten fruits	Cosmopolitan	C. Besuchet, pers. comm.

Table 4.1. Established alien Insects in Switzerland: Coleoptera.

Species	Habitat - life traits	Origin	Reference for Switzerland
Gnatocerus cornutus (F.)	Stored products	Central America	Lucht, 1987
Latheticus oryzae Waterhouse	Stored products, cereals	India	C. Besuchet, pers. comm.
Tenebrio molitor L., polyphagous	Stored products	Cosmopolitan	Lucht, 1987
Tribolium castaneum (Herbst)	Stored products	Cosmopolitan	Lucht, 1987
Tribolium confusum Jacquelin du Val	Stored products	Perhaps America, cosmopolitan	Lucht, 1987
Tribolium destructor Uyttenboogaart	Stored products	South America	C. Besuchet, pers. comm.
Tribolium madens Charpentier	Stored products	Cosmopolitan	C. Besuchet, pers. comm.

Table 4.2. Established alien insects in Switzerland: Lepidoptera.

Species	Habita - Life traits	Origin	References for Switzerland
LEPIDOPTERA			
Arctiidae			
Hyphantria cunea (Drury)	Polyphagous defoliator, in Ticino	North America	Rezbanyai-Reser, 1991; Jermini et al., 1995
Gelechiidae			
Scrobipalpa ocellatella (Boyd)	Defoliator/ borer on Chenopodiaceae, particularly on beet	Southern Europe	Karsholt and Razowski, 1996; CABI, 2001
Sitotroga cerealella (Olivier)	On stored products	North America	CABI, 2001

Table 4.2. Established alien insects in Switzerland: Lepidoptera.

Species	Habita - Life traits	Origin	References for Switzerland
Geometridae			
Eupithecia sinuosaria Eversmann	On *Chenopodium* (not sure if established in Switzerland)	Eastern Europe	Rezbanyai-Reser et al., 1998
Gracillariidae			
Cameraria ohridella Deschka & Dimic	Leaf miner on *Aesculus*	Unknown	Kenis and Förster, 1998
Caloptilia azaleella (Brants)	Leaf miner on *Rhododendron*, in greenhouses	EastAsia	CSCF, unpublished list
Parectopa robiniella Clemens	Leaf miner on *Robinia*	North America	Sauter, 1983
Phyllonorycter leucographella (Zeller)	Leaf miner on *Pyracantha* and *Crataegus*	East Mediterranean Region	Sauter, 1983
P. platani (Staudinger)	Leaf miner on *Platanus*	Balkans, Asia Minor	M. Kenis, personal observation
P. robiniella (Clemens)	Leaf miner on *Robinia*	North America	M. Kenis, personal observation
Lycaenidae			
Cacyreus marshalli (Butler)	On *Pelargonium*, in Ticino	South Africa	Y. Gonzeth, pers. comm.
Noctuidae			
Caradrina ingrata Staudinger	Defoliator (not sure if established)	East Mediterranean Region	Rezbanyai-Reser L. 1983, Withebread, 1997
Chrysodeixis chalcites Esper	Vegetables, in glasshouses, migrant (not sure if established)	Mediterranean Region?	Hächler et al., 1998
Helicoverpa armigera (Hübner)	Polyphagous defoliator, mainly in glasshouses (not sure if established)	Africa?	Rezbanyai-Reser L. 1984, Hächler et al., 1998
Sedina buettneri (Hering)	Defoliator, mainly on *Carex*	Siberia	Blattner (1959)
Psychidae			
Typhonia beatricis Hättenschwiler	Polyphagous, in particular on mosses	Eastern Mediterranean	Hättenschwiler (2000)

Table 4.2. Established alien insects in Switzerland: Lepidoptera.

Species	Habita - Life traits	Origin	References for Switzerland
Pyralidae			
Cadra cautella (Walker)	On stored products	Africa	Hoppe (1981)
Ephestia elutella (Hübner)	On stored products	Cosmopolitan	Hoppe (1981)
E. kuehniella (Zeller)	On stored products	North and Central America	Hoppe (1981)
Plodia interpunctella (Hübner)	On stored products	Cosmopolitan	Hoppe (1981)
Sclerocona acutella (Eversmann)	On *Phragmites*	Siberia	Grimm (1986)
Saturniidae			
Samia cynthia walkeri (C. and R. Felder)	Defoliator on *Ailanthus*	East Asia	CSCF, unpublished list
Tineidae			
Monopis crocicapitella (Clemens)	On fabrics	Cosmopolitan	CSCF, unpublished list
Opogona sacchari (Bojer)	Polyphagous pest in glasshouses	Africa	CABI, 2001
Tortricidae			
Cydia molesta (Busck)	Orchard pest, on Rosaceae	East Asia	CABI, 2001
Yponomeutidae			
Argyresthia thuiella (Packard)	Leaf miner on Cupressaceae	North America	Fischer (1993)

Table 4.3. Established alien insects in Switzerland: Hymenoptera.

Species	Habitat - Life traits	Origin	References for Switzerland
HYMENOPTERA			
Symphyta			
Siricidae			
Sirex cyaneus Fabricius	Feeds on conifer trunks (mainly *Abies*)	North America	Pschorn-Walcher and Taeger, 1995
Tenthredinidae			
Nematus tibialis Newman	Defoliator on *Robinia*	North America	Liston, 1981, Pschorn-Walcher and Taeger, 1995
Apocrita			
Aphelinidae			
Aphelinus mali (Haldeman)	Parasitoid of *Eriosoma lanigerum* (Hausmann), introduced in Switzerland	North America	Greathead, 1976; Noyes, 2002
Aphytis proclia (Walker)	Parasitoid of scale insects, introduced in Italy	Asia	Greathead, 1976; Noyes, 2002
Encarsia berlesei (Howard)	Parasitoid of *Pseudaulacaspis pentagona* (Targioni-Tozzetti), introduced in Italy	East Asia	Mani et al., 1997
Encarsia formosa Gahan	Biocontrol agent against whiteflies. Only in greenhouses	South and Central America	Greathead, 1976; Noyes, 2002
Encarsia lounshuryi (Berlese & Paoli)	Parasitoid of *Chrysomphalus dictyospermi* (Morgan), introduced in Italy	Madeira	Greathead, 1976; Noyes, 2002
Encarsia perniciosi (Tower)	Parasitoid of San José scale, introduced in Switzerland	Probably Asia	Mani and Baroffio, 1997
Braconidea			
Aphidius colemani Viereck	Biocontrol agent against aphids in greenhouses	India	

Table 4.3. Established alien insects in Switzerland: Hymenoptera.

Species	Habitat - Life traits	Origin	References for Switzerland
Dryinidae			
Neodryinus typhlocybae (Ashmead)	Parasitoid of *Metcalfa pruinosa* Say, introduced in Ticino	North America	Jermini et al., 2000
Encyrtidae			
Metaphycus helvolus (Compere)	Biocontrol agent against scale insects. Only in greenhouses	South Africa	Noyes, 2002
Ooencyrtus kuvanae (Howard)	Parasitoid of *Lymantria dispar* L., introduced in Europe. Not reported from Switzerland but from all adjacent countries	East Asia	Greathead, 1976; Noyes, 2002
Formicidae			
Hypoponera schauinslandi (Emery)	Antropophilic, in greenhouses or other heated buildings.	Unclear, tropics	Neumeyer & Seifert, 2005
Linepithema humile (Mayr)	Various habitats indoors and outdoors, perhaps not established in Switzerland	South America	Kutter, 1981
Monomorium pharaonis (L.)	On stored products, antropophilic, mainly indoors	South Asia	Freitag et al., 2000
Paratrechina longicornis (Latreille)	Omnivorous, antropophilic, found in Zürich airport in 1999, perhaps not established	Old world tropics	Freitag et al., 2000
Tapinoma melanocephalum (F.)	On stored products, antropophilic, indoors only	Cosmopolitan, tropics	Dorn et. al., 1997
Sphecidae			
Isodontia mexicana (Saussure)	Predatory wasp, feeds on criquets, In Ticino and Lemanic region	North America	Vernier, 1995, 2000
Sceliphron curvatum (F. Smith)	Predatory wasp, anthropophilic	Asia	Gonseth & al. 2001

Table 4.3. Established alien insects in Switzerland: Hymenoptera.

Species	Habitat - Life traits	Origin	References for Switzerland
Torymidae			
Megastigmus spermotrophus Wachtl	Feeds on seeds of *Pseudotsuga*	North America	Roques and Skrzypczynska, 2003
Trichogrammatidae			
Trichogramma brassicae Bezdenko	Biocontrol agent against Lepidoptera	Eastern Europe	Noyes, 2002

Table 4.4. Established alien insects in Switzerland: Diptera.

Species	Habitat - Life traits	Origin	References for Switzerland
DIPTERA			
Agromyzidae			
Liriomyza huidobrensis (Blanchard)	Polyphagous leaf miner, pest in glasshouses	Central and South America	CABI, 2001
Liriomyza trifolii (Burgess)	Polyphagous leaf miner, pest in glasshouses in Europe, particularly on *Chrysanthemum*	North America	CABI, 2001
Napomyza gymnostoma (Loew)	Leaf miner on *Allium* spp., especially onion and leek.	Unclear, perhaps indigenous	Eder and Baur (2003)
Calliphoridae			
Chrysomya albiceps (Wiedemann)	On cadavers	Cosmopolitan	Rognes, 1997
Cecidomyiidae			
Rhopalomyia chrysanthemi (Ahlberg)	Pest on *Chrysanthemum*	North America	Skuhrava and Skuhravi 1997

Table 4.4. Established alien insects in Switzerland: Diptera.

Species	Habitat - Life traits	Origin	References for Switzerland
Culicidae			
Aedes albopictus (Skuse)	Human nuisance through its bites, and potential vector of various diseases	South-east Asia	Unpublished information
Drosophilidae			
Chymomyza amoena (Loew)	Fruits of various broadleaved trees (apple, walnut, plum, etc.)	North America	Burla and Bächli, 1992
Drosophila curvispina Watabe & Toda	Fruits	East Asia	Bächli et al., 2002
Milichiidae			
Desmometopa varipalpis Malloch	Saprophagous/coprophagous	Probably Cosmopolitan	Merz et al., 2001
Muscidae			
Hydrotaea aenescens (Wiedemann)	On human or animal cadavers	North America	Merz et al., 2001
Phoridae			
Dohrniphora cornuta (Bigot)	Saprophagous, sometimes carnivorous	Tropical, Cosmopolitan	Prescher et al., 2002
Stratiomyidae			
Hermetia illucens (L.)	Saprophagous, very abundant in Ticino.	North and South America , Africa	Sauter, 1989
Tephritidae			
Bactrocera oleae (Gmel.)	Fruit fly, on olive, in Ticino	Mediterranean region	Neuenschwander, 1984
Ceratitis capitata (Wiedemann)	On various fruits, e.g. peach, apricot, peer, etc.	Africa	CABI, 2001
Rhagoletis cingulata Curran	Fruit fly, on cherry. First determined as *R. indifferens* Curran (B. Merz, pers. comm.)	North America	Merz 1991, Mani et al., 1994
Rhagoletis completa Cresson	Fruit fly, on walnut	North America	Merz 1991, Mani et al, 1994

Table 4.4. Established alien insects in Switzerland: Diptera.

Species	Habitat - Life traits	Origin	References for Switzerland
Ulidiidae			
Euxesta pechumani Curran	In carrion and dung, in Ticino	North America	B. Merz., pers. comm.

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
HEMIPTERA			
Sternorrhyncha			
APHIDINA			
Adelgidae			
Dreyfusia nordmannianae (Eckstein)	On *Abies*	Caucasus	Eichhorn, 1967
Dreyfusia prelli Grosmann	On *Abies*	Caucasus	Eichhorn, 1967
Eopineus strobus (Hartig)	On *Pinus strobus* L., *Picea* spp. Not recorded but probably in Switzerland	North America	Schwenke, 1972
Gilletteella cooleyi (Gillette)	On *Picea* and *Pseudotsuga*	North America	Forster, 2002
Aphididae			
Acyrthosiphon caraganae (Choldokovsky)	On *Caragana* and other Fabaceae	Siberia	CSCF/Lampel, unpublished list
Aphis forbesi Weed	On strawberry	North America	Meier, 1975
Aphis gossypii Glover	Polyphagous, mainly Cucurbitaceae and Malvaceae, [illegible]	Cosmopolitan, tropical regions	CABI, 2001

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
	in greenhouses in Central Europe		
Aphis spiraecola Patch	Polyphagous, e.g. *Citrus*, apple	East Asia	Hohn et al., 2003
Aphis spiraephaga F.P. Müller	On *Spiraea*	Central Asia	Stary, 1995
Appendiseta robiniae (Gillette)	On *Robinia*	North America	Lethmayer and Rabitsch, 2002
Aulacorthum circumflexum (Buckton)	Polyphagous, in greenhouses	South East Asia	CSCF/Lampel, unpublished list
Elatobium abietinum (Walker)	On *Picea*	North America	CABI, 2001
Idiopterus nephrelepidis Davis	On ferns, mostly indoors	Neotropics	CSCF/Lampel, unpublished list
Illinoia azaleae (Mason)	On *Rhododendron* and other Ericaceae	North America	CSCF/Lampel, unpublished list
Illinoia lambersi (Mac Gillivray)	On *Rhododendron* and *Kalmia*	North America	CSCF/Lampel, unpublished list
Impatientinum asiaticum Nevsky	On *Impatiens*	Central Asia	CSCF/Lampel, unpublished list
Macrosiphoniella sanborni (Gillette)	On *Chrysanthemum*	East Asia	Meier, 1972
Macrosiphum albifrons Essig	On *Lupinus*	North America	CSCF/Lampel, unpublished list
Macrosiphum euphorbiae (Thomas)	Polypgagous, on vegetables	North America	Derron and Goy, 1995
Megoura lespedezae (Essig & Kuwana)	On *Lespedeza*, Japanese clover	East Asia	Giacalone & Lampel, 1996
Microlophium primulae (Theobald)	On *Primula*	Asia	CSCF/Lampel, unpublished list
Myzus ascalonicus Doncaster	On *Allium* spp.	Near East	CSCF/Lampel, unpublished list
Myzus cymbalariae Stroyan (=cymbalariellus Str.)	Polyphagous	Not clear. In UK, South Africa, New Zealand and Australia	Meier, 1972
Myzus ornatus Laing	On *Prunus cornuta* (Wallich ex Royle) (primary host) and many herbaceous plants (secondary hosts	Himalaya	CSCF/Lampel, unpublished list
Myzus persicae (Sulzer)	Polyphagous	Cosmopolitan, probably from	CABI, 2001

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
		Asia	
Myzus varians Davidson	On *Clematis*	East Asia	Giacalone & Lampel, 1996
Nearctaphis bakeri (Cowen)	Maloideae (primary hosts) and Fabaceae (secondary hosts)	North America	CSCF/Lampel, unpublished list
Pentatrichopus fragaefolii (Cockerell)	On strawberry	North America	CSCF/Lampel, unpublished list
Rhodobium porosum (Sanderson)	On *Rosa*, in greenhouses in Central Europe	Tropics and subtropics	Meier, 1972
Rhopalosiphoninus latysiphon (Davidson)	Polyphagous	North America	CSCF/Lampel, unpublished list
Rhopalosiphum maidis (Fitch)	On Maize, Sorghum, sugar cane and other Poaceae	Probably Asia	Meier, 1975
Toxoptera aurantii (Boyer de Fonscolombe)	Polyphagous, in Europe mainly on *Citrus*	Cosmopolitan, tropics and subtropics	CSCF/Lampel, unpublished list
Uroleucon erigeronense (Thomas)	On Asteraceae (*Erigeron*, *Coniza*, etc.)	North America	CSCF/Lampel, unpublished list
Callaphididae			
Myzocallis (=*Lineomyzocallis*) *walshii* (Monell)	On *Quercus*	North America	Giacalone and Lampel (1996)
Takecallis arundicolens (Clarke)	On bamboo	South East Asia	Lampel and Meier (2003)
Takecallis arundinariae (Essig)	On bamboo	South East Asia	Giacalone and Lampel (1996)
Takecallis taiwanus (Takahashi)	On bamboo	South East Asia	Giacalone and Lampel (1996)
Tinocallis nevskyi Remaudière, Quednau & Heie	On *Ulmus*	Western Asia	Giacalone and Lampel (1996)
Chaitophoridae			
Periphyllus californiensis (Shinji)	On *Acer*	East Asia	Lampel and Meier (2003)
Pemphigidae			

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
Eriosoma lanigerum (Hausmann)	On orchard trees	North America	CPC
Lachnidae			
Cinara cupressi (Buckton)	On Cupressaceae	North America? Taxonomy confusing	Lampel, 1974. Watson et al., 1999
Phylloxeridae			
Viteus vitifoliae (Fitch)	On grapevine	North America	CPC
PSYLLINA			
Psyllidae			
Acizzia jamatonica (Kuwayama)	On *Albizia julibrissin* Durazz	East Asia	D. Burckhardt, pers. comm.
Bactericera trigonica Hodkinson	On *Daucus carota* L.	Mediterranean region	Burckhardt and Freuler, 2000
Cacopsylla fulguralis (Kuwayama)	On *Elaeagnus*	East Asia	D. Burckhardt, pers. comm.
Cacopsylla pulchella (Löw)	On *Cercis siliquastrum* L.	Mediterranean region	Burckhardt and Freuler, 2000
Camarotoscena speciosa (Flor)	On *Populus*. Maybe natural spread	Probably Mediterranean region, or Asia	Burckhardt and Freuler, 2000
Ctenarytaina eucalypti (Maskell)	On *Eucalyptus*	Australia	D. Burckhardt, pers. comm.
Homotoma ficus (L.)	On *Ficus carica* L.	Mediterranean region and Middle East	Burckhardt and Freuler, 2000
Livilla spectabilis (Flor)	On *Spartium junceum* L.	Mediterranean region	Schaefer, 1949
Livilla variegata (Löw)	On *Laburnum*	Southern Europe	Schaefer, 1949
Phyllopecta trisignata (Löw)	On *Rubus fruticosus* L. Maybe natural spread	Southern Europe, Near East	Schaefer, 1949
Spanioneura fonscolombii Foerster	On *Buxus sempervirens* L. Maybe natural spread	Mediterranean region	Schaefer, 1949

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
Triozidae			
Trioza alacris Flor	On *Laurus nobilis* L.	Mediterranean region to Caucasus	Schaefer, 1949
Trioza centranthi (Vallot)	On *Centranthus rubber* (L.)	Mediterranean region	Schaefer, 1949
ALEYRODINA			
Aleyrodidae			
Bemisia tabaci (Gennadius)	Polyphagous, in greenhouse	Cosmopolitan, probably Asia	CABI, 2001
Trialeurodes vaporariorum Westwood	Polyphagous, in greenhouse	Central America	CABI, 2001
COCCINA			
Diaspididae			
Aonidia lauri (Bouché)	Polyphagous, on ornamentals	Mediterranean region	Kozar et al., 1994
Diaspidiotus distinctus (Leonardi)	On *Corylus*, *Matricaria* and *Quercus*	Mediterranean region. Maybe indigenous	Kosztarab and Kozar, 1988
Diaspidiotus osborni (Newell & Cockerell)	On *Platanus*, *Corylus* and *Gleditsia*	North America	Kozar et al., 1994
Dynaspidiotus britannicus (Newstead)	Polyphagous, indoors and outdoors	Unclear	Kozar et al., 1994
Pseudaulacaspis pentagona (Targioni-Tozzetti)	Polyphagous, on ornamental and orchard trees	East Asia	Mani et al., 1997
Quadraspidiotus labiatarum (Marshal)	Polyphagous	Mediterranean region. Maybe indigenous	Kozar et al., 1994
Quadraspidiotus lenticularis (Lindinger)	Polyphagous on broadleaved trees	Mediterranean region. Maybe indigenous	Kozar et al., 1994
Quadraspidiotus perniciosus (Comstock)	Polyphagous, pest in orchards	East Asia	Mani and Baroffio, 1997

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
Quadraspidiotus pyri (Lichtenstein)	Polyphagous, pest of fruit trees	Mediterranean region. Maybe indigenous	Kozar et al., 1994
Ortheziidae			
Orthezia insignis Browne	Polyphagous, in greenhouses	Neotropics	Kozar et al., 1994
Pseudococcidae			
Peliococcus multispinus (Siraiwa)	On *Thymus*	East Asia, Caucasus?	Kozar et. al, 1994
Planococcus citri (Risso)	Polyphagous, in greehouses and on indoor plants	Tropics and subtropics	Kozar et. al, 1994
Trionymus penium (Williams)	On *Pseudosasa*	South-east Asia	Kozar et. al, 1994
Coccidae			
Chloropulvinaria floccifera (Westwood)	Polyphagous	Mediterranean region or East Asia?	Kozar et al., 1994
Coccus hesperidum L.	Polyphagous, indoors and outdoors	Cosmopolitan, but prob. not from Europe	Kozar et al., 1994
Eupulvinaria hydrangeae (Steinweden)	Polyphagous on broadleaved trees	Perhaps East Asia	Kozar et al., 1994
Pulvinaria regalis Canard	Polyphagous on broadleaved trees	Perhaps East Asia	Kozar et al., 1994
Margarodidae			
Icerya purchasi Maskell	Polyphagous, indoors and outdoors in Switzerland	Australia	Kozar et al., 1994
Auchenorrhyncha			
Cicadellidae			
Edwardsiana platanicola (Vidano)	On *Platanus*	Unknown. Introduced from Northen Italy	Günthart, 1987
Eupteryx decemnotata Rey	On *Salvia*	Southern Europe	Günthart, 1987

Table 4.5. Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
Graphocephala fennahi Young	On *Rhododendron*	North America	Günthart, 1987
Orientus ishidae (Matsumura)	On *Salix* and *Betula*	East Asia	Günthart et al., 2004
Scaphoideus titanus Ball	On vine, vector of 'flavescence dorée'	North America	Günthart, 1987
Flatidae			
Metcalfa pruinosa Say	Polyphagous	North America	Bonavia and Jermini, 1998
Membracidae			
Stictocephala bisonia Kopp & Yonke	Polyphagous	North America	Günthart, 1987
Heteroptera			
Lygaeidae			
Arocatus longiceps Stal	On *Platanus*	Mediterranean region, perhaps expanding naturally	Giacalone et al., 2002
Orsillus depressus Dallas	On Cupressaceae	Mediterranean region, perhaps expanding naturally	R. Heckmann, pers. comm.
Oxycarenus lavaterae (F.)	On Malvaceae and Tiliaceae	Mediterranean region, perhaps expanding naturally	R. Heckmann, pers. comm.
Miridae			
Deraeocoris flavilinea (A. Costa)	Predator on aphids on broead-leaved trees	Mediterranean Region, perhaps expanding naturally	Rabitsch, 2002
Tingidae			
Corythucha arcuata (Say)	On *Quercus*	North America	Meier et al., 2004
Corythucha ciliata (Say)	On *Platanus*	North America	Barbey, 1996

Table 4.6. Established alien insects in Switzerland: Orthoptera, Dictyoptera, Thysanoptera, Psocoptera, Syphonaptera and Anoplura.

Species	Habitat - Life traits	Origin	References for Switzerland
ORTHOPTERA			
Gryllidae			
Acheta domesticus (L.)	Omnivorous, synanthropic, also ouside in the Valais	North Africa, Cosmopolitan	Thorens and Nadig, 1997
Rhaphidophoridae			
Tachycines asynamorus Adelung	Omnivorous, greenhouses and botanical gardens	Cosmopolitan, probably from East Asia	Thorens and Nadig, 1997
DICTYOPTERA			
Blattellidae			
Blattella germanica (L.)	Omnivorous, synanthropic	Cosmopolitan	Landau et al., 1999
Supella longipalpa (F.)	Omnivorous, synanthropic	Africa	Landau et al., 1999
Blattidae			
Blatta orientalis L.	Omnivorous, synanthropic	Cosmopolitan, possibly indigenous	Landau et al., 1999
Periplaneta americana (L.)	Omnivorous, synanthropic	Africa, cosmopolitan,	Landau et al., 1999
Periplaneta australasiae (F.)	Omnivorous, synanthropic	Cosmopolitan, tropics and subtropics	Landau et al., 1999
THYSANOPTERA			
Thripidae			
Frankliniella intonsa (Trybom)	Polyphagous, mainly in greenhouses	East Asia	CABI, 2001, Linder et al., 1998

Table 4.6. Established alien insects in Switzerland: Orthoptera, Dictyoptera, Thysanoptera, Psocoptera, Syphonaptera and Anoplura.

Species	Habitat - Life traits	Origin	References for Switzerland
Frankliniella occidentalis (Pergande)	Polyphagous, mainly in greenhouses	North America. Now cosmopolitan	CABI, 2001, Ebener et al., 1989
Heliothrips haemorrhoidalis (Bouché)	Polyphagous, in greenhouses	Probably tropical America. Now cosmopolitan	CABI, 2001
Thrips simplex (Morison)	Develops on *Gladiolus*, but found also on many other plants, in greenhouses	Probably South Africa	CABI, 2001
PSOCOPTERA			
Trogiomorpha			
Trogiidae			
Cerobasis annulata (Hagen)	Domestic	Unclear (see text)	Lienhard, 1994
Lepinotus inquilinus von Heyden	Domestic, rarely outdoors	Unclear (see text)	Lienhard, 1994
Lepinotus patruelis Pearman	Domestic, rarely outdoors	Unclear (see text)	Lienhard, 1994
Lepinotus reticulatus Enderlein	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Trogium pulsatorium (L.)	Domestic	Unclear, perhaps Mediterranean region (see text)	Lienhard, 1994
Psyllipsocidae			
Dorypteryx domestica (Smithers)	Domestic	Unclear, perhaps Africa (see text)	Lienhard, 1994
Dorypteryx longipennis Smithers	Domestic	Unclear (see text)	Lienhard, 1994
Dorypteryx pallida Aaron	Domestic	Unclear, perhaps North America (see text)	Lienhard, 1994

Table 4.6. Established alien insects in Switzerland: Orthoptera, Dictyoptera, Thysanoptera, Psocoptera, Syphonaptera and Anoplura.

Species	Habitat - Life traits	Origin	References for Switzerland
Psyllipsocus ramburii Sélys-Longchamps	Domestic and in caves	Unclear (see text)	Lienhard, 1994
Troctomorpha			
Liposcelididae			
Liposcelis bostrychophila Badonnel	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis brunnea Motschulsky	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis corrodens (Heymons)	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis decolor (Pearman)	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis entomophila (Enderlein)	Domestic	Unclear (see text)	Lienhard, 1994
Liposcelis mendax Pearman	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Liposcelis pearmani Lienhard	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis pubescens Broadhead	Domestic	Unclear (see text)	Lienhard, 1994
Sphaeropsocidae			
Badonnelia titei Pearman	Domestic	Unclear (see text)	Lienhard, 1994
Psocomorpha			
Ectopsocidae			
Ectopsocus pumilis (Banks)	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Ectopsocus richardsi (Pearman)	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Ectopsocus vachoni Badonnel	Domestic	Unclear, perhaps Mediterranean region (see text)	Lienhard, 1994

Table 4.6. Established alien insects in Switzerland: Orthoptera, Dictyoptera, Thysanoptera, Psocoptera, Syphonaptera and Anoplura.

Species	Habitat - Life traits	Origin	References for Switzerland
SIPHONAPTERA			
Pulicidae			
Ctenocephalides felis felis (Bouché)	Ectoparasite on cat and, occasionally, other carnivores	Cosmopolitan, probably not Europe	Beaucournu and Launay (1990)
Spilopsylus cuniculi (Dale)	Ectoparasite on rabbit and, occasionally, other mammals	Probably Iberian Peninsula	Beaucournu and Launay (1990)
ANOPLURA			
Hoplopleuridae			
Haemodipsus ventricosus (Denny)	Ectoparasite on rabbit	Probably Iberian Peninsula	Büttiker and Mahnert (1978)

5 Spiders and Allies – Arachnida

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Introduction

This chapter summarizes the available information on Arachnida, except Acari, covering species' distribution, biology, and potential harm to the environment and economy. Since knowledge of the natural distribution, origins and movement for the Arachnida is very limited, it was decided to use specific definitions for the terms described below, so that coverage of invasive species is expanded to include native species which are spreading, thereby not discriminating between natural spread and human-mediated expansion. The following definitions characterize the framework for this chapter, and explain which species are covered and which are not.

- **Neozoa** (Geiter et al., 2002): A neozoan animal has been introduced, by direct or indirect human mediation, to a region to which it is not native and has established a population there.
- **Invasive Species** (Geiter et al., 2002): This term does not discriminate between natural and human-mediated colonization of a new territory and focuses on species causing problems.

The spiders discussed in this report are categorized mainly by habitat and biology, as follows:

- **Species of natural habitats**: spiders and their relatives which live in natural, near-natural or human-influenced habitats (e.g. crop fields), but not in close proximity to human buildings. The report focuses on species which have changed their distribution, mainly during the last two decades because of a lack of older data. It is based on pitfall trap results, since continuous and standardized information on orb web species is not available.
- **Species inside, and in close proximity, to human buildings:** spiders and their relatives which typically inhabit walls of buildings or live in direct contact with humans, and which have expanded their distribution range into Central Europe during recent decades.
- **House-dwelling species**: spiders and their relatives which exclusively occur in buildings, and no populations in natural habitats are known.
- **Greenhouse-inhabiting species**: spiders and their relatives which, in Central Europe, exclusively inhabit greenhouses and other similarly warm buildings. They have established populations in these warm environments, but cannot survive outside due to their climatic requirements. They can also be introduced into houses, e.g. with flowers (e.g. *Eperigone eschatological* (Crosby)).
- **'Banana spiders'**: spiders which are introduced with fruit commodities, especially bananas. They are often rather spectacular individuals, but they are not able to establish in our climate.
- **Terrarium species**: spiders, mostly tarantulas/theraphosids (so-called 'bird-eating spiders') from warm regions, which escape captivity, but cannot breed in the Central European climate and at the most survive until the following winter.

The orders Araneae (spiders), Opiliones (harvestmen) and Pseudoscorpiones (false scorpions) within the class Arachnida are covered in this report. Acari (ticks and mites), although very important for the agricultural and the health sectors, are not included in this review, because of the difficulties of preparing comprehensive lists and their minor relevance for the environmental sector. Species which were introduced to Switzerland more than a few decades ago are not included, because of their largely unresolved status. Thus, the wasp spider (*Argiope bruennichi* (Scopoli)) is not included in the list. Additionally, species which besides inhabiting houses and basements also live in caves, rock screes, walls in vineyards or quarries, as for example the genus *Pholcus* or the jumping spider *Salticus scenicus* (Clerck), are not discussed here.

The main general literature sources for the report are Thaler and Knoflach (1995), Geiter et al. (2002) and Komposch (2002).

Knowledge about synanthropic spiders and their relatives in Switzerland is extremely limited. Therefore many observations discussed in the report are based on knowledge, although likewise rudimentary, accumulated in other Central European countries, and extrapolated to Switzerland. The situation in these countries will be similar to that in Switzerland and including the information gives a more comprehensive picture of the alien spider fauna of Central Europe.

Generally, synanthropic spiders seem to attract less attention than species inhabiting natural habitats even among arachnologists or, rather, little is published about them. The spitting spider *Scytodes thoracica* (Latr.) is an example of a spider almost exclusively found in houses in Central Europe; its distribution is fairly well-known by arachnologists, but there are few publications about it. The same is true for species of the genus *Araneus*, which frequently occur in houses and gardens.

List of species

Table 5.1 introduces the species mentioned in this report.

Table 5.1: Species mentioned in this report, named after Platnick (2004).

Species name	Author, Year	Family	Habitat
Achaearanea tabulata *	Levi, 1980	Theridiidae	In houses
Artema atlanta *	Walckenaer, 1837	Pholcidae	In houses
Astrobunus laevipes *	(Canestrini, 1872)	Phalangiidae	Natural
Chelifer cancroides	(L., 1758)	Cheliferidae	In houses
Cicurina japonica	(Simon, 1886)	Dictynidae	Natural
Coleosoma floridanum	Banks, 1900	Theridiidae	Greenhouses
Collinsia inerrans	(O. P.-Cambridge, 1885)	Linyphiidae	Natural
Dasylobus graniferus	(Canestrini, 1871)	Phalangiidae	Natural
Dictyna civica	(Lucas, 1850)	Dictynidae	On buildings
Diplocephalus graecus *	(O. P.-Cambridge, 1872)	Linyphiidae	Natural
Eperigone eschatologica	(Crosby, 1924)	Linyphiidae	Greenhouses
Eperigone trilobata	(Emerton, 1882)	Linyphiidae	Natural
Erigone autumnalis	Emerton, 1882	Linyphiidae	Natural
Harpactea rubicunda	(C.L. Koch, 1838)	Dysderidae	In houses, but also natural
Hasarius adansoni	(Audouin, 1826)	Salticidae	Greenhouses
Heteropoda venatoria	(L., 1767)	Sparassidae	Greenhouses
Holocnemus pluchei	(Scopoli, 1763)	Pholcidae	In houses
Micropholcus fauroti *	(Simon, 1887)	Pholcidae	In houses
Nesticus eremita	Simon, 1879	Nesticidae	Natural
Oecobius maculatus	Simon, 1870	Oecobiidae	Natural
Opilio canestrinii	(Thorell, 1876)	Phalangiidae	On buildings
Ostearius melanopygius	(O. P.-Cambridge, 1879)	Linyphiidae	Natural
Pseudeuophrys lanigera	(Simon, 1871)	Salticidae	On buildings

Psilochorus simoni	(Berland, 1911)	Pholcidae	In houses
Thanatus vulgaris *	Simon, 1870	Philodromidae	Greenhouses
Uloborus plumipes	Lucas, 1846	Uloboridae	Greenhouses
Zodarion italicum	(Canestrini, 1868)	Zodariidae	Natural
Zodarion rubidum	Simon, 1914	Zodariidae	Natural
Zoropsis spinimana	(Dufour, 1820)	Zoropsidae	In houses

*Species not yet recorded from Switzerland.

Species of natural habitats

Eperigone trilobata (Emerton)

This spider has a wide distribution range in North America (Millidge, 1987) and was first recorded from Europe in the 1980s at Karlsruhe, Germany. A catalogue of Swiss spiders (Maurer and Hänggi, 1990) noted several records from the Swiss cantons Jura and Ticino. This species is a common member of the spider fauna in all open habitats (e.g. Blick et al., 2000) and was first recorded in the Jura in 1999 at about 800 m above sea level (T. Blick, unpubl.).

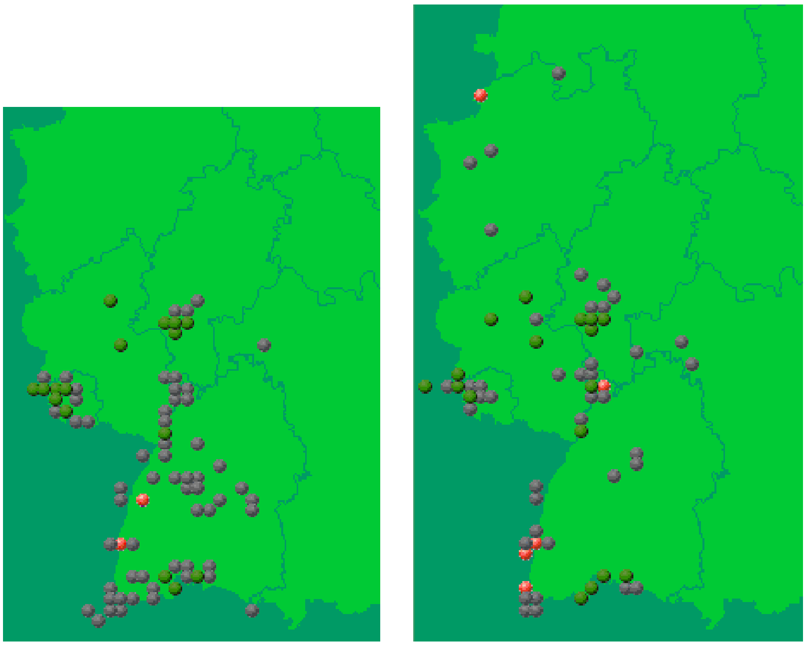

Figure 5.1: Records of Eperigone trilobata (left) and Zodarion italicum (right) in Germany and north-west Switzerland.
After Staudt (2004). (green dots: since 2000, grey dots: 1990-1999, red dots: 1980-1989)

In Germany, this species has spread from Baden-Württemberg, where it was first found, to Hessen and Rheinland-Pfalz and into north-western Bayern (Staudt, 2004: see Fig. 5.1). There are also records from outside this area, i.e. in the east of Bayern and the south of Niedersachsen (T. Blick, unpubl.; pers. comm. of various arachnologists – these data are not included in Fig. 5.1). The data presented above indicate that this species will colonize Central Europe in the foreseeable future. However, it is unclear what the altitude limit will be or whether its frequency in samples will increase. During past years, there has been no indication that the frequency of the species is increasing – to the contrary, investigations on the same field site in 1994 and 1999 showed a decrease in numbers of the species (Baur et al., 1996; Hänggi and Baur, 1998; Blick, unpubl.). In most samples the frequency of the species reached only about 5% – the maximum was 30% at Basel railway station in 2002 (Hänggi and Heer, unpubl.).

Displacement of native spider species has not been recorded and would be very difficult to prove. Such studies would involve standardized experiments at the same field site over decades, with year-round sampling and also Swiss-wide sites for comparative work. Funding for this kind of research seems unlikely, although the samples could be used for other arthropod research.

Zodarion italicum (Canestrini)

The origin of the aptly named *Zodarion italicum* is the south of Europe. It has expanded its distribution since the publication of the catalogue of Swiss spiders (Maurer and Hänggi, 1990 – cited as sub *Z. gallicum*), and has since reached the south of Switzerland. It is possible that it is even native to that region (see, e.g., Lessert, 1910). This spider is a highly specialized predator of ants (Pekar and Kral, 2002) and occurs mainly in open habitats. The rapid expansion of its range is probably attributable to human-mediated transport to new areas and to global warming, which allows species of southern origin to survive north of the Alps. However, this probable relationship would be difficult to demonstrate. The species is also expanding its range in Germany, as is its sister species *Z. rubidium* Simon (see Bosmans, 1997; Staudt, 2004; also see Figure 5.1).

Other species found in natural habitats

Besides the two species mentioned above, a number of other species are spreading in Central Europe, or their spread is likely within the next few years. A selection of these species is discussed below.

- ***Collinsia inerrans*** (O.P.-Cambridge) (syn. *Milleriana inerrans*, *C. submissa*) has been found locally in Switzerland during the last 50 years. Currently, the species is expanding its range in western Germany (Klapkarek and Riecken, 1995), and has reached the north-east of Bayern (Blick, 1999). However, it has not yet reached the abundance of *Eperigone trilobata*, despite their similarities in size and ecological niche. The future expansion of this species in Switzerland should be monitored.
- ***Ostearius melanopygius*** (O.P.-Cambridge): Ruzicka (1995) portrays the spread of this cosmopolitan species of unknown origin (cryptogenic) in Europe. In Switzerland, a similar pattern as for *C. inerrans* has been observed. However, occasionally the species exhibits mass outbreaks, which can be a nuisance to humans although it does no actual harm (Sacher, 1978); for cases in Switzerland see, e.g., Benz et al. (1983). The normal sampling techniques using traps at ground level are not effective under these circumstances and generally catch only single individuals. The reasons for the mass outbreaks are not yet understood.
- The distribution of ***Harpactea rubicunda*** (C.L. Koch) described by Wiehle (1953) was restricted to the eastern part of Germany at that time. Since then, the species has expanded its range considerably westwards, most probably by human-mediated transport. It occurs in houses as well as in other synanthropic habitats. In Switzerland, the species was found near Zurlinden (Hänggi, 1988) and in a disused railway area at Basel (Hänggi and Weiss, 2003).
- ***Erigone autumnalis*** Emerton, like *Eperigone trilobata,* originates in North America. The species has been found at several locations in Switzerland (Maurer and Hänggi, 1990; Hänggi, unpubl.). However, it seems to be less abundant and covers a smaller range than *E. trilobata*.
- ***Nesticus eremita*** Simon can be found outdoors around Basel (Hänggi and Weiss, 2003; Hänggi, unpubl.), whereas further north the species is restricted to underground canals and artificial caves (Jäger, 1995, 1998; Blick, unpubl.). It is very likely that this southern European species will expand its range further in the near future.
- ***Cicurina japonica*** (Simon): this spider of Japanese–Chinese origin was not accepted as an established spider species in Germany by Platen et al. (1995), since the introduction of the species near Kehl am Rhein was thought to be temporary. Since then, fairly large populations have been found in the area around the railway at Basel (Hänggi and Heer, unpubl.). This indicates that the species is able to establish in Europe and the further development of its populations should be monitored.
- ***Diplocephalus graecus*** (O.P.-Cambridge): Blick et al. (2000) presents a record of this species of Mediterranean origin from agricultural areas near Paris, France. Today the species has reached

Belgium (Bonte et al., 2002), so it is very likely that it will expand its range into most of Central Europe, including Switzerland, in the near future.

- ***Dasylobus graniferus*** (Canestrini) (syn. *Eudasylobus nicaeensis*): Martens (1978) mentions records of this harvestman species from southern Switzerland. However, in 1997 more than 100 individuals were collected near Liestal (canton Baselland) (I. Weiss, unpubl.). Thus, an expansion into Central Europe of this southern European species is expected, but will probably be difficult to document, since almost no research on harvestmen distribution is being carried out in Switzerland or in adjacent areas of Germany.
- Another harvestman, ***Astrobunus laevipes*** (Canestrini), is already in an expansion phase in Central Europe (see Höfer and Spelda, 2001), especially along rivers. It reached the Netherlands recently (Wijnhoven, 2003). There are no records for Switzerland yet. However, its taxonomic differentiation from *A. bernardinus* Simon, known from the Jura, would merit attention (see Höfer and Spelda, 2001).

Any estimation of potential impacts of the species discussed above would only be guesswork. Economic damage can reasonably be excluded, but it is possible that native species would be replaced or at least populations reduced due to the invaders. However, testing this hypothesis would necessitate long-term monitoring studies in the field on established plots. These investigations are not being carried out to the knowledge of the authors.

Species in, and in close proximity to, human buildings

Only a few members of the Arachnida are restricted to the outside of houses and other human-made structures, although there are native species naturally occurring on rocks and tree bark. The species which have expanded their range in recent decades are discussed below:

- ***Dictyna civica*** (Lucas) inhabits walls of houses particularly in warm climates (Braun, 1952; Billaudelle, 1957; van Keer and van Keer, 1987). The species is considered to be a nuisance by owners of houses in the lowland parts of Switzerland as well as in the Rhine valley in Baden-Württemberg (Stächele, 2002).
- ***Pseudeuophrys lanigera*** (Simon) (syn. *Euophrys lanigera*) is a good example of a spider which has been continuously expanding its range in Central Europe in recent decades (Braun, 1960; Wijnhoven, 1997; Staudt 2004). Although Maurer and Hänggi (1990) listed only a few sites for this species in Switzerland, it is likely to expand its range in the near future. It is not known whether the species is replacing or influencing the population of native jumping spiders with similar ecological niches on house walls, e.g. *Salticus scenicus*.
- The harvestman ***Opilio canestrinii*** (Thorell) has established populations on walls of houses in Central Europe (Enghoff, 1987; Bliss, 1990; Gruber, 1988; Malten, 1991; van der Weele, 1993). However, records of natural populations, i.e. on bark of trees, have been documented since then (e.g. Staudt, 2004). As the monitoring of harvestmen distribution and ecology in Switzerland is minimal, there are almost no data available from Switzerland on this species (Martens, 1978: sub *O. ravennae*).

House-dwelling species

Spiders living in residential houses have either adapted from native natural habitats such as tree bark, caves and cliffs, or have been introduced from southern Europe and become established. Sacher (1983) gives an overview of spiders living in houses. Some additional house-dwelling species are occasionally observed (Hänggi, 2003), e.g. *Achaearanea tabulata* Levi in Austria and Germany (see Knoflach, 1991; Thaler and Knoflach, 1995), and therefore this species is likely to be found in Switzerland in the future. However, with the exception of *Zoropsis spinimana* (Dufour), which is discussed below, no house-dwelling species is showing signs of being invasive.

Zoropsis spinimana (Dufour)

The first record of *Z. spinimana* was an individual caught in 1994 in a residential house in Basel (Hänggi, 2003). Since then other records have been reported from houses in the south of Switzerland (Ticino). Observations in Austria (Thaler and Knoflach, 1998) suggest this species could cause problems, as it is one of the very few spiders in Central Europe which can penetrate the human skin with its cheliceres and produce a painful bite (Hansen, 1996). This species has not (yet) been recorded from Germany (Blick et al., 2002).

Other species of house-dwelling spiders and their relatives

Some other spider species living in houses are currently found more regularly in Central Europe, e.g. *Psilochorus simoni* (Berland). These species do expand their range, but are found only in small numbers or as individuals. More invaders can be expected, in particular in the family Pholcidae (daddy long legs spiders). This is indicated by observations in the harbour at Antwerpen, Belgium (van Keer and van Keer, 2001), where the introduced *Artema atlanta* Walckenaer and *Micropholcus fauroti* (Simon) have become established, and from German cities, where stable populations of *Holocnemus pluchei* (Scopoli) have been found (Jäger, 1995, 2000).

Interestingly, in contrast to the expanding nature of many house-dwelling species, the false scorpion *Chelifer cancroides* (L.) seems to be decreasing in abundance, although the distribution and population sizes of this group are very poorly investigated in Switzerland, especially in synanthropic areas. Apparently, the increased hygiene and the changed climate in houses caused by central heating affects this species. The considerable alteration in temperature, and changes in daily temperature and humidity, might favour some species, especially species adapted to a warm environment, and negatively affect others.

Greenhouse-inhabiting species

- ***Hasarius adansoni*** (Audouin) is a cosmopolitan species, which is widespread in European greenhouses (Simon, 1901; Holzapfel, 1932; König and Pieper, 2003). Records from Switzerland are summarized by Hänggi (2003). Information on synanthropic spiders in general, and this species in particular, is too limited to come to any conclusion about the status of species, e.g. whether populations are increasing.
- ***Uloborus plumipes*** Lucas is another greenhouse species, but is much more common than the species above (Jonsson, 1993, 1998; Thaler and Knoflach, 1995). However, misidentifications in some records arising from confusion with the congeneric *U. glomosus* (Walckenaer) cannot be ruled out.
- The first record of ***Coleosoma floridanum*** Banks in Switzerland was reported by Knoflach (1999) from the tropical greenhouse of the Old Botanical Garden at Basel. This pantropical species is occasionally reported from greenhouses in Europe (Hillyard, 1981; Broen et al., 1998; Knoflach, 1999). However, its status cannot be evaluated yet.
- ***Eperigone eschatologica*** (Crosby) was first recorded in Europe from Germany and Belgium (see Klein et al., 1995; Bosmans and Vanuytven, 1998) but very recently it was found in Switzerland in a private flat, most probably carried on a plant from a German garden centre (Hänggi, unpubl.). It remains to be seen whether it will become established in greenhouses in Switzerland.
- ***Heteropoda venatoria*** (L.), a member of the family Thomisidae (crab spiders) of South-east Asian origin, was repeatedly reported from heated buildings, e.g. in zoos (Jäger, 2000). Surveys and research on the spider faunas of heated buildings and greenhouses would be a useful exercise, since this species is also able to penetrate human skin (c.f. *Zoropsis spinimana*).
- ***Thanatus vulgaris*** Simon, a Mediterranean sister species of the native *T. atratus* Simon, would most probably be found in Swiss greenhouses if an intensive survey were undertaken (see Jones, 1997; Jäger, 2002).

‘Banana spiders’ and terrarium species

Since the species introduced by trade in bananas and other tropical fruits (see e.g. Schmidt, 1971) cannot establish populations in our climate, they are only of medical interest, because they include some dangerous members of the family Ctenidae from South America. Pesticides used before or during transport will often lead to the death of spiders en route or shortly afterwards (pers. obs. by T. Blick of a ctenid which arrived in Bayreuth, Germany in a consignment of bananas from Brazil).

However, some of the many stable populations of spider species in greenhouses are probably the result of such introductions with trade. Thus, it is possible that poisonous species, especially small ones, including some dangerous for humans could be accidentally introduced and established in greenhouses (see, e.g., Huhta, 1972).

Spiders appropriately kept in terrariums are of no concern, but escaped specimens should be handled with care, since the bite of some species (although not many) can be dangerous for humans. If they escape into the wild they will die when temperatures drop, since all species are of tropical or subtropical origin.

Discussion and recommendations

Monitoring spider species currently expanding their range after introduction, and surveys at places prone to introductions, are recommended as elements of an early warning system. This would allow the spread of the alien species to be followed and document any displacement of native species. Some species are invading, but there is no way of evaluating their potential threat to native biodiversity. The data collected on synanthropic spiders in Switzerland, as well as other Central European countries, are too limited to allow any conclusions to be drawn. Some cases of established tropical species and increasing trade indicate the possibility of venomous spider species arriving in Switzerland. If a venomous spider becomes established, the public would need to be well-informed about how to handle the situation and anti-venom kits should be made available.

Furthermore, to document threats to native species in natural habitats, the establishment of long-term surveys in specific habitats is recommended. Without further studies on alien spider species, potential impacts are only guesswork.

Surveys for synanthropic alien spiders and their relatives are of lesser importance, as long as no dangerous spiders are introduced and the species that do arrive cannot become established outside. Thus, the costs of conducting surveys for these would probably not be justified. However, monitoring of some selected species (e.g. *Oecobius maculatus* Simon and *Zoropsis spinimana*) to document their spread would be both worthwhile and manageable.

In particular, we recommend an assessment of alien spiders in greenhouses and other heated buildings. Greenhouses in nurseries and garden centres are the most likely to be colonized by alien spider species, and from there these can be spread to households on plant material (e.g. *Eperigone eschatologica*). Research and monitoring are needed, because of the potential economic impact of some species. The first encounter with *Uloborus plumipes* is an example: a nursery started an inquiry to find out what species had infested their property after this spider had covered all plants with webs, so that plants became difficult to sell. Moreover, the possibility of accidental introductions of poisonous spiders should not be underrated. Nurseries would be the main targets for these monitoring programmes, but other heated buildings in botanical gardens and zoos should be included.

The following are considered to have the greatest potential for economic impacts:

- Mass outbreaks of nuisance species (see *Ostearius melanopygius*), but without causing real damage.
- A dramatic increase in the population of the wall-inhabiting spider *Dictyna civica*.
- The potential medical costs for treatments of bites of introduced poisonous spiders, see ‘banana spiders’, and escaped terrarium species.

Having noted the potential threats to humans, it has to be stressed that broad use of pesticides against spiders is not a reasonable reaction, because of the non-target effects of these chemicals and the fact that publicity of such measures will exaggerate arachnophobia, already well-grounded in the human population.

In conclusion, only a very small number of spiders and their relatives are considered as problem species on a global scale, including Central Europe (e.g. Welch et al., 2001 do not list any alien spiders for Scotland). A reasonable explanation could be that many phytophagous insects live in closer association with their host plants, e.g. eggs, larvae and pupae are firmly attached to host plants or inside them. This would facilitate their transport with plant material. Another factor is that spiders with their predatory behaviour are less obvious than phytophagous insects that damage their host plants. Moreover, as pointed out earlier, the group is rather neglected and many information gaps still exist. However, after successful introduction into a new area, many spiders are highly capable of a rapid expansion in range either by natural means such as ballooning or by hitching a ride on vehicles.

References

Baur, B., Joshi, J., Schmid, B., Hänggi, A., Borcard, D., Stary, J., Pedroli-Christen, A., Thommen, G.H., Luka, H., Rusterholz, H.-P., Oggier, P., Ledergerber S. and A. Erhardt (1996) Variation in species richness of plants and diverse groups of invertebrates in three calcareous grasslands of the Swiss Jura mountains. Rev. Suisse Zool. 103 (4), 801-833.

Benz, G., Nyffeler M. and R. Hug (1983) *Ostearius melanopygius* (O.P.-Cambridge) (Aran., Micryphantidae) neu für die Schweiz. Über ein Massenauftreten der Spinne in Zürich und die Zerstörung der Population durch Schneefall. Mitt. schweiz. Ent. Ges. 56, 201-204.

Billaudelle, H. (1957) Zur Biologie der Mauerspinne *Dictyna civica* (H. Luc.) (Dictynidae, Araneida). Zeitschr. Angew. Entomol. 41, 475-512.

Blick, T. (1999) Spinnen auf Kopfsalatfeldern bei Kitzingen (Unterfranken, Bayern). Arachnol. Mitt. 17, 45-50.

Blick, T., Pfiffner L. and H. Luka (2000) Epigäische Spinnen auf Äckern der Nordwest-Schweiz im mitteleuropäischen Vergleich (Arachnida: Araneae). Mitt. Dt. Ges. allg. angew. Entomol. 12, 267-276

Blick, T., Hänggi A. and K. Thaler (2002) *Checkliste der Spinnentiere Deutschlands, der Schweiz, Österreichs Belgiens und der Niederlande (Arachnida: Araneae, Opiliones, Pseudoscorpiones, Scorpiones, Palpigradi). Version 1.* June 2002. Internet: http://www.AraGes.de/checklisten.html

Bliss, P. (1990) Zur Verbreitung von *Opilion canestrinii* (Thorell) in der Deutschen Demokratischen Republik (Arachnida: Opiliones, Phalangiidae). Acta Zool. Fennica 190, 41-44.

Bonte, D., Criel, P., Baert L. and D. De Bakker (2002) The invasive occurrence of the Mediterranean dwarfspider *Diplocephalus graecus* (O. P.-Cambridge, 1872) in Belgium (Araneae: Linyphiidae). Belgian Journal of Zoology 132, 171-173.

Bosmans, R. and H. Vanuytven (1998) *Eperigone eschatologica* een Amerikaanse immigrant in West Europa (Araneae, Erigonidae). Nwsbr. Belg. Arachnol. Ver. 13 (1), 15-16.

Bosmans, R. (1997) Revision of the genus *Zodarion* Walckenaer, 1833, part II. Western and Central Europe, including Italy (Araneae: Zodariidae). Bulletin of the British Arachnological Society 10, 265-294.

Braun, R. (1952) “Maserung“ von Wänden durch Spinnen. Natur u. Volk 82, 230-233.

Braun, R (1960) Eine für Deutschland neue Springspinne, *Euophrys lanigera* (E. Simon 1871) (Araneae; Salticidae, Heliophaninae, Euophryeae) mit Bemerkungen zu ihren Männchenvarianten. Nachr. Naturwiss. Mus. Aschaffenburg 64, 77-85, Taf. I-II.

Broen, B. von, Thaler-Knoflach B. and K. Thaler (1998) Nachweis von *Coleosoma floridanum* in Deutschland (Araneae: Theridiidae). Arachnol. Mitt. 16, 31-32.

Enghoff, H. (1987) *Opilio canestrinii* (Thorell, 1876) - en nyinvandret mejer i Danmark (Opiliones). Ent. Meddr. 55, 39-42.

Geiter, O., Homma S. and R. Kinzelbach (2002) *Bestandsaufnahme und Bewertung von Neozoen in Deutschland. Untersuchung der Wirkung von Biologie und Genetik ausgewählter Neozoen auf Ökosysteme und Vergleich mit den potenziellen Effekten gentechnisch veränderter Organismen.* Texte Umweltbundesamt 25/2002, Berlin, 290 pp.

Gruber, J. (1988) Neunachweise und Ergänzungen zur Verbreitung von *Opilio canestrinii* (Thorell) und *Opilio transversalis* Roewer. Ann. Naturhist. Mus. Wien 90B, 361-365.

Hänggi, A. (2003) Nachträge zum ”Katalog der schweizerischen Spinnen“. 3. Neunachweise von 1999 bis 2002 und Nachweise synanthroper Spinnen. Arachnol. Mitt. 26.

Hänggi, A. and B. Baur (1998) The effect of forest edge on ground-living arthropods in a remnant of unfertilized calcareous grassland in the Swiss Jura mountains. Mitt. schweiz. entomol. Ges. 71, 343-354.

Hänggi, A. and I. Weiss (2003) Spinnen (Araneae) und Weberknechte (Opiliones). In: Fauna und Flora auf dem Eisenbahngelände im Norden Basels. Monogr. Entomol. Ges. Basel 1, 74-79 and 204-205 (Anhang 7).

Hansen, H. (1996) L'importenza medica di alcuni ragni viventi negli ambienti urbani di Venezia. Boll. Mus. civ. St. nat. Venezia 45 (1994), 21-32.

Hillyard, P.D. (1981) *Coleosoma floridanum* Banks (Araneae: Theridiidae) and *Boeorix manducus* Thorell (Opiliones: Assamiidae): two tropical arachnids in botanical gardens. Newsletter of the British Arachnological. Society 31, 3-4.

Höfer, A.M. and J. Spelda (2001) On the distribution of *Astrobunus laevipes* Canestrini, 1872 (Arachnida: Opiliones) in Central Europe. Arachnol. Mitt. 22, 42-49.

Holzapfel, M. (1932) Die Gewächshausfauna des Berner Botanischen Gartens. Rev. suisse Zool. 39, 325-371.

Huhta, V. (1972) *Loxosceles laeta* (Nicolet) (Araneae, Loxoscelinae), a venomous spider established in a building in Helsinki, Finland, and notes on some other synanthropic spiders. Ann. Ent. Fennici 38, 152-156.

Jäger, P. (1995) Erstnachweis von *Holocnemus pluchei* und zweiter Nachweis von *Nesticus eremita* für Deutschland in Köln (Araneae: Pholcidae, Nesticidae). Arachnol. Mitt. 10, 23-24.

Jäger, P. (1998) Weitere Funde von *Nesticus eremita* (Araneae: Nesticidae) in Süddeutschland mit Angaben zur Taxonomie im Vergleich zu N. cellulanus. Arachnol. Mitt. 15, 13-20.

Jäger, P. (2000) Selten nachgewiesene Spinnenarten aus Deutschland (Arachnida: Araneae). Arachnol. Mitt. 19, 49-57.

Jäger, P. (2002) *Thanatus vulgaris* Simon, 1870 - ein Weltenbummler (Araneae: Philodromidae). Mit Anmerkungen zur Terminologie der weiblichen Genitalien. Arachnol. Mitt. 23, 49-57.

Jones, D. (1997) *Thanatus vulgaris* Simon, 1870 a further British record. Newsletter of the British Arachnological Society 80, 6-7.

Jonsson, L.J. (1993) Nachweis von *Uloborus plumipes* in einem Gewächshaus in Niedersachsen. Arachnol. Mitt. 6, 42-43.

Jonsson. L.J. (1998) Toftspideln – en spindelart som invanderat Europas växthus. Fauna och Flora 93, 119-124.

Klapkarek, N. and U. Riecken (1995) Zur Verbreitung und Autökologie von *Collinsia submissa* (Araneae: Linyphiidae). Arachnol. Mitt. 9, 49-56.

Klein, W., Stock M. and J. Wunderlich (1995) Zwei nach Deutschland eingeschleppte Spinnenarten (Araneae) - *Uloboris plumipes* Lucas und *Eperigone eschatologica* (Bishop) - als Gegenspieler der Weissen Fliege im geschützen Zierpflanzenbau? Beitr. Araneol. 4, 301-306.

Knoflach, B. (1991) *Achaearanea tabulata* Levi, eine für Österreich neue Kugelspinne (Arachnida, Aranei: Theridiidae). Ber. nat.-med. Verein Innsbruck 78, 59-64.

Knoflach, B. (1999) The comb-footed spider genera *Neottiura* and *Coleosoma* in Europe (Araneae, Theridiidae). Mitt. schweiz. entomol. Ges. 72, 341-371.

Komposch, C. (2002) Spinnentiere: Spinnen, Weberknechte, Pseudoskorpione, Skorpione (Arachnida: Araneae, Opiliones, Pseudoscorpiones, Scorpiones, Solifugae). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 250-252.

König, R. and H. Pieper (2003) Notizen zur Taxonomie und geographischen Verbreitung von Hasarius adansoni (Audouin, 1826). Faun.-Ökol. Mitt. 8, 197-200.

Lessert, R. de (1910) Araignées. Catalogue Invertébrés Suisse 3, 1-639.

Malten, A. (1991) Über *Opilio canestrinii*. Arachnol. Mitt. 1, 81-83.

Martens, J. (1978) *Weberknechte, Opiliones - Spinnentiere, Arachnida*. Tierwelt Deutschlands 64, 464 pp.

Maurer, R. and A. Hänggi (1990) Katalog der schweizerischen Spinnen. Doc. Faun. Helv. 12: o. Pag.

Millidge, A.F. (1987) The Erigonine spiders of North America. Part 8. The genus *Eperigone* Crosby and Bishop (Araneae, Linyphiidae). Amer. Mus. Novit. 2885, 1-75.

Pekár, S. and J. Král (2002) Mimicry complex in two central European zodariid spiders (Araneae, Zodariidae): how *Zodarion* deceives ants. Biological Journal of the ?Linnean Society 75, 517-532.

Platen, R., Blick, T., Bliss, P., Drogla, R., Malten, A., Martens, J., Sacher P. and J. Wunderlich (1995) Verzeichnis der Spinnentiere (excl. Acarida) Deutschlands (Arachnida: Araneida, Opilionida, Pseudoscorpionida). Arachnol. Mitt. Sonderband 1, 1-55.

Platnick, N.I. (2004) *The world spider catalog. Version 4.0.*
Internet: http://research.amnh.org/entomology/spiders/catalog/index.html

Ruzicka, V. (1995) The spreading of *Ostearius melanopygius* (Araneae: Linyphiidae) through Central Europe. European Journal of Entomology 92 (4), 723-726.

Sacher, P. (1978) Ein Massenvorkommen der Baldachinnetzspinne *Ostearius melanopygius* (O.P.-Cambridge) in Ostthüringen (Araneae: Linyphiidae, Donacochareae). Veröff. Mus. Gera Naturw. R. 6, 53-63.

Sacher, P. (1983) Spinnen (Araneae) an und in Gebäuden - Versuch einer Analyse der synanthropen Spinnenfauna in der DDR. Entomol. Nachrichten Berichte 27, 97-104, 141-152, 197-204, 224.

Schmidt, G.E.W. (1971) Mit Bananen eingeschleppte Spinnen*. Zool. Beitr. 17* (3), 387-433

Simon, E. (1901) Note sur une Araignée exotique (*Hasarius adansoni* Aud.) acclimatée dans les serres chaudes, aux environs de Paris. Bulletin de la Société Entomologique de France 1901 (7), 154-155.

Stächele (verfasst von B. Krauss) (2002) *Bekämpfung der Mauerspinnen an Hausfassaden. Kleine Anfrage der Abg. Dr. Carmina Brenner CDU und Antwort des Ministeriums für Ernährung und Ländlichen Raum.* Landtag Baden-Württemberg, Drucksache 13/1276, 1-4.
Internet: http://www3.landtag-bw.de/WP13/Drucksachen/1000/13_1276_D.PDF

Staudt, A. (2004) Nachweiskarten der Spinnentiere Deutschlands.
Internet: http://www.spiderling.de.vu

Thaler, K. and B. Knoflach (1995) Adventive Spinnentiere in Österreich - mit Ausblicken auf die Nachbarländer. Stapfia 37, 55-76.

Thaler, K. and B. Knoflach (1998) *Zoropsis spinimana* (Dufour), eine für Österreich neue Adventivart (Araneae, Zoropsidae). Ber. nat.-med. Verein Innsbruck 85, 173-185.

Van der Weele, R. (1993) *Opilio canestrinii* nieuw voor de nederlandse fauna (Opilionida: Phalangiidae). Ent. Ber. Amsterdam 53, 91.

Van Keer, J. and K. Van Keer (1987) Bevestiging van het voorkommen van *Dictyna civica* (Lucas) in Belgie en de verspreiding van de soort. Nwsbr. Belg. Arachnol. Ver. 6, 7-8

Van Keer, K. and J. Van Keer (2001) Ingeburgerde exotische trilspinnen (Araneae: Pholcidae) in Antwerpse haven en enkele algemen bedenkinkgen bij spinnenmigratie. Nwsbr. Belg. Arachnol. Ver. 16 (3), 81-86.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review 139, 1-225.

Wijnhoven, H. (1997) *Euophrys lanigera* (Simon) met recht op de nederlandse soortenlist. Nieuwsbrief Spined 12, 1-3.

Wijnhoven, H. (2003) De hooiwagen *Astrobunus laevipes* nieuw voor Nederland (Opiliones: Phalangiidae). Nederl. Faun. Meded. 19, 73-78.

Fact Sheets

Eperigone trilobata

Taxonomic status

Scientific name	*Eperigone trilobata* (Emerton, 1882)
Family	Linyphiidae
Taxonomic group	Araneae
English name	
German name	
French name	
Italian name	

Description and identification

Description	Sexes are similar in size, between 1.6 and 2.1 mm in length. The prosoma is yellowish-brown to orange-brown. Sternum is orange and the legs are brown to orange-brown. The abdomen of both sexes is grey to almost black. Female epigyne and male palps are distinctive. Side plate of the epigyne is protrusive backwards, male tibial apophyses is rounded. Literature: Helsdingen, 1982; Nentwig et al., 2003. Identification only possible by means of a stereomicroscope.
Similar species	There is only one other species from the genus *Eperigone* present in Europe. *E. eschatologica* (Crosby) is somewhat larger (female: 2.8-3.3 mm, male: 1.9-2.5 mm) than *E. trilobata.* The colouration is similar in both species but they can be easily distinguished by their genitalia.

Biology and ecology

Behaviour	Adults are found year-round.
Food	Insects and other arthropods.
Habitat	Meadows, forest litter, wetlands, sandy beaches.

Origin North America, Holarctic (Platnick, 2004).

Introduction and dispersal

History of introduction	First record from south-western Germany in 1982. First record for Switzerland in 1990 (Hänggi, 1990). Meanwhile it spread northwards up to 51°N in western Germany and eastwards to 12°E in Bayern.
Pathways of introduction	Probably introduced by the US Army.
Dispersal	The fast invasion may be facilitated by ballooning (dispersal through the air).

Current status

Actual and potential distribution in CH	Regularly found in most open land habitats. *E. trilobata* is a common ground-living species. Highest record in 1999 in the Jura Mountains at almost 800 m above sea level.
Introduced distribution	*Eperigone trilobata* is mainly reported from Switzerland and Germany, but is expected to disperse eastwards and northwards in within the next decade. Spider data from southern Europe and France are too scattered to prove whether it has dispersed in those areas.

Impacts

Environmental impact	No displacement of native species has been shown and would be difficult to prove; it would require expensive long-term studies.

Economic impact — No economic impact is known.

Management options

Information gaps — In general, knowledge of spiders in Switzerland is rather limited.

References

Literature

Blick, T., Hänggi, A. and K. Thaler (2002) Checklist of the arachnids of Germany, Switzerland, Austria, Belgium and the Netherlands (Arachnida: Araneae, Opiliones, Pseudoscorpiones, Scorpiones, Palpigradi). Version 2002 June 1, online at http://www.AraGes.de/checklist_e.html

Hänggi, A. (1990) Beiträge zur Kenntnis der Spinnenfauna des Kt.Tessin III - Für die Schweiz neue und bemerkenswerte Spinnen (Arachnida: Araneae). Mitt. schweiz. ent. Ges. 63, 153-167

Helsdingen, P.J. van. (1982) *Eperigone trilobata* revealed as a trans-American species. Bull. Br. arachnol. Soc. 5, 393-396

Maurer, R. and A. Hänggi (1990) Katalog der Schweizerischen Spinnen. CSCF, Neuchâtel, 412 pp.

Nentwig, W., Hänggi, A., Kropf, C. and T. Blick (2003) Spinnen Mitteleuropas/Central European Spiders. An internet identification key. http://www.araneae.unibe.ch Version of 8.12.2003

Platnick, N.I. (2004) The world spider catalog. Version 4.5. American Museum of Natural History, online at http://research.amnh.org/entomology/spiders/catalog/index.html

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Zodarion italicum

Taxonomic status

Scientific name	*Zodarion italicum* (Canestrini, 1868)
Family	Zodariidae
Taxonomic group	Araneae
English name	
German name	
French name	
Italian name	

Description and identification

Description	Total length of female is 2.1-4.3 mm, of male 1.6-2.9 mm. Colouration is identical in both sexes. Prosoma is brown to dark brown, with variable dark markings. Legs are yellowish orange, femora often with dark markings. Abdomen dorsally dark purplish brown, ventrally uniformly pale yellowish. Female epigyne and male palp are distinctive. Literature: Bosmans, 1997; Nentwig et al., 2003. Identification only possible by means of a stereomicroscope.
Similar species	In Europe there are more than 30 species of *Zodarion* known. In Central Europe four species are established. All of these species have a similar appearance. The most similar species is *Z. gallicum* (Canestrini), which for a long time was confused with *Z. italicum*. The related taxa can be distinguished by their genitalia: the females by the trapezoid epigynal plate, limited at each side by a comma-shaped structure, and by the oval spermathecae; the males by the broad distal part of the retinaculum and by the hooked-back tip of the embolus.

Biology and ecology

Behaviour	*Z. italicum* looks ant-like when running and is found in association with ants. It lives on the ground in tubes spun from silk and integrated with particles of stones and twigs.
Food	This spider is an ant predator and feeds exclusively on them.
Habitat	*Z. italicum* inhabits dry and open habitats.

Origin Southern Europe

Introduction and dispersal

History of introduction	*Z. italicum* is native in southern Europe but is spreading rapidly northwards.
Pathways of introduction	Its spread might be enhanced by soil transport.
Dispersal	One reason for the rapid dispersal may be due to global warming. However, this hypothesis cannot be proven without appropriate research.

Current status

Actual and potential distribution in CH	The species may be autochthonous for the south of Switzerland. Today, *Z. italicum* is dispersed throughout the entire country below 800-1000 m above sea level.
Introduced distribution	In Europe there are records extending from Italy to southern England.

Impacts

Environmental impact	No displacement of native species has been shown and would be difficult to prove; it would require expensive long-term studies.
Economic impact	No economic impact is known.

Management options

Information gaps In general, knowledge of spiders in Switzerland is rather limited.

References

Literature

Blick, T., Hänggi, A. and K. Thaler (2002) Checklist of the arachnids of Germany, Switzerland, Austria, Belgium and the Netherlands (Arachnida: Araneae, Opiliones, Pseudoscorpiones, Scorpiones, Palpigradi). Version 2002 June 1, online at http://www.AraGes.de/checklist_e.html

Bosmans, R. (1997) Revision of the Genus *Zodarion* Walkenaer, 1833, part II. Western and Central Europe, including Italy (Araneae: Zodariidae). Bull. Br. Arachnol. Soc. 10 (8), 265-294.

Maurer, R. and A. Hänggi (1990) Katalog der Schweizerischen Spinnen. CSCF, Neuchâtel, 412 pp.

Nentwig, W., Hänggi, A., Kropf, C. and T. Blick (2003) Spinnen Mitteleuropas/Central European Spiders. An internet identification key. http://www.araneae.unibe.ch Version of 8.12.2003

Platnick, N.I. (2004) The world spider catalog. Version 4.5. American Museum of Natural History, online at http://research.amnh.org/entomology/spiders/catalog/index.html

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Zoropsis spinimana

Taxonomic status

Scientific name	*Zoropsis spinimana* (Dufour, 1820)
Family	Zoropsidae
Taxonomic group	Araneae
English name	
German name	
French name	
Italian name	

Description and identification

Description	Females are 10-19 mm and males are 10-13 mm in length. General appearance is similar in both sexes and resembles a large wolf spider (Lycosidae) but, being a cribellate spider, it has a cribellum and calamistrum. Prosoma is pale yellowish with broad black markings. White around the eyes. Anterior the opisthosoma is yellowish-white, in the middle with a black marking and posteriorly grey. Legs are yellowish-grey, black annulated. Genitalia of both sexes are distinctive. Female epigyne has a long, small scapus. Male cymbium found dorsally with a field of short bristles. Literature: Thaler and Knoflach, 1998; Nentwig et al., 2003. Identification only possible by means of a stereomicroscope.
Similar species	Five species of the genus *Zoropsis* are known from (southern) Europe. *Z. spinimana* can be distinguished from the other species by details of the genitalia.

Biology and ecology

Behaviour	*Z. spinimana* is an ambush predator; it does not spin a web to catch prey. The females are often found in a breeding chamber, guarding their cocoons. Egg deposition takes place in spring, while maturity is reached in autumn. The species is annual.
Food	Insects and other arthropods.
Habitat	In forests, under stones and bark. Often synanthropic either in or around houses.

Origin Mediterranean, to the southern border of the Alps.

Introduction and dispersal

History of introduction	First record in Switzerland was from a residential house in Basel in 1994, first published in Hänggi (2003). Subsequently, some individuals were found in southern Switzerland. Few records are known from Austria.
Pathways of introduction	In Austria, the most northerly expansion of the range of this species is thought to follow the valley of the river Etsch/Adige, aided by human activities.
Dispersal	The most likely way of dispersal of this quite large species is through human-mediated transport.

Current status

Actual and potential distribution in CH	Residential houses are the replacement habitats for this thermophilous species. Thus, *Z. spinimana* occurs north of the Alps only synanthropically. Therefore the potential range is the whole country, but always in close vicinity to humans.

Introduced distribution	Introduced also into the USA in 2001.

Impacts

Environmental impact	No displacement of native species has been shown and would be hardly to demonstrate.
Economic impact	*Z. spinimana* is capable of penetrating human skin with its cheliceres. The painful but otherwise harmless bite could constitute a problem for humans.

Management options

Information gaps In general, knowledge of spiders in Switzerland is rather limited, especially for synanthropic species like *Z. spinimana*.

References

Literature

Blick, T., Hänggi, A. and K. Thaler (2002) Checklist of the arachnids of Germany, Switzerland, Austria, Belgium and the Netherlands (Arachnida: Araneae, Opiliones, Pseudoscorpiones, Scorpiones, Palpigradi). Version 2002 June 1, online at http://www.AraGes.de/checklist_e.html

Hansen, H. (1996) L'importanza medica di alcuni ragni viventi negli ambienti urbani di Venezia. Boll. Mus. Civ. storia nat. Venezia 45 (1994), 21-32

Nentwig, W., Hänggi, A., Kropf, C. and T. Blick (2003) Spinnen Mitteleuropas/Central European Spiders. An internet identification key. http://www.araneae.unibe.ch Version of 8.12.2003

Platnick, N.I. (2004) The world spider catalog. Version 4.5. American Museum of Natural History, online at http://research.amnh.org/entomology/spiders/catalog/index.html

Thaler, K. and B. Knoflach (1995) Adventive Spinnentiere in Österreich – mit Ausblicken auf die Nachbarländer (Arachnida ohne Acari). Stapfia 37, zugleich Katalog des OÖ. Landesmuseums N.F. 84, pp. 55-76.

Thaler, K. and B. Knoflach (1998) *Zoropsis spinimana* (Dufour), eine für Österreich neue Adventivart (Araneae, Zoropsidae). Ber. nat.-med. Verein Innsbruck 85, 173-185.

Thaler, K. and B. Knoflach (2002) *Zoropsis spinimana* (Dufour, 1820): an invader into Central Europe? Newsl. Br. Arachnol. Soc. 95, 15.

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6 Molluscs – Mollusca

Prepared by Rüdiger Wittenberg

The molluscs are a very large successful group of about 130,000 described species, making them second in number of species only to the arthropods (Remane et al., 1981). However, of the molluscs' seven classes only two occur in Switzerland, since the others are strictly marine species.

In the text below, gastropod and bivalve species are discussed separately. For ease of reference, in Table 6.2 the species are divided into terrestrial snails (including slugs), freshwater snails and bivalves, while the Fact Sheets are in alphabetical order of species.

A total of 16 gastropods and three bivalves are regarded as established alien species.

Snails and slugs (Gastropoda)

Gastropods make up 70% of all molluscs and are well represented in marine, freshwater and terrestrial habitats. About 196 terrestrial and 50 aquatic species occur in Switzerland (Turner et al., 1998).

The exact natural distribution of the gastropod species in Switzerland is not well known, and many current populations may be early relocations (introductions within Switzerland). Snails are very successful at hitching a ride, so that many former barriers have been easily bridged through human-mediated transport. Snails arrived on plant material as early as during Roman times. The aquatic snail *Viviparus ater* (Molina) is an example of relocation in Switzerland. Its native range is believed to be south of the Alps, including the Ticino, but today its range north of the Alps encompasses the lower regions between Lac de Genève and Bodensee. It was released into Lac de Genève before 1900.

Snails found in greenhouses are not covered by this report if they do not occur outside as well. Turner et al. (1998) provide a discussion of greenhouse snails and species that have been recorded only temporarily, and which are therefore not considered to be established in the wild.

The snail ***Solatopupa similis*** (Bruguière) (Chondrinidae) was introduced to a location close to Locarno in the 19th century for unknown reasons. This population thrives, but the species' impact is considered minimal because of its very localized distribution.

The family Milacidae with two native species, has been supplemented in Switzerland with two more, i.e. ***Milax gagates*** (Draparnaud) and ***Tandonia budapestensis*** (Hazay), both from other parts of Europe. *M. gagates* has been found only in gardens, where it probably arrived with plant material, so it is not known whether it is established in Switzerland. *T. budapestensis* is an anthropochorous (disperses as a result of human activity) species that is widely distributed within Europe. It is regarded as a pest, especially in winter crops (Fischer and Reischütz, 1998), but is rather difficult to observe because of its cryptic, nocturnal habits.

Another synanthropic species (in addition to members of the Milacidae) is ***Limacus flavus*** (L.) (Limacidae), which is only rarely encountered in Switzerland. It is likely that this species will be introduced with plant material in the future, but it is probably not adapted to the Swiss environment, so that it is less likely to become established.

The slugs ***Deroceras sturanyi*** (Simroth) and ***D. panormitanum*** (Lessona & Pollonera) belong to the Agriolimacidae. This family is taxonomically challenging and new species have recently been described (Kerney et al., 1983). These slugs prefer fresh green plant material and therefore some are recognized as pests. The former species has been considered a pest in gardens, while the latter species is only rarely found in Switzerland. However, *D. panormitanum* is expanding its range in Europe and is increasingly reported as damaging plants of economic importance. This is a species that should be monitored, since it is likely to establish populations in agricultural areas, with the potential to cause economic damage in the near future.

The origin of the slug ***Boettgerilla pallens*** Simroth (Boettgerillidae) is assumed to be the Caucasus, although Jungbluth (1996) argued that it might be a native species in Central Europe which had not been reported earlier. Most collections of slugs are fairly recent and the lack of a shell makes it difficult to find species as subfossils. This species is a predator of slug eggs and young slugs (Reischütz, 2002), so it is a beneficial organism in agricultural settings rather than a pest, as sometimes stated. However, in natural localities, it may have a negative impact on native slugs through predation.

Arion lusitanicus Mabille (Arionidae) (see Fact Sheet) is rapidly expanding its range, and is the most serious invader amongst the snails and slugs. It is not only a pest in agriculture and gardens, but also displaces a native congeneric species in the lowland parts of Switzerland (Turner et al., 1998).

The snail ***Hygromia cinctella*** (Draparnaud) (Hygromiidae) has been accidentally introduced into the northern parts of Switzerland, but could be native around Genève or in the Ticino. It was introduced prior to the start of malacological recording and is mostly found in gardens and other anthropogenic settings (Kerney et al., 1983).

The only introduced species of Helicidae is ***Cryptomphalus aspersus*** (O.F. Müller), which was introduced prior to the start of malacological recording. It is mostly found in gardens and other anthropogenic habitats, although it is recorded from natural habitats, e.g. in the Valais. Its environmental impact is not known, but it is regarded as a pest in gardens.

The freshwater snail ***Potamopyrgus antipodarum*** (Gray) (Hydrobiidae) (see Fact Sheet) is one of the few long-distance invaders in this group. It is native to New Zealand and has been spread around the world probably with ballast water between freshwater systems and on ornamental aquatic plants. Haynes et al. (1985) have suggested another pathway as they have shown that *P. antipodarum* can survive a six-hour passage through the gut of a trout and produce live young shortly afterwards. It is very likely to induce ecosystem changes because of its enormous numbers in some places.

Two *Physella* species, ***Physella acuta*** (Draparnaud) and ***P. heterostropha*** (Say) (Physidae), have been introduced into Switzerland. The latter species is of North American origin, but the origin of the former species is disputed, although it probably originates in south-western Europe. Since *P. heterostropha* is cold-tolerant, the expansion of its range could lead to competition with native snails. While Turner et al. (1998) state that the two species are morphologically distinct and occur together in some parts of Switzerland, Anderson (2003) records the two species as synonyms.

Two alien species of Planorbidae, ***Gyraulus parvus*** (Say) and ***Planorbarius corneus*** (L.), probably cause no concern, because the former is a rare species of North American origin and the latter is a native species in Europe. It is likely that *P. corneus* cannot establish populations in Switzerland, because of unsuitable climatic conditions. However, it is found frequently, probably released from aquariums or transported by birds from garden ponds.

Bivalves (Bivalvia)

There are only three introduced and established bivalves, but they are of concern, because of their high abundance and feeding behaviour.

The two *Corbicula* species (***Corbicula fluminea*** (O.F. Müller) and ***C. fluminalis*** (O.F. Müller)) are very similar, so that they are discussed together (see Fact Sheet). Hakenkamp and Palmer (1999) have demonstrated the strong influence *Corbicula* spp. have on ecosystem functioning by linking pelagic and benthic processes as a result of their intense filter feeding activity.

The zebra mussel ***Dreissena polymorpha*** (Pallas) (Dreissenidae) (see Fact Sheet) is one of the most widely cited case studies of a freshwater invader. Whereas the species is often considered to be beneficial in Europe, especially as a food source for diving ducks, it is inflicting huge costs to the USA and Canada in the Great Lakes area. The transformation of freshwater ecosystems by *D. polymorpha* is documented by Strayer et al. (1999) and Karateyev et al. (2002).

The 19 established alien mollusc species belong to very different groups, i.e. 14 families, with only one or two species per family. However, the species can be considered as belonging to a number of major groups. Seven species from four families of slugs (Milacidae, Limacidae, Agriolimacidae and Arionidae) have been introduced into Switzerland. The total number of species in these families found in Switzerland is 33, so about 21% are introduced. This is a rather high percentage, as will be seen below. It seems that slugs are very good at hiding in plant material, decaying material and other commodities and are widely transported. Today there are three established introduced bivalves, which is about 11% of the total of 28 species found in Switzerland. Probably six out of the 50 freshwater snail species are alien (12%). Finally, the large group of terrestrial snails (terrestrial molluscs excluding the four families of slugs mentioned above) comprise approximately 160 species, of which a mere three species (2%) are introduced. With the exception of the slugs, the pattern that emerges might be a random phenomenon due to small sample sizes; whereby a few introductions of species in smaller groups form a higher percentage of the total fauna. The extreme would be a randomly introduced species from a group comprising one species, which would form 100% of the fauna of that particular group. The total percentage of established molluscs is about 6.9% (19 of 274 species).

A comparison of the established mollusc species in Switzerland and Austria shows a very similar picture; the percentage of introduced mollusc species is 6.9% in Switzerland and 7.6% in Austria (Essl and Rabitsch, 2002). Of course, the total number of species differs because Austria is about twice the size of Switzerland (83,855 km^2 compared to 41,285 km^2). About 435 mollusc species occur in Austria, including 33 aliens. Even more established alien mollusc species are recorded in Germany, about 40, but five of those are marine (Geiter et al., 2002). There is a remarkable overlap of the alien species in the three countries, emphasizing the regular introduction of some species (in some cases using the same frequent pathways).

Most of the established alien mollusc species originate within Europe (Tab. 5.1), although the exact origin of some Ponto–Caspian species is not known, so whether these species originate in Europe or Asia may be disputable. Only five (about a quarter) of the species travelled a long distance to Switzerland. The majority have apparently profited from short-distance transport of commodities between European countries.

Table 6.1: Origin of alien molluscs established in Switzerland.

Origin	No. species
Europe	13
Asia	2
North America	2
Switzerland	1
New Zealand	1
Total	19

This leads to an evaluation of the pathways by which these 19 species arrived in Switzerland. It is possible that at least some species could have arrived by several pathways, and for some species the pathways by which they were introduced are speculative rather than proven. The most likely pathways for each species are listed in Table 6.2. About 74% (14 species) were accidentally introduced, while the others were released for unknown reasons and from aquariums (often with the good intention of ‘freeing’ surplus animals). Five of the eight aquatic species were probably transported by boats and ships, either in ballast water or attached to hulls. The accidental terrestrial introductions were most likely made with imported vegetables and other plant material.

The impacts of the established alien molluscs are discussed in some detail and further references are given in the Fact Sheets and in the text above. Only five out of 19 species can be regarded as harmless, based on present knowledge. The terrestrial slugs (and to a certain extent snails) are mainly economic pests of agriculture and in gardens. However, research on environmental impacts is largely lacking, with the exception of *Arion lusitanicus* displacing the native *A. rufus* (L.). The situation is different in freshwater ecosystems, with demonstrated dramatic impacts of the introduced bivalves on native biodiversity and ecosystem functioning. The introduced bivalves are a novel life form in their new range, because of their densities and intense filter-feeding activities, which alter the correlation between benthic and pelagic communities. They may also have some economic impact because of their colonization of pipes and other artificial structures.

In general, alien species should be treated separately from the native fauna and should not appear on a Red List of endangered species, when they are beyond doubt introduced. This is especially true for the intercontinental invader, since some European species could also expand their range into Switzerland and distinguishing between the two categories (aliens of European and extra-continental origin) is often challenging. However, species such as *Physella heterostropha*, a Nearctic invader, should not appear on the Red List as potentially vulnerable (‘potentiell gefährdet’), as it does. Thus, the concept of the Red List of Switzerland should be re-addressed, with alien species being excluded.

Prevention of new mollusc invasions is dependent on identification of the pathways of introduction. Plant health inspection has improved recently and should be vigilant for new arrivals of slugs and snails, as well as insects and other invertebrates. The ballast water issue is currently being addressed for sea-going ships by the International Maritime Organization (IMO) whereby methods are evolving to treat ballast water. Some of these measures can also be used for ships on inland waterways. Another crucial topic is public education and awareness; when using a boat, boots or fishing gear, people should take care not to transport potential hitchhikers. Aquarium owners and pet store merchants need to be made aware of potential problems arising from the release of pets.

Several slug species are major pests in crops, and management strategies to reduce harvest losses have been implemented. Slug pellets, a bait that contains slug attractants and a molluscicide (e.g. metaldehyde), are frequently used. Alternative methods include the use of nematodes and runner ducks (a special breed of the mallard) as biological control agents, as well as hand-picking. The latter approach, although very laborious, was successfully used to eradicate the giant African snail (*Achatina fulica* Bowdich) in Florida, USA (Simberloff, 1996). This was a remarkable achievement. Slug fences and beer traps are often used in gardens. However, these methods are usually used to protect plants at a specific location and are not designed to reduce numbers of snails and slugs of environmental concern on a large scale.

In conclusion, the freshwater ecosystems need to receive more attention and the potential impacts of alien invaders should not be underrated. It is generally very difficult to give conclusive proof of the impacts of invasive species on native biodiversity. However, many of the freshwater invaders reach remarkable densities and will have impacts on natural ecosystems. These invaders are not only molluscs, but often crustaceans and fish (see respective chapters). The boom-and-bust phenomenon (Williamson, 1996) that is frequently observed with many invading species seems often to be caused in European freshwater systems by the arrival of yet another invader. Thus, this does not solve the problem, but simply shifts it to another invader and its impacts. In a terrestrial context, the slug *Arion lusitanicus* is probably of greatest concern in Switzerland (and Central Europe).

Table 6.2: Established alien molluscs in Switzerland.

Scientific name	Family	Year	Origin	Pathway	Impact	Note
Terrestrial snails						
Solatopupa similis (Bruguière)	Chondrinidae	19th century	Genoa, Italy	Released to enrich fauna	Probably harmless	Only one location near Locarno, Ticino
Milax gagates (Draparnaud)	Milacidae	1968	Western and southern Europe	Accidental with vegetables shipment?	Pest in crops and gardens	Not clear whether established or only repeatedly introduced
Tandonia budapestensis (Hazay)	Milacidae	1935	South-eastern Europe	Accidental with vegetables shipment?	Pest, in particular in winter crops, when abundant	Anthropochorous – introduced widely by human-mediated transport
Limacus flavus (L.)	Limacidae	1927	Mediterranean	Accidental	Harmless	Very rare in Switzerland, mostly synanthropic
Deroceras sturanyi (Simroth)	Agriolimacidae	1963	South-eastern Europe	Accidental	Damage to plants in gardens	Mostly secondary habitats
Deroceras panormitanum (Lessona & Pollonera)	Agriolimacidae	1982	South-western Europe	Accidental	Future damage anticipated	Very rare in Switzerland, only in gardens and parks
Boettgerilla pallens Simroth	Boetgerillidae	1960	Caucasus?	Accidental	Predator of native slugs?	Impact not known, but a predator of slugs
Arion lusitanicus Mabille	Arionidae	1950s	Western Europe	Accidental	Most serious pest in gardens and agriculture Displaces native *Arion rufus* (L.)	Most problematic terrestrial snail
Hygromia cinctella (Draparnaud)	Hygromiidae	1824?	Mediterranean	Accidental	Harmless	Perhaps native in southern and south-western Switzerland, but introduced to the northern parts

Table 6.2: Established alien molluscs in Switzerland.

Scientific name	Family	Year	Origin	Pathway	Impact	Note
Cryptomphalus asperus (O.F. Müller)	Helicidae	Before 1789	South-western Europe	Released	Garden pest	Mainly synanthropic, but also found in natural habitats
Freshwater snails						
Viviparus ater (Molina)	Viviparidae	Before 1900	South Switzerland	Accidental introduction with boat traffic	Probably harmless	Native in southern Switzerland
Potamopyrgus antipodarum (Gray)	Hydrobiidae	1972	New Zealand	Accidental introduction with boat traffic and birds	Can drastically alter primary production	Rapid expansion throughout Europe
Physella acuta (Draparnaud)	Physidae	1848	South-western Europe	Accidental release from aquariums?	Not known	Maybe of North American origin
Physella heterostropha (Say)	Physidae	Before 1991	North America	Accidental	Competition with native snails?	Expanding in Europe
Gyraulus parvus (Say)	Planorbidae	1994	North America	Accidental with aquatic plants	Not known	Rare in Switzerland
Planorbarius corneus (L.)	Planorbidae	1840	Europe	Releases from aquariums	Probably harmless	Perhaps not established
Bivalves						
Corbicula fluminalis (O.F. Müller)	Corbiculidae	1997	Asia, introduced via North America	Probably ballast water	Competition with native bivalves	The two *Corbicula* species are very similar
Corbicula fluminea (O.F. Müller)	Corbiculidae	1997	Asia, introduced via North America	Probably ballast water	Competition with native bivalves	The two *Corbicula* species are very similar

Table 6.2: Established alien molluscs in Switzerland.

Scientific name	Family	Year	Origin	Pathway	Impact	Note
Dreissena polymorpha (Pallas)	Dreissenidae	1850	Ponto–Caspian region	Probably ballast water and/or hull fouling	Ecosystem engineer. Overgrows native mussel species .Costs to prevent them clogging pipes, etc. are fairly small compared with North America	Species of high concern

References

Anderson, R. (2003) *Physella* (*Costatella*) *acuta* Draparnaud in Britain and Ireland – its taxonomy, origins and relationships to other introduced Physidae. Journal of Conchology 38, 7-21.

Essl, F. and W. Rabitsch (eds) (2002) *Neobiota in Österreich*. Federal Environment Agency, 432 pp.

Fischer, W. and P.L. Reischütz (1998) General aspects about the slugpests. Die Bodenkultur 49 (4), 281-292.

Geiter, O., Homma, S. and R. Kinzelbach (2002) *Bestandsaufnahme und Bewertung von Neozoen in Deutschland.* Umweltbundesamt, 308 pp.

Hakenkamp, C.C. and M.A. Palmer (1999) Introduced bivalves in freshwater ecosystems: the impact of *Corbicula* on organic matter dynamics in a sandy stream. Oecologia 119, 445-451.

Haynes, A., Taylor, B. J. R. and M.E. Varley (1985) The influence of the mobility of *Potamopyrgus jenkinsi* (Smith, E.A.) (Prosobranchia: Hydrobiidae) on its spread. Arch. Hydrobiol. 103, 497-508.

Jungbluth, J.H. (1996) Einwanderer in der Molluskenfauna von Deutschland. I. Der chorologische Befund. In: Gebhardt, H., Kinzelbach, R. and S. Schmidt-Fischer (eds) *Gebietsfremde Tierarten. Auswirkungen auf einheimische Arten, Lebensgemeinschaften und Biotope; Situationsanalyse*. Ecomed Verlagsgesellschaft, Landsberg, pp. 287-296.

Karateyev, A.Y., Burlakova, L.E. and D.K. Padilla (2002) Impacts of zebra mussels on aquatic communities and their role as ecosystem engineers. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management*. Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 426-432.

Kerney, M.P., Cameron, R.A.D. and J.H. Jungbluth (1983) Die Landschnecken Nord- und Mitteleuropas. Paul Parey, Hamburg and Berlin, Germany, 384 pp.

Reischütz, P. (2002) Weichtiere (Mollusca). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, Austria, pp. 214-221.

Remane, A., Storch, V. and U. Welsch (1981) *Kurzes Lehrbuch der Zoologie*. Gustav Fischer Verlag, Stuttgart, 537 pp.

Simberloff, D. (1996) Impacts of introduced species in the United States. Consequences 2 (2), 13-23.

Strayer, D.L., Caraco, N.F., Cole, J.J., Findlay, S. and M.L. Pace (1999) Transformation of freshwater ecosystems by bivalves: A case study of zebra mussels in the Hudson River. Bioscience 49, 19-27.

Turner, H., Kuiper, J.G.J., Thew, N., Bernasconi, R., Rüetschi, J., Wüthrich, M. and M. Gosteli (1998) *Mollusca, Atlas. Fauna Helvetica*. CSCF, Neuchâtel, 527 pp.

Williamson, M (1996) *Biological invasions*. Chapman & Hall, London, Weinheim, New York, Tokyo, Melbourne, Madras, 244 pp.

Fact Sheets

Arion lusitanicus

Taxonomic status

Scientific name	*Arion lusitanicus* Mabille
Family	Arionidae
Taxonomic group	Gastropoda
English name	Iberian slug
German name	Spanische Wegschnecke
French name	
Italian name	

Description and identification

Description	A large slug with a total length of about 14 cm at maximum when fully stretched out. The colouration is extremely variable, but is often a greyish to greenish colour with a dark band along the lateral sides. The breathing hole is on the right side of the snail in the front half of the mantle.
Similar species	*A. rufus* (L.) can be very similar and specimens of similar colouration can only be distinguished by dissection and comparison of the anatomy.

Biology and ecology

Behaviour	Prefers moist conditions, like other slugs. Mainly active at night or during rainy periods.
Food	Herbivorous species with a broad spectrum of host plants, but feeds readily on dumped plant material and carcasses.
Habitat	Predominantly a species of human created habitats, such as gardens and agricultural land, but also found in wasteland.

Origin South-western Europe.

Introduction and dispersal

History of introduction	Accidentally introduced in many countries of Europe.
Pathways of introduction	Accidentally introduced, probably with plant material.
Dispersal	Natural dispersal is slow, but they are moved around with human-mediated transport.

Current status

Actual and potential distribution in CH	The species has invaded all lowland parts of Switzerland. The mountains will limit its distribution.
Introduced distribution	It has been introduced into many European countries.

Impacts

Environmental impact	Displacement of native *Arion* species is of grave concern. The native *A. rufus* survives only at higher altitudes, where spread of the invader is limited.
Economic impact	This is the most important slug pest. It feeds on almost all green plants. Most of the damage is in gardens, but it is spreading into agricultural land.

Management options In agricultural fields and gardens the species is controlled by different methods, which are discussed in the main text of this chapter.

Information gaps Impact on native biodiversity. Best control methods in natural environment. Control options are limited, since the species is widely distributed in high numbers.

References

Literature

Fischer, W. and P.L. Reischütz (1998) General aspects about the slugpests. Die Bodenkultur 49 (4), 281-292.
Kerney, M.P., Cameron, R.A.D. and J.H. Jungbluth (1983) Die Landschnecken Nord- und Mitteleuropas. Paul Parey, Hamburg and Berlin, 384 pp.
Turner, H., Kuiper, J.G.J., Thew, N., Bernasconi, R., Rüetschi, J., Wüthrich, M. and M. Gosteli (1998) Mollusca, Atlas. Fauna Helvetica. CSCF, Neuchâtel, 527 pp.

Corbicula spp.

Taxonomic status

Scientific name	*Corbicula fluminalis* (O.F. Müller) and *C. fluminea* (O.F. Müller)
Family	Corbiculidae
Taxonomic group	Bivalvia
English name	Asian clam
German name	Brackwasser-Körbchenmuschel and Fluss-Körbchenmuschel
French name	
Italian name	

Description and identification

Description	The two Asian clam species are very similar and are considered to be conspecific by some authorities. The shell is asymmetric with a roundish front and a more angled rear. Concentric ridges are conspicuous. The colour varies between yellowish and brown. The inside is whitish to light blue. The maximum length is between 5 and 6 cm.
Similar species	The 2 species are very difficult to distinguish.

Biology and ecology

Behaviour	Asian clams are synchronous hermaphrodites and incubate their young within their branchial cavity. Self-fertilization may occur. Approximately 350 larvae are released daily per clam. A total of 10,000 larvae per reproductive cycle can be released. The larva's planktonic stage lasts about 3-5 days before it settles. The life span is 3-4 years.
Food	Intense filter-feeding activity.
Habitat	Both species occur in lakes and rivers. While *C. fluminea* is a strict freshwater species, *C. fluminalis* prefers brackish water. However, they occur together in sandy bottoms of water bodies.

Origin Asia.

Introduction and dispersal

History of introduction	Both species were introduced to North America from Asia. Subsequently they were transported to Europe, where they rapidly spread along the rivers and canals. Both species were recorded in the Rhine near Basel for the first time in 1997.
Pathways of introduction	The most likely mode of transport between North America and Europe was ballast water. The introduction of the species to North America is usually attributed to Chinese immigrants who use Asian clams as food.
Dispersal	Natural spread is downstream, so they depend on human-mediated transport to travel upstream in large rivers, such as the Rhine.

Current status

Actual and potential distribution in CH	They are very recent invaders and are still restricted to the Rhine near Basel, but will spread further upstream.
Introduced distribution	Introduced to North America and Europe.

Impacts

Environmental impact	Given the high growth and production rates of these species,

	concerns have been raised over the potential for Asian clams to alter trophic and nutrient dynamics of aquatic systems, and to displace native bivalves. Their intense filter-feeding activity strongly influences ecosystem functioning. The linkage between pelagic and benthic systems is being altered by these benthic species feeding on planktonic organisms.
Economic impact	In North America they clog irrigation systems and disrupt the operations of numerous electricity generating stations. One estimate put total losses at US$ 1 billion annually in the early 1980s.
Management options	Opportunities for preventing invasions into uninfested rivers and lakes should be explored.
Information gaps	Impact on native biodiversity in Switzerland. Potential distribution in Switzerland.

References

Literature

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the Rhine river determines biodiversity and ecosystem function: an affair between amphipods and mussels. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Mackie, G.L. (2002) Traits of endangered and invading freshwater mollusks in North America. In: Claudi, R., Nantel, P. and E. Muckle-Jeffs (eds) Alien invaders in Canada's waters, wetlands, and forests. Canadian Forest Service, Ottawa, pp 187-198.

Turner, H., Kuiper, J.G.J., Thew, N., Bernasconi, R., Rüetschi, J., Wüthrich, M. and M. Gosteli (1998) Mollusca, Atlas. Fauna Helvetica. CSCF, Neuchâtel, 527 pp.

US Congress, Office of Technology Assessment (1993) Harmful non-native species in the United States. OTA-F-565, US Government Printing Office, Washington, DC.

Other source

http://nis.gsmfc.org/nis_factsheet.php?toc_id=128

Dreissena polymorpha

Taxonomic status

Scientific name	*Dreissena polymorpha* (Pallas)
Family	Dreissenidae
Taxonomic group	Bivalvia
English name	Zebra mussel
German name	Wandermuschel
French name	Dreissène, moule zébrée
Italian name	

Description and identification

Description	The zebra mussel is of triangular shape with an obvious ridge between side and bottom. Its maximum length is about 40 mm. The colour and pattern are variable, but a typical shell is yellowish with dark zigzagging stripes (hence its name). It attaches itself to hard substrates with byssal threads, produced by a gland in the foot.
Similar species	There are no similar species in Switzerland.

Biology and ecology

Behaviour	Zebra mussels live 4-5 years and reproduce from the second year onwards. Eggs are fertilized outside the body. Over 40,000 eggs can be laid in a reproductive cycle and up to 1 million in a spawning season. The larvae (veligers) hatch and remain in the dispersal stage for 3-5 days. They are pelagic for about 1 month before they settle on a hard substrate. They attach themselves to the substrate with the byssal threads. The veliger larval stage is uncommon in European freshwater mussels.
Food	Zebra mussels are filter feeders. They are capable of filtering about 1 litre of water per day, feeding primarily on algae.
Habitat	Zebra mussels normally inhabit freshwater, but are also found in brackish water. They prefer lakes and large rivers.

Origin Ponto-Caspian origin (Black and Caspian Sea region).

Introduction and dispersal

History of introduction	The species was introduced into Europe in the 19th century through the developing canal systems. It expanded its range rapidly and reached Switzerland around 1850 near Basel. Zebra mussels were first discovered in North America (Great Lakes) in 1988. They are continuing their astonishing spread through North America.
Pathways of introduction	Zebra mussels are carried around through human-mediated transport, mainly ships and boats. They can be transported as veligers in ballast water or as adults attached to a hull (hull-fouling). The adults remain attached to the boat and spawn at the various places that it visits. Adult mussels are very hardy and can survive out of water for extended periods.
Dispersal	The dispersal stage of the zebra mussel is the veliger larva, which is unusual among European freshwater mussels. The veliger usually drifts downstream with the current. Thus, for upstream spread they need, in most cases, human-mediated transport, as described above.

Current status

Actual and potential	The zebra mussel has invaded most lakes and rivers in the lowland

distribution in CH	parts of Switzerland. However, it seems that some suitable lakes have not yet been reached. Since the zebra mussel needs temperatures in excess of 15ºC for reproduction, its distribution will remain restricted to the lowland lakes and rivers.
Introduced distribution	Accidentally introduced to Europe and North America.

Impacts

Environmental impact	Zebra mussels alter and redirect linkages within aquatic food webs. Since they preferentially consume phytoplankton, they compete with zooplankton for food. They compete for space on hard substrate and overgrow native mussels, cutting them off from their food supply. Their filter feeding also affects nutrient availability and turnover. When zebra mussels invade new freshwater areas they generally become the dominant benthic species in terms of biomass, with 10-50 times the total mass of all other benthic invertebrates combined. The numbers are very impressive, in the Rhine upstream from Basel a maximum of 11,200, and in North America even up to 100,000, individuals per square metre have been recorded. With these densities it is not surprising, that the invader is a completely new element in the ecosystem, affecting the benthos and the pelagic system, and acting as an ecosystem engineer. These direct and indirect effects drastically alter native ecosystems.
Economic impact	Zebra mussels attach to water pipes with their tough byssal threads, clogging water flow and increasing sedimentation and corrosion. In North America the incurred costs are immense, perhaps about several million US dollars per annum. However, an economic study for Germany concludes that the high costs generated in North America cannot, or can no longer be, demonstrated in Germany due to adjustments taken after the invasion decades ago.

Management options	A wide array of control methods have been used under different situations. These control options are mostly intended to prevent clogging of water intakes at power stations and other plants. For natural situations, prevention strategies should be implemented to halt new invasions to uninfested lakes and rivers, e.g. cleaning of boat hulls.
Information gaps	Impact on native biodiversity in Switzerland.

References

Literature

Simberloff, D. (2002) Ecological and economic impacts of alien species: a phenomenal global change. In: Claudi, R., Nantel, P. and E. Muckle-Jeffs (eds) Alien invaders in Canada's waters, wetlands, and forests. Canadian Forest Service, Ottawa, pp. 187-198.

Haas, G., Brunke, M. and B. Streit (2002) Fast turnover in dominance of exotic species in the Rhine river determines biodiversity and ecosystem function: an affair between amphipods and mussels. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Karateyev, A.Y., Burlakova, L.E. and D.K. Padilla (2002) Impacts of zebra mussels on aquatic communities and their role as ecosystem engineers. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic

Publishers, Dordrecht, pp. 426-432.
Kotta J., Orav H., Kotta I. (1998) Distribution and filtration activity of the zebra mussel, Dreissena polymorpha, in the Gulf of Riga and the Gulf of Finland. Proceedings of the Estonian Academy of Sciences, 47 (1), 32-41.
Mackie, G.L. (2002) Traits of endangered and invading freshwater mollusks in North America. In: Claudi, R., Nantel, P. and E. Muckle-Jeffs (eds) Alien invaders in Canada's waters, wetlands, and forests. Canadian Forest Service, Ottawa, pp. 187-198.
Ojaveer, H., Leppäkoski, E., Olenin, S. and A. Ricciardi (2002) Ecological impact of ponto-caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.
Pfleger, V. (1984) Weichtiere. Artia, Prag, 192 pp.
Rey, P. and J. Ortlepp (2002) Koordinierte biologische Untersuchungen am Hochrhein 2000; Makroinvertebraten. Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Bern, 98 pp.
Ricciardi A., Whoriskey F.G., Rasmussen J.B. 1996. Impact of the Dreissena invasion on native unionid bivalves in the upper St. Lawrence River. Canadian Journal of Fish. Aquat. Science 53, 1434-1444.
Ricciardi A., Whoriskey F.G., Rasmussen J.B. (1997) The role of the zebra mussel (Dreissena polymorpha) in structuring macroinvertebrate communities on hard substrata. Can. J. Fish. Aquat. Sci. 54, 2596-2608.
Turner, H., Kuiper, J.G.J., Thew, N., Bernasconi, R., Rüetschi, J., Wüthrich, M. and M. Gosteli (1998) Mollusca, Atlas. Fauna Helvetica. CSCF, Neuchâtel, 527 pp.
US Congress, Office of Technology Assessment (1993) Harmful non-native species in the United States. OTA-F-565, US Government Printing Office, Washington, DC.
Van der Velde, G., Nagelkerken, I., Rajagopal, S. and A. Bij de Vaate (2002) Invasions by alien species in inland freshwater bodies in western Europe: the Rhine delta. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Other sources

http://nis.gsmfc.org/nis_factsheet.php?toc_id=128
http://www.glsc.usgs.gov/_files/publications/factsheets/zebra_mussels00/zebra_mussels00.htm
http://nas.er.usgs.gov/zebra.mussel/docs/sp_account.html
http://www.zin.ru/projects/invasions/gaas/drepol.htm

Potamopyrgus antipodarum

Taxonomic status

Scientific name	*Potamopyrgus antipodarum* (Gray)
Family	Hydrobiidae
Taxonomic group	Gastropoda
English name	New Zealand mudsnail
German name	Neuseeland-Zwergdeckelschnecke
French name	
Italian name	

Description and identification

Description	The New Zealand mudsnail is a small aquatic snail, reaching a maximum length of about 5 mm. The colour of the shell ranges from light to dark brown. The shell is elongate with a pointed tip. It normally has about 5.5 whorls and is dextral (opening on the right). The species has a hardened operculum, which it can close during adverse conditions.
Similar species	It is difficult to distinguish from other small snails, especially because of the tiny size. People accustomed to working with small snails can identify the species by the above-mentioned combination of characters.

Biology and ecology

Behaviour	The New Zealand mudsnail has a tremendous reproductive potential. Reproduction is both sexual and parthenogenetic. Some populations (in the USA) comprise only females. Losses in the hazardous egg stage are avoided by bypassing this stage – the mudsnails are livebearers.
Food	It is a grazer of diatoms and plant and animal detritus.
Habitat	The preferred habitat is lake shores (down to 10 m depth), but the snails also inhabit all river habitats and even ponds.

Origin New Zealand.

Introduction and dispersal

History of introduction	Initial transport to continents was probably in ballast water and/or on ornamental plants in the 19th and 20th centuries. The first record in Switzerland was in 1972.
Pathways of introduction	Spread between continents can be by ballast water, on ornamental plants or in guts of live fish. On a smaller scale, the tiny New Zealand mudsnail is also transported on boats and boots of fishermen.
Dispersal	Spread in Europe was faster than a snail's pace, so that most new colonies were either founded from specimens using the pathways mentioned above or spread by birds.

Current status

Actual and potential distribution in CH	It has invaded most of the lakes and river systems of the lowland parts of Switzerland, but not all are colonized as yet. The Ticino has not yet been invaded. Since it cannot tolerate cold water, it will be restricted by altitude.
Introduced distribution	It has spread throughout Australia, Asia, Europe and North America.

Impacts

Environmental impact	Impact has not yet been studied, but it is likely to inflict resource competition on native molluscs owing to its high densities. Up to 800,000 individuals have been reported per square metre. In North America, a negative correlation between the densities of the invader and native species was found.
Economic impact	In the USA it is assumed to affect trout fisheries by alteration of ecosystem functioning.

Management options Eradication and control would probably be impossible. Prevention of new infestations should be the priority. Fishermen using boats and boots in an infested lake should not enter uninfested lakes without killing attached snails. This could be achieved by placing potentially infested items in cold or hot conditions.

Information gaps Impact on native biodiversity.

References

Literature

Glöer, P., Meier-Brook, C. and O. Ostermann (1985) Süsswassermollusken. Ein Bestimmungsschlüssel für die Bundesrepublik Deutschland. Deutscher Bund für Naturbeobachtung, Hamburg, 81 pp.

Richards, D.C. (2002) The New Zealand mudsnail invades. Aquatic Nuisance Species Digest, 4 (4), 42-44.

Robinson, D.G. (1999) Alien invasions: the effects of the global economy on non-marine gastropod introductions into the United States. Malacology 41 (2), 413-438.

Strayer, D.L. (1999) Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthol. Society 18 (1), 74-98.

Turner, H., Kuiper, J.G.J., Thew, N., Bernasconi, R., Rüetschi, J., Wüthrich, M. and M. Gosteli (1998) Mollusca, Atlas. Fauna Helvetica. CSCF, Neuchâtel, 527 pp.

7 Other selected invertebrate groups

Prepared by Rüdiger Wittenberg and Marc Kenis

This chapter gives only a few examples of alien species from groups which can cause problems for the environment not dealt with in other chapters of this report. It is not possible to give comprehensive lists of most of these invertebrate groups. Therefore, the objective is to give a brief overview of potential problematic species for biodiversity and ecosystems in Switzerland. As mentioned before, there is a great need for more taxonomic work on these groups, not only the alien species, but the native species as well. Based on future work, more comprehensive lists of some groups may be added in the future to complete the knowledge of established alien species in Switzerland.

Nematodes – Nemathelminthes

Nematodes are a large but little-known group of tiny worms. There is no comprehensive checklist of species in this group for Switzerland, but many species are of great economic importance as pests in agriculture and forestry. Species exclusively causing economic damage are not part of the report, since they are the best-known species in this group; the Swiss Federal Research Stations are actively working on them, and there are other sources dealing with them, e.g. CABI (2001) lists the following 11 problematic nematodes for Switzerland: *Globodera pallida* (Stone) Behrens, *G. rostochiensis* (Wollenweber) Behrens, *Heterodera avenae* Wollenweber, *H. schachtii* A.Schmidt, *Longidorus elongatus* (de Man) Micoletzky, *Meloidogyne arenaria* (neal) Chitwood, *M. hapla* Chitwood, *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans, *Punctodera punctata* (Thorne) Mulvey & Stone, *Xiphinema diversicaudatum* (Micoletzky) Thorne, and *X. index* Thorne & Allen.

The **pine wood nematode** (*Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle) (see Fact Sheet) is an example of a species that has recently been found in Europe and is considered to be a potential threat to *Pinus* spp. here. Thus, its wider spread within Europe should be prevented.

The nematode ***Anguillicola crassus*** Kuwahara, Niimi & Itagaki (Anguillicolidae) is an example of a nematode that is having an extensive impact by attacking a fish species. This nematode is a parasite of eel species. In Europe the native *Anguilla anguilla* L. is under threat following the invasion of the nematode. The nematode was accidentally introduced with imports of live Asian eels to Europe in 1982 (Konecny et al., 2002). Besides the negative impact on natural populations of the European eel, it affects Europe’s important fishing industries. The European eel is native in the river systems emptying into the Atlantic, as its life history involves spawning grounds in the Sargasso Sea. It has itself been introduced to some parts of Europe, e.g. the Danube basin. The construction of the Rhine–Danube Canal opened the way from the Rhine, where it is native, to the Danube basin.

Another nematode was accidentally introduced into Europe together with its North American host, i.e. ***Baylisascaris procyonis*** (Stefanski & Zarnowski) with the raccoon, Procyon lotor (L.) (see mammal chapter). This species is of concern for human health.

Flatworms – Turbellaria, Plathelminthes

In the group Turbellaria (part of the Plathelminthes), one species is an abundant alien inhabitant of lakes and rivers, including the Rhine in Switzerland. The predatory aquatic flatworm ***Dugesia tigrina*** (Gerard) is abundant and widespread in standing and slow-moving water bodies in Europe (Pöckl and Rabitsch, 2002). It was probably introduced on aquarium plants or fish from North America around 1900. Although this species is found in high densities, a negative impact has not (yet) been shown.

Other flatworms of environmental concern are terrestrial. The **New Zealand flatworm** (*Artioposthia triangulate* (Dendy)) (see Fact Sheet) serves as an example of several predatory flatworm species introduced into Europe from New Zealand and Australia. Native earthworms are a major prey for these flatworms. Earthworms play an important role in nutrient cycling in soil, so that their reduction could lead to ecosystem changes. They are also a significant element of vertebrate prey.

Segmented worms – Annelida

The Ponto–Caspian invaders in European waters are an interesting group – see the Crustacea Chapter for more information. The annelid polychaete worm ***Hypania invalida*** (Grube) has become very numerous in the sandy sediment of the Rhine, where it burrows its tubes vertically into the mud (Rey and Ortlepp, 2002; Van der Velde et al., 2002). The impact of this abundant species has not been evaluated. It is approximately 1-2 cm long and can reach densities of about 10,000 individuals per square metre. The species reached the Rhine after the opening of the Rhine–Danube canal, probably in the ballast tanks of ships.

Another possibly harmless species in the group Annelida, but an oligochaete worm (Tubificidae), is the large (up to 20 cm long) ***Branchiura sowerbyi*** Beddard, which originates in south-eastern Asia. It was probably introduced on tropical aquatic plants at the beginning of the 20th century. At first it occurred only in greenhouses, but it adapted to the colder climate and is now found in many slow-moving rivers (Pöckl and Rabitsch, 2002). It lives in self-made tubes in muddy soil and feeds on detritus.

A member of a third group of the Annelida is the leech ***Caspiobdella fadejewi*** (Epshtein) (Hirundinea; Piscicolidae), which can be found in low densities in the Rhine between Basel and the Bodensee. This species, also from the Ponto–Caspian system, is an ectoparasite of various fish species.

Centipedes and millipedes – Myriapoda

A neglected group in this report is the **Myriapoda**, including the Diplopoda and the Chilopoda. It is impossible to give a comprehensive list. In particular the former group, as plant and detritus feeders, are probably regularly introduced with plant and soil material. Some tropical or subtropical species might be restricted to greenhouses. However, the number of established species in the wild is likely to be small (probably less than ten species) and none is of particular threat to native biodiversity and ecosystems.

References

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Konecny, R., Schabussova, I. and H. Sattmann (2002) ”Helminthen“ – Neozoen der Fische Österreichs. In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich.* Umweltbundesamt, Wien, pp. 221-224.

Pöckl, M. and W. Rabitsch (2002) Ausgewählte aquatische Neozoen (Cnidaria, Plathelminthes, Kamptozoa, Annelida, Isopoda). In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 228-239.

Rey, P. and J. Ortlepp (2002) Koordinierte biologische Untersuchungen am Hochrhein 2000; Makroinvertebraten. BUWAL Schriftenreihe Umwelt Nr. 345, Gewässerschutz, 98 pp.

Van der Velde, G., Nagelkerken, I., Rajapogal, S. and A. Bij de Vaate (2002) Invasions by alien species in inland freshwater bodies in Western Europe: the Rhine delta. In: Leppäkoski, E., Gollasch, S. and Olenin, S. (eds) *Invasive aquatic species of Europe. Distribution, impacts and management.* Kluwer Academic Publishers, Dordrecht, pp. 426-432.

Weidema, I.R. (ed) (2000) *Introduced species in the Nordic countries*. Nordic Council of Ministers, Copenhagen, 242 pp.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) *An audit of alien species in Scotland.* Scottish Natural Heritage Review No 139, 225 pp.

Fact Sheets

Artioposthia triangulata

Taxonomic status

Scientific name	*Artioposthia triangulata* (Dendy)
Taxonomic group	Terricola
Taxonomic group	Turbellaria
English name	New Zealand flatworm
German name	Neuseeländische Landplanarie
French name	
Italian name	

Description and identification

Description	A large terrestrial flatworm growing up to 15 cm in length. The worm is pointed at both ends and flattened, as the common name implies. It is coloured dark purple-brown with pale lateral margins and is glistening, being covered in mucus. There are numerous eyes at the head end.
Similar species	The size and colouration, for a terrestrial flatworm, is more or less unique in Central Europe.

Biology and ecology

Behaviour	It is subterranean, living near the soil surface, often below stones, tiles, pots or pieces of old wood. It needs dark and damp soil and is intolerant of light, high temperatures and freezing. Dry conditions can be tolerated by aestivation. Reproduction is continuous and hermaphroditic, all mature individuals may thus produce eggs after mutual fertilization. Egg cocoons are laid in the soil.
Food	The New Zealand flatworm feeds almost exclusively on native earthworms thereby reducing the number of these markedly. Digestion is external.
Habitat	It is found in the upper layer of damp and cool soil. In its native range it is found in woodland and gardens. In the introduced range it is largely restricted to nurseries and gardens.

Origin It is native to New Zealand.

Introduction and dispersal

History of introduction	The New Zealand flatworm was probably introduced to Great Britain around 1960. The most likely pathway is containeriszed plant imports from New Zealand. The flatworm could also be a stowaway in shipments of bulbs. It has spread within the UK and was also accidentally introduced to the Faroe Islands with plants from the UK.
Pathways of introduction	Accidental introduction with plant material shipments.
Dispersal	The New Zealand flatworm moves around in naturally occurring crevices in the soil or by utilizing passages that earthworms have made and by human activities (horticulture).

Current status

Actual and potential distribution in CH	The New Zealand flatworm has not been recorded from Switzerland, but has been introduced to the UK and the Faroe Islands. It is not known whether this species would be able to establish in Switzerland. It is possible that the species would only be able to colonize gardens and nurseries. However, other related species might be better adapted for the Swiss climate.
Introduced distribution	Thus far it is restricted to the UK and the Faroe Islands.

Impacts

Environmental impact	New Zealand flatworms prey mostly if not exclusively on native earthworms. Field experiments in Ireland have demonstrated that the flatworm severely and quickly reduces the diversity and number of native earthworm species. Earthworms play a vital role in the nutrient cycle of soil, improving soil structure, fertility and productivity. They aerate the soil and enhance the water balance. The loss of earthworms may also have a detrimental effect on biodiversity, since they are a significant food source for native birds and other animals.
Economic impact	The loss of earthworms owing to predation by the introduced New Zealand flatworm, particularly from pastures, may have an economic impact on European farmland.

Management options

There are no effective eradication methods described for the New Zealand flatworm. Hygienic practices in nurseries and garden centres are the most important methods to control the further spread of the species. It has not yet reached Switzerland, but plant imports need to be thoroughly monitored for terrestrial flatworms. The border control measures currently in use seem to be not sufficiently effective to prevent introduction of the New Zealand flatworm to some European countries.

Information gaps

More information is needed on the impact on natural ecosystems and the economic effects of the species. The potential distribution of terrestrial earthworm-feeding flatworms in Switzerland is not known.

References

Literature

Weidema, I.R. (ed) (2000) Introduced species in the Nordic countries. Nordic Council of Ministers, Copenhagen, 242 pp.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. and J. Holbrook (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Bursaphelenchus xylophilus

Taxonomic status

Scientific name	*Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle
Synonyms	*Aphelenchoides xylophilus* Steiner & Buhrer
Taxonomic position	Nematoda: Aphelenchoididae
English name	Pine wood nematode, pine wilt disease
German name	Kiefernholz-Fadenwurm
French name	Nématode des pins
Italian name	Nematode del pino

Description and identification

Identification character	Identification can be made only by specialists. A description of the species is found in Nickle et al. (1981) and CABI/EPPO (1997). Molecular tools are available to identify the species as well as congeneric species.
Similar species	Several *Bursaphelenchus* spp. occur in the world. *B. mucronatus*, a very similar but non-pathogenic species, is found on coniferous trees in Europe.

Biology and Ecology

Life cycle	This nematode is transmitted from tree to tree by a cerambycid beetle of the genus *Monochamus*, which primarily develops in conifers that have recently died. In general, 4th, last-instar nematode larvae carried by an adult beetle are transmitted during oviposition into a dead or dying tree. The nematode develops and several generations occur, which feed on the hyphae of fungi also transmitted by the beetle. At a certain time after infection, the nematode population ceases to multiply and a specific 3rd stage larva ('dispersal 3rd stage larva') is produced, which searches for a pupal chamber of *Monochamus*. The 4th instar then hitches a ride under the beetle's elytra, to disperse to another tree. This is the life cycle normally observed in North America. However, the nematode can also be transmitted to healthy trees of susceptible pine species through beetle feeding punctures in young shoots, as observed in Asia, Europe and, occasionally, North America. In this case, the nematodes multiply in the resin canals, attacking the epithelial cells. The exudation of oleoresin is reduced, and the nematode can move freely throughout the trunk. The tree dies within 30-40 days of infection, attracting secondary insect pests, including *Monochamus* spp., which will be used for transmission to another tree.
Host plant	All *Pinus* spp. can act as substrate for the development of *B. xylophilus*, but only a few species are susceptible to attack as living trees, among which are several European species, *Pinus sylvestris* L., *P. nigra* Arnold and *P. pinaster* Aiton. Other conifer trees (*Larix*, *Abies*, *Picea*, *Pseudotsuga*) can act as hosts (CABI/EPPO, 1997).
Habitat	Restricted to conifers, but in various habitats.

Origin North America.

Introduction and dispersal

History of introduction	First introduced into Japan in the early 20th century, from where it spread to other Asian countries, including China, Republic of Korea and Taiwan. Recently introduced into Portugal (Mota et al., 1999),

	where it is the target of an eradication programme.
Pathways of introduction	Introduced from North America to Japan in infested timber.
Dispersal	The nematode spreads locally with its vectors, *Monochamus* spp., which can fly up to several kilometres. On a larger scale, the transport of infested wood, with or without beetles, is the main mode of dispersal. Dispersal means are discussed in CABI/EPPO (1997) and CABI (2001).

Current status

Actual and potential distribution in CH	Not yet present in Switzerland. All regions with pine stands and plantations are at risk.
Distribution in Europe	Presently restricted to Portugal, where it has been recently introduced.

Impacts

Damage on plant	Nematodes in living trees reduce oleoresin production. Transpiration of the leaves decreases and, eventually, stops completely, which results in the death of the tree, usually 30-40 days after infection. The first symptoms are the yellowing and wilting of the needles.
Environmental impact	If the nematode spread through Europe, it could have serious ecological impacts on forest ecosystems, since several European pine species are among its most vulnerable hosts (i.e. *P. sylvestris*, *P. nigra* and *P. pinaster*), and the European beetle *Monochamus galloprovincialis* (Olivier) is known to be a suitable vector (Sousa et al., 2002). In Japan, *B. xylophilus* also damages natural pine forests, although the ecological impact has been less documented than the economic impact on pine plantations.
Economic impact	The pine wood nematode is a very serious forest pest in eastern Asia. Wood losses in Japan alone exceed 2 million cubic metres per year (CABI/EPPO, 1997). In its region of origin in North America, it is a minor problem, because native pine species are resistant. It can, however, kill exotic trees, e.g. amenity plantings, ornamentals, windbreaks and Christmas trees. If its establishment in Europe is confirmed, it could also have a tremendous economic impact on European forestry.

Management options	It is impossible to control the nematode once it has entered a living tree. Control options include cultural practices, such as the removal of dead or dying trees, and the control of the vector by insecticidal treatments. Research is presently being carried out to develop biological control methods against the nematode and the vector, insect attractants, development of resistant clones of *Pinus* spp., resistance induction by inoculation of non-pathogenic nematode strains, etc.
Information gaps	The potential damage (both environmental and economic) the nematode is likely to cause in Europe is unclear. It will depend on the capacity of European *Monochamus* spp. to serve as vectors, and on the susceptibility of European pine species. The impact is likely to be high because at least one vector has been identified (*M. galloprovicialis*) and some European pines (e.g. *P. sylvestris*, *P. nigra* and *P. pinaster*) have shown to be highly susceptible to the nematode.

References

Literature

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith I.M., McNamara, D.G., Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Mota, M.M., Braasch, H., Bravo, M.A., Penas, A.C., Burgermeister, W., Metge, K. and E. Sousa (1999) First report of *Bursaphelenchus xylophilus* in Portugal and in Europe. Nematology 1, 727-734.

Nickle, W.R., Golden, A.M. Mamiya, Y. and W.P. Wergin (1981) On the taxonomy and morphology of the pine wood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer 1934) Nickle 1970. Journal of Nematology 13 (3), 385-392.

Sousa, E., Naves, P., Bonifácio, L., Bravo, M.A., Penas, A.C., Pires, J. and M. Serrão (2002) Preliminary survey for insects associated with *Bursaphelenchus xylophilus* in Portugal. Bulletin OEPP, 32, 499-502.

8 Lichens (Lichen-forming fungi)

Prepared by Rüdiger Wittenberg

There are no lichens known to be introduced and established in Switzerland (C. Scheidegger, pers. comm.). Lichens, with their extremely slow growth, seem ill-adapted to human-mediated transport and the colonization of new regions. There is no doubt that species must be introduced with timber, etc., but the step from introduction to establishment has apparently not been achieved. Breuss (2002) mentions *Anisomeridium polypori* (Ellis & Everh.) M.E. Barr as a neomycete for Austria. However, recently described new species are not necessarily introduced. They could also have been overlooked in the past, in particular as floristic research in microlichens does not have a long history and is rather incomplete. Changes in the environment can also favour some previously rare species, so that they become more abundant and widespread, feigning a new arrival. Aptroot (1999) doubts the neomycete character of *A. polypori*, instead assuming a wide natural distribution.

References

Aptroot, A. (1999) Notes on taxonomy, distribution and ecology of *Anisomeridium polypori*. Lichenologist 31 (6), 641-642.

Breuss, O. (2002) Flechten. In: Essl, F. and W. Rabitsch (eds) *Neobiota in Österreich*. Umweltbundesamt, Wien, pp. 214-221.

9 Fungi and a selected bacterium

Prepared by Rüdiger Wittenberg and Marc Kenis

Fungi are an often-neglected group and it is not possible to compile a list of neomycetes for Switzerland, let alone to list the fungi occurring in Switzerland. It is a group where the percentage of undescribed species is exceptionally high. In this report, species which are of concern for native biodiversity and economics alike are summarized. Species exclusively causing economic damage are not part of the report, since they are the best-known species; the Swiss Federal Research Stations are responsible for working on them, and there are also other sources, such as university research departments, dealing with them. Two examples of excellent sources are:

The Alert List of the European and Mediterranean Plant Protection Organization (EPPO). The purpose of the Alert List is to draw attention to certain pests that may present a risk to member countries, thereby functioning as an early warning system: ***http://www.eppo.org/QUARANTINE/Alert_List/alert_list.html***

The Crop Protection Compendium (CPC) (see e.g. CABI, 2004) lists, for example, 104 fungi for Switzerland and provides Fact Sheets incorporating exhaustive information on the species. It is also available on the Internet at: ***http://www.cabi.org/compendia/cpc/index.htm***

These sources give other links as well, so that a wealth of information is available for the species of economic importance.

Six fungal species of immediate threat to the native biodiversity are discussed in this section. There is also one bacterium, which is pathogenic to plants, included in the text and a Fact Sheet.

Chestnut blight (*Cryphonectria parasitica* (Murrill) Barr) (see Fact Sheet) was introduced into North America and Europe. In North America chestnut blight has been an ecological disaster. It changed the tree composition of the eastern forests completely by removing one of the dominant trees, *Castanea dentata* (Marshall). Fortunately, it seems that the European congeneric is less susceptible to the disease, although it has suffered and tree composition is altering, in particular in the Ticino.

Another tree-attacking fungus, causing tremendous ecosystem changes in Europe, is **Dutch elm disease** (*Ceratocystis ulmi* (Buisman) C.Moreau and *C. novo-ulmi* (Brassier)) (see Fact Sheet). Mature elm (*Ulmus* spp.) trees have disappeared from the landscape in many regions. *C. novo-ulmi* seems to have arrived decades after *C. ulmi* and is replacing it in many parts of Europe, e.g. Austria (Kirisits et al., 2001). Reinhardt et al. (2003) estimate that Germany incurs annual costs of about €5 million for the removal and replacement of trees, the lost value of dead trees, and additional expenditure of planting resistant varieties.

While ***Phytophthora quercina*** Jung et al. (see Fact Sheet) is a rather recent invader (or at least attention has been drawn to it by its recent impact), *P. ramorum* Werres, de Cock & Man in`t Veld (**sudden oak death**) (see Fact Sheet) is already well-known from its devastating effect in North America. In Europe it is still only a problem in nurseries, but it can be expected to infest native forests in the not-too-distant future. Many woody hosts have been shown to be susceptible to sudden oak death and it has been recorded from Switzerland (Heiniger and Stadler, 2003).

The **crayfish plague** (*Aphanomyces astaci* (Schikora)) (see Fact Sheet) is one of the most devastating fungi attacking European wildlife. The fungus was introduced with North American crayfish species, which are asymptomatic carriers of the disease, into Europe. The European crayfish species are highly susceptible and almost 100% die within two weeks of infection. There are regular outbreaks in European populations resulting in total collapse (Voglmayr and Krisai-Greilhuber, 2002).

The bacterium *Erwinia amylovora* (Burrill) Winslow et al. (see Fact Sheet) is the causal agent of **fire blight**, which was first found on *Cotoneaster* species and is now widely distributed in Switzerland (Hasler et al., 2002).

An interesting case of a mutual relationship between two invaders may be the association between mycorrhizal fungi and plant species. There is some evidence that alien mycorrhiza can help their alien host plant to become a weed in the introduced range (e.g. Crawley, 1993; Harrington et al., 1998). In that way, an introduced mycorrhiza might have an indirect detrimental effect on native biodiversity.

In can be concluded that although quarantine measures are successfully implemented in Switzerland, non-crop plants need to get more attention, e.g. plants in the nursery industry. The few examples described here indicate the enormous impacts diseases can have. Some introduced diseases are completely changing entire ecosystems by eliminating important key species. Moreover, there are human diseases not mentioned in this report with global impact, such as AIDS (a viral disease).

The Fact Sheets are presented after the references, in alphabetical order for ease of location of specific sheets.

References

CABI (2004) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Crawley, M.J. (1993) Succeeding in the sand dunes. Nature 362, 17-18.

Harrington, K.C., Hodder, L.M. and H.A. Outred (1998) Biology and control of pypgrass. Proceedings, 51st New Zealand Plant Protection Conference, pp. 255-259.

Hasler, T., Schaerer, H.J., Holliger, E., Vogelsanger, J., Vignutelli, A. and B. Schoch (2002) Fire blight situation in Switzerland. Acta Horticulturae 590, 73-79.

Heiniger, U. and Stadler, B. (2003) Gefährliche Quarantänekrankheit gefunden. *Phytophthora ramorum* jetzt erstmals auch in der Schweiz. Der Gartenbau 51/52/2003, pp. 10-12.

Kirisits, T., Krumböck, S. Konrad, H., Pennerstorfer, J. and E. Halmschlager (2001) Untersuchungen über das Auftreten der Erreger der Holländischen Ulmenwelke in Österreich. Forstwissenschaftliches Zentralblatt 120, 231-241.

Reinhardt, F., Herle, M. Bastiansen, F. and B. Streit (2003) Economic impact of the spread of alien species in Germany. Federal Environmental Agency of Germany, 190 pp.

Voglmayr, H. and I. Krisai-Greilhuber (2002) Pilze. In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 214-221.

Fact Sheets

Aphanomyces astaci

Taxonomic status

Scientific name	*Aphanomyces astaci* (Schikora)
Family	Saprolegniaceae
Taxonomic group	Oomycetes
English name	Crayfish plague
German name	Krebspest
French name	Peste de l'écrevisse
Italian name	

Description and identification

Description	Diagnosis of crayfish plague requires the isolation of the fungus and its growth on agar for subsequent identification. The identification to genus depends on sporangial morphology and to species on the morphology of the sexual reproductive stages. However, a reliable sign of a crayfish plague infestation is a large number of dead crayfish in a given water system without mortality of other aquatic organisms.
Similar species	There is no other disease with such a high mortality rate in a crayfish population.

Biology and ecology

Behaviour	Zoospores actively swim with their two flagellae in search of a crayfish. When they locate one, they burrow into the skin and build a cyst. Whilst they are encapsulated in North American crayfish species, the European crayfish species have no effective defence reaction against the invader. The fungus grows inside the crayfish attacking all kind of tissues, including the nerves, which leads to abnormalities in behaviour, such as diurnal activity.
Food	Hosts are crayfish species; the European species have no effective defence mechanism.
Habitat	Crayfish species.

Origin North America

Introduction and dispersal

History of introduction	The crayfish plague was introduced into Europe with North American crayfish in about 1860. The most likely pathway was in North American crayfish transported in ballast water to Lombardia/Italy.
Pathways of introduction	Intra-continental transport of the crayfish plague is via movement of their North American hosts and also via new imports from North America. The North American crayfish species are attacked by the fungus, but the disease does not develop, since the cysts are encapsulated within the carapace. However, they carry and spread the fungus, so that their occurrence is a great threat to native crayfish populations. The release of crayfish for farming and nowadays from aquariums is probably the most effective way for the crayfish plague to spread around Europe. Crayfish are a very successful farm product, and they escape from time to time.
Dispersal	The natural dispersal stage are the zoospores. They swim actively for about 5 days, but they can be transported longer distances on fishing equipment and animals (birds and mammals).

Current status

Actual and potential distribution in CH	The crayfish plague is widely distributed in Switzerland.
Introduced distribution	The entire European continent seems to be invaded by the crayfish plague and it is probably still carried around on live crayfish shipments.

Impacts

Environmental impact	The crayfish plague is an exceptional disease, because 100% mortality is the norm. Entire susceptible populations are wiped out by the infection. The rather small populations of native crayfish species are at high risk of extinction due to the alien disease and its carrier, the North American crayfish species. The introduction of the crayfish plague to Europe was an absolute disaster for the native crayfish species, which were already under threat from habitat destruction, overfishing, and water pollution. Interestingly, no adaptation and resistance to the fungus has taken place in the few decades since its introduction to Europe. This might be attributed to the fact that in most cases 100% mortality occurs. Larger populations of native crayfish species can survive only in isolated water bodies, but even there the threat of introduction of the disease is high. The fungus can be easily transported to them by animals, as mentioned above, or be introduced by aquarium releases.
Economic impact	The native crayfish populations were drastically reduced due to the invading alien disease, so that the industry had to use North American species. Some 3,300 tonnes of alien crayfish are imported into Europe every year to satisfy the growing demand of the market. This, of course, worsened the situation for the native crayfish species. In conclusion, the economic losses caused by the crayfish plague in Europe are enormous.

Management options

Management of infested watersheds is practically impossible and the disease kills very rapidly, so that measures would be too late in most cases. The European crayfish species die within 2 weeks of attack. Only the prevention of all introductions of crayfish to natural waters and into enclosed water bodies from which they may escape could be an effective measure to manage the threat posed by crayfish plague. However, equipment and water can also carry the disease. All potentially infested equipment should therefore be left to dry before being used in a new water body. Awareness raising with respect to releases of any pets (e.g. from aquariums) is a crucial tool in management of IAS.

Information gaps

Effective prevention.

References

Literature

Frutiger, A. and R. Müller (2002) Der rote Sumpfkrebs im Schübelweiher (Gemeinde Küssnacht ZH). Auswertung der Massnahmen 1998-2001 und Erkenntnisse. EAWAG, Dübendorf, 29 pp.

Voglmayr, H. and Krisai-Greilhuber, I. (2002) Pilze. In: Essl, F. and W. Rabitsch (eds) Neobiota in Österreich. Umweltbundesamt, Wien, pp. 214-221.

Westman, K. (2002) Alien crayfish in Europe: negative and positive impacts and interactions with native crayfish. In: Leppaekoski, E., Gollasch, S. and S. Olenin (eds) Invasive aquatic species in Europe, Kluwer, pp. 76-95.

Williamson, M. (1996) Biological invasions. Chapman & Hall, London, Weinhaim, New York, Tokyo, Melbourne, Madras, 244 pp.

Other source

http://www.oie.int/esp/normes/fmanual/a_00053.htm Office international des épizooties (OIE) information page on the crayfish plague.

Ceratocystis ulmi

Taxonomic status

Scientific name	*Ceratocystis ulmi* (Buisman) C. Moreau, *Ceratocystis novo-ulmi* (Brassier)
Synonyms	*Ophiostoma ulmi* (Buisman) Nanaf., *Ophiostoma novo-ulmi*
Taxonomic position	Fungi: Ascomycetes: Ophiostomatales
English name	Dutch elm disease
German name	Holländische Ulmenkrankheit
French name	Graphiose de l'orme
Italian name	Grafiosi dell'olmo

Description and identification

Description	Fruiting bodies are not produced in the field, but are easily obtained in the laboratory, through standard techniques. However, the identification of these fungi can be carried out by specialists only. Molecular markers are used as taxonomic tools. Symptoms on elm first appear in the crown of the tree. Leaves of infected trees will wilt, turn yellow, then curl and turn brown.
Similar species	Both genera names *Ceratocystis* and *Ophiostoma* are commonly used. *C. ulmi* and *C. novo-ulmi* are recognized as two different species, that can be separated morphologically and physiologically. The latter exists in two forms, EAN in Eurasia and NAN in North America, which subsequently invaded Europe (Hoegger et al., 1996).

Biology and Ecology

Life cycle	The life cycle of the disease is strongly associated with that of its vectors, scolytid beetles of the genus *Scolytus*. Beetles breed under the bark of diseased trees. New generations emerge from dead trees and carry fungal spores, infesting healthy elms on which they feed. Spores penetrate the tree and the fungus infects the xylem vessels, resulting in the mortality of branches or of the whole tree. The dead bark is suitable for egg deposition and larval development. In the meantime, the fungus produces new spores in the bark, which contaminate the newly emerging beetles.
Host plant	Nearly all European and American elm species (*Ulmus* spp.) are susceptible. In contrast, Asian species are more resistant.
Habitat	All habitats where elms are found.

Origin Uncertain, probably Central Asia.

Introduction and dispersal

History of introduction	*C. ulmi* first appeared in Holland in 1919 and spread through Europe and to North America, where it caused enormous damage to American elms. In the 1960s, a new strain (subsequently recognized as a different species, *C. novo-ulmi*) appeared in both continents. This species had a tremendous impact on European elm species.
Pathways of introduction	Pathways of introduction include the transportation of infested plant material (e.g. logs) and bark beetles carrying the fungus.
Dispersal	On a local scale, the disease is dispersed by its insect vectors. It can be transmitted to adjacent trees by root grafts.

Current status

Actual and potential distribution in CH	Both species are now present throughout Switzerland. A discussion on the presence of the two species and their forms is provided in Hoegger et al. (1996).
Distribution in Europe	Both species occur throughout of Europe. The more virulent *C. novo-ulmi* has displaced *C. ulmi* in many countries (see, e.g., Kirisits et al., 2001).

Impacts

Damage on plant	The fungus kills trees by clogging the water vessels. Trees may die soon after infestation, but more usually one year later. Coppice shoots often regenerate from the root system.
Environmental impact	The ecological impact of the disease has been enormous, in both Europe and North America. Entire ecosystems have been modified. In many regions, elm species simply do not exist anymore as mature trees, although young trees resulting from coppice shoots are still common.
Economic impact	Elm species used to be very valuable multi-purpose indigenous trees, e.g. for timber, ornamentals, protection, hedges, fodder, medicine, etc. Because of Dutch elm disease, elms are no longer used.

Management options

Management options are limited (Röhrig, 1996). Silvicultural practices include the removal and burning or burying of infested trees, or winter pruning. Systemic fungicides are sometimes used as a preventive method to protect high-value trees. Breeding elm for resistance is probably the most promising option. Chemical or biological control methods targeting bark beetles have been implemented, with little success.

Information gaps

References

Literature

Kirisits, T., Krumböck, S., Konrad, K., Pennerstorfer, J. and E. Halmschlager (2001) Untersuchungen über das Auftreten der Erreger der Holländischen Ulmenwelke in Österreich. Forstwissenschaftliches Zentralblatt 120, 231-241.

Hoegger, P.J., Binz T. and U. Heiniger (1996) Detection of genetic variation between *Ophiostoma ulmi* and the NAN and EAN races of *O. novo-ulmi* in Switzerland using RAPD markers. European Journal of Forest Pathology 26, 57-68.

Röhrig, E. (1996) Die Ulmen in Europa. Ökologie und epidemische Erkrankung. Forstarchiv 67, 179-198.

Cryphonectria parasitica

Taxonomic status

Scientific name	*Cryphonectria parasitica* (Murrill) Barr
Synonyms	*Endothia parasitica* (Murrill) P.J. & H.W. Anderson
Taxonomic position	Ascomycetes: Diaporthales
English name	Chestnut blight or canker
German name	Kastanienrindenkrebs
French name	Chancre de l'écorce du châtaignier
Italian name	Cancro della corteccia del castagno

Description and identification

Description	There are several *Cryphonectria* spp. worldwide, which are morphologically difficult to distinguish (CABI, 2001). Some of the other species are found on *Castanea* and *Quercus*, but only *C. parasitica* is pathogenic on these trees. Diagnosis to species level can most effectively be carried out through microscopic examination of ascospores, which do not form until late in the disease cycle. The canker produced by the fungus (described in CABI/EPPO, 1997 and CABI, 2001) is more characteristic. It may be confused with ink disease, caused by *Phytophthora* spp., another serious fungal disease in Europe.

Biology and Ecology

Life cycle	Conidia and ascospores are transported by rain and wind and enter into wood via wounds that are caused by mechanical damage, pruning or natural events. Lesions become sunken as bark erodes and cambium is killed, and the bark swells and cracks. Pale-brown mycelial fans may often be detected in the cambial layers, especially when the fungus is actively growing. Stromata are formed over wide areas of cankered bark, producing conidiomata from which large numbers of conidia are extruded in damp conditions. The stromata expand and coalesce along cracks in the bark, and the ascomata are then formed in large numbers. By this stage, the affected plant tissues are dead (CABI, 2001).
Host plant	Mainly chestnut species (*Castanea* spp.). Other trees are sometimes reported as hosts, especially *Quercus* spp. and *Acer* spp. For a full list of hosts and a discussion of host range, see CABI (2001).
Habitat	Forests and plantations.

Origin	Eastern Asia

Introduction and dispersal

Introduction history	Introduced into North America at the end of the 19th century. Found in Italy in 1938, from where it rapidly spread to most of Europe. It was observed in the Ticino in 1947, and north of the Alps in 1986 (Bissiger and Heiniger, 1991).
Pathways of introduction	The pathway of introduction into North America and Europe is unknown. It was probably carried by host plants, or on wood or bark. There is a small risk of transmission by fruits and seeds.
Dispersal	Conidia and ascospores are spread by wind and rain, but it has been shown that they are also transmitted by beetles (e.g. buprestids of the genus *Agrilus*). Human-mediated transport of host plants or wood may also have been responsible for the spread

within Europe.

Current status

Actual Potential distribution in CH	The fungus is now well distributed in Switzerland and probably matches the distribution of its main host, *Castanea sativa*.
Distribution in Europe	Most European countries where *C. sativa* grows have already been invaded.

Impacts

Damage on plant	Tree parts above the point of invasion die. Coppice shoots often regenerate.
Environmental impact	In North America, the introduction of the chestnut blight has resulted in dramatic changes in forest ecosystems. In the early 20th century, the chestnut was one of the most abundant hardwoods of the eastern deciduous forests of the USA. The fungus killed over a billion trees over 36.8 million hectares. Although the American chestnut (*Castanea dentata*) still survives as a species - mainly as a bush - it is no longer a functional part of the ecosystem (Anagnostakis, 1987). In Europe, the damage is less severe, and healthy coppice shoots usually arise from stumps. This has been explained by the occurrence of hypovirulent strains in Europe – infected by a virus – which are vegetatively compatible with virulent strains. A tree infected by the hypovirulent strain is able to produce callus, overgrow the canker, and survive. However, European chestnut forests have also suffered and have often been replaced, naturally or intentionally, by other associations, e.g. in Italy, France and the Ticino.
Economic impact	In Europe and North America, chestnut is a valuable cash crop and an important timber species. The introduction of the chestnut blight has caused serious economic losses in both sectors, on both continents.

Management options

Two main management options have been applied. Firstly, the selection of blight-resistant strains has been widely investigated. In North America, some success was obtained in breeding resistant hybrid chestnuts by making use of the more resistant Asian species. In Europe, however, attempts to develop resistant *C. sativa* strains were not very successful. The second option is the use of hypovirulent strains of the fungus, applied to developing lesions, which enable the lesions to recover and convert the virulent strain into a hypovirulent strain. Chemical control methods have often been investigated, with little success.

Information gaps

There is an obvious lack of information on the real environmental impact of the chestnut blight in Europe.

References

Literature

Anagnostakis, S.L. (1987) Chestnut blight: the classical problem of an introduced pathogen. Mycologia 79, 23-37.

Bissegger, M. and U. Heiniger (1991) Chestnut blight (*Cryphonectria parasitica*) north of the Swiss Alps. European Journal of Forest Pathology 21 (4), 250-252.

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G., Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Erwinia amylovora

Taxonomic status

Scientific name	*Erwinia amylovora* (Burrill) Winslow et al.
Synonyms	
Class: Order	Gammaproteobacteria: Enterobacteriales
English name	Fire blight
German name	Feuerbrand
French name	Feu bactérien
Italian name	Colpo fi fuoco

Description and identification

Description	Identification is made first by characteristic symptoms on susceptible host plants, described in CABI/EPPO (1997) and CABI (2001). For a confirmation of the disease, however, isolation and laboratory tests should be performed.
Similar species	Other *Erwinia* spp. occur on other host plants, and the damage by *E. amylovora* could be confused with that of other bacteria or fungi. For a list of other diseases with similar damage, see CABI (2001).

Biology and Ecology

Life cycle	Bacteria are carried by insects or wind-driven rain and enter the plant through blossoms, natural openings or wounds. They invade branches and trunks during the growing season, and produce a secondary inoculum (exudate). Then they form a canker in lignified tissues in which they overwinter.
Host plant	The main hosts are in the subfamily Pomoideae of the family Rosaceae: *Pyrus* spp. (pear), *Malus* spp. (apple), *Cotoneaster* spp, *Crataegus* spp., *Pyracantha* spp., *Cydonia* spp., etc. For a complete list of hosts, see Van der Zwet and Keil (1979) and CABI (2001).
Habitat	Orchards, urban, rural and forest habitats.

Origin North America

Introduction and dispersal

History of introduction	*E. amylovora* was introduced into the UK in the 1950s, in northern Europe in the 1960s, and the eastern Mediterranean region in the 1980s. Most European countries have now been invaded, although areas remain free of the disease. It has also been reported occasionally from other regions of the world, e.g. several Asian countries and New Zealand (CABI/EPPO, 1997). It was first found in Switzerland on two *Cotoneaster* plants in north-eastern Switzerland (SH) in 1989 (Hasler et al., 2002).
Pathways of introduction	Probably introduced with host plants.
Dispersal	Natural, local dispersion is due to insects (including honey bees) or rain. On a larger scale, the movement of host plants is probably the main mode of dispersal, although the possibility that aerosols play a significant role cannot be ruled out.

Current status

Actual and potential distribution in CH	*E. amylovora* has now reached most Swiss cantons, but it still has a localized distribution. It is subject to strict quarantine regulation. A well-maintained website (***http://www.feuerbrand.ch/***) provides details on the spread of the bacteria in Switzerland, and other

	general information on fire blight in Switzerland and elsewhere. Given the large host range of *E. amylovora*, most regions of Switzerland are at risk, except high elevation regions.
Distribution in Europe	Most European countries are now partly infested, although some regions (e.g. in France, Germany, Switzerland) are still free of the disease. See CABI/EPPO (1997) and CABI (2001) for details.

Impacts

Damage on plant	The disease rapidly kills the most susceptible plant species.
Environmental impact	Since the host range of *E. amylovora* also includes many wild, native species in Europe (e.g. *Crataegus* spp., *Cotoneaster* spp., *Pyrus* spp., etc.), it is suspected that some European ecosystems are or will be threatened, particularly in the Mediterranean region. However, very little research has been conducted on these environmental threats.
Economic impact	*E. amylovora* is a serious threat to both the pome fruit industry and the nursery trade. It is destructive of the current year's crop but also extremely dangerous to the plants themselves. The Mediterranean countries are particularly affected, because of favourable climatic conditions. Many susceptible cultivars have suffered severe losses and are tending to disappear. In Switzerland, it is estimated that, between 1994 and 2002, about 23,000 pear and apple trees were infected. The costs for the eradication and control programmes in the years 1989- 2000 amounted to SFR 12 million (US$ 9 million) (Hasler et al., 2002). In some US states, pear cultivation has been largely abandoned because of the disease. In addition, fire blight is a quarantine disease in most countries and, therefore, a single introduction, even of very limited importance in the field, may have a considerable economic impact in a newly infected country, due to possible limitations in international trade of plants (Van der Zwet and Keil, 1979; CABI/EPPO, 1997; CABI, 2001).

Management options

Management options include legislative control (quarantine measures, eradication, prohibition of the most susceptible plants or cultivars), chemical control (e.g. copper), biological control (e.g. antagonistic bacteria), cultural control (pruning, tree nutrition, sanitation, monitoring and warning systems), and use of resistant or tolerant cultivars. See CABI (2001) for a general discussion on control methods, and ***http://www.feuerbrand.ch/*** for regulations in Switzerland.

Information gaps

Too little is known about the occurrence and abundance level of the fire blight in natural habitats to assess properly its impact on natural ecosystems.

References

Literature

CABI/EPPO (1997) Quarantine pests for Europe. 2nd edition. Smith, I.M., McNamara, D.G. Scott, P.R. and M. Holderness (eds) CAB International, Wallingford, UK.

CABI (2001) Crop Protection Compendium. CD-ROM. CAB International, Wallingford, UK.

Hasler, T., Schaerer, H.J., Holliger, E., Vogelsanger, J., Vignutelli, A. and B. Schoch (2002) Fire blight situation in Switzerland. Acta Horticulturae 590, 73-79.

Van der Zwet T. and H.L. Keil (1979) Fire blight, a bacterial disease of rosaceous plants. Agriculture Handbook, Science and Education Administration USDA, Beltsville, USA. USDA, No. 510, 200 pp.

Phytophthora quercina

Taxonomic status

Scientific name	*Phytophthora quercina* Jung et al.
Synonyms	
Taxonomic position	Oomycota: Peronosporales
English name	
German name	
French name	
Italian name	

Description and identification

Description	Many *Phytophthora* spp. occur in Europe, including on oak. Characterizing different *Phytophthora* spp. is difficult. Identifications can be performed by traditional isolation and culturing of the pathogen on standard, selective media, but are best carried out by specialists. Identification can be confirmed by molecular analyses (Cooke et al., 1999).
Similar species	The other *Phytophthora* spp. on oak in Europe do not seem to be pathogenic. In the USA, *P. ramorum* Werres, de Cock & Man in't Veld is a new, serious pathogen of oak species (see Fact Sheet on *P. ramorum*).

Biology and Ecology

Life cycle	*P. quercina* is a recently described species. Its biology is still unknown.
Host plant	To date, *P. quercina* has been found associated only with various oak species in Europe and Asia Minor: *Q. robur* L., *Q. petraea* (Mattuschka), *Q. cerris* L., *Q. pubescens* (Willd.), *Q. ilex* L., *Q. hartwissiana* Stev., *Q. frainetto* Ten. and *Q. vulcanica* Boiss. & Heldr.
Habitat	Probably oak habitats.
Origin	Unknown, perhaps native to Europe, although its newly discovered pathogenicity, and the fact that it is not present in all European countries, suggest an exotic origin.

Introduction and dispersal

History of introduction	Unknown
Pathways of introduction	Probably through movements of nursery stock and forestry seedlings.
Dispersal	Unknown. More data are needed on the biology of the fungus.

Current status

Actual and potential distribution in CH	Not yet found in Switzerland, but since it is present in all neighbouring countries, it may also be present in Switzerland. Its potential distribution is probably limited to the distribution of *Quercus* spp.
Distribution in Europe	Austria, France, Germany, Hungary, Italy and Turkey.

Impacts

Damage on plant	*P. quercina* has been recently associated with oak decline in Europe (Vettraino et al., 2002). In some cases, however, a relationship was not clearly established (e.g. Hartmann and Blank,

2002). *P. quercina* is perhaps detrimental only in combination with other biotic or abiotic factors. For example, Jung et al. (2000) found that *P. quercina* is strongly involved in oak decline syndrome on sandy-loamy to clayey soils with pH values above 3.5. In pathogenicity tests *Q. robur* seedlings showed severe dieback, root necrosis and leaf chlorosis (EPPO, 2003).

Environmental impact	If the relationship with oak decline, a serious threat to oak ecosystems in Europe, is confirmed, *P. quercina* can be considered an important environmental pest.
Economic impact	Oak is an important amenity and forest tree in Europe. Oak decline is considered a serious problem in European forestry.

Management options No management option is available at present.

Information gaps Little is known about *P. quercina*. More data are needed on its taxonomic identity, biology, host range, geographic distribution, epidemiology, pathogenicity and role in oak decline.

References

Literature

EPPO (2003) Alert list, *Phytophthora quercina*: http://www.eppo.org/QUARANTINE/Alert_List/Fungi/phytqu.html .

Hartmann, G. and R. Blank (2002) Vorkommen und standortbezüge von *Phytophthora* -Arten in geschädigten Eichenbeständen in Nordwestdeutschland (Niedersachsen, Nordrhein-Westfalen und Schleswig-Holstein). Forst und Holz 57, 539-545.

Jung, T., Blaschke, H. and W. Osswald (2000) Involvement of soilborne *Phytophthora* species in Central European oak decline and the effect of site factors on the disease. Plant Pathology 49, 706-718.

Vettraino, A. M., Barzanti, G.P., Bianco, M.C., Ragazzi, A., Capretti, P., Paoletti, E., Luisi, N., Anselmi, N. and A. Vannini (2002) Occurrence of *Phytophthora* species in oak stands in Italy and their association with declining oak trees. Forest Pathology 32, 19-28.

http://www.forst.uni-muenchen.de/EXT/LST/BOTAN/LEHRE/PATHO/QUERCUS/oakdec.htm

Phytophthora ramorum

Taxonomic status

Scientific name	*Phytophthora ramorum* Werres, de Cock & Man in't Veld
Synonyms	
Taxonomic position	Oomycota: Peronosporales
English name	Sudden oak death, Ramorum die-back
German name	
French name	Mort subite du chêne
Italian name	

Description and identification

Identification character	Many *Phythophthora* spp. occur in Europe, including on oak. Characterization of *Phytophthora* spp. is difficult. Identifications can be performed by traditional isolation and culturing of the pathogen on standard, selective media, but are best carried out by specialists. Symptoms depend on the host tree (see Eppo, 2003; Anon., 2003) but can easily be mistaken for other diseases.
Similar species	A new species*, P. quercina* has been recently described, and associated with oak decline in some European countries, including Austria, France, and Germany (see Fact Sheet on *P. quercina*)

Biology and Ecology

Life cycle	*P. ramorum* is a recently described species. Its biology is still largely unknown, and seems to vary with host plant. The pathogen has been recovered from above-ground plant material, rain -splash, stream water, and soil, but not from below-ground host tissues. Deciduous sporangia, thick-walled chlamydospores are produced in vitro and in vivo. Sexual oospores have been obtained in vivo in Europe but not in North America.
Host plant	*P. ramorum* has already been found in many plants in various families. It severely affects a few oak species in western North America (*Q. agrifolia* Née, *Q. kellogii* Newberry, *Q. parvula* Greene and *Lithocarpus densiflorus* (Hook. & Arn.)). It is also found on many other plant species, causing various levels of damage (see lists in Rizzo, 2002, EPPO, 2003, and Anon., 2003). In Europe, it was originally found only on *Rhododendron* spp. and *Viburnum* spp., causing twig blight and wilting (Werres, 2002; Heiniger and Stadler, 2003), but has now been recorded in the UK on *Q. falcata* Michx., *Q. ilex* L., *Castanea sativa* Mill., *Aesculus hippocastanum* L. and *Fagus sylvatica* L. (Anon., 2004).
Habitat	Given its wide host range, it is probably present in various habitats.

Origin Unknown

Introduction and dispersal

History of introduction	Unknown. Recently found and identified in western North America (Oregon and California) and, at the same time, in several western European countries.
Pathways of introduction	The pathways of introduction into newly infested regions are unknown, but introductions probably occurred through the movement of infested nursery stock, wood, bark, or soil.
Dispersal	Infection could occur through oospores, sporangia and chlamydospores. Local dispersal could be caused by rain splash, wind (sporanges are deciduous), soil and plant transportation, hiking boots, etc.

Current status

Actual and potential distribution in CH	Recorded for the first time in Switzerland in September 2003, in a nursery in central Switzerland, on *Viburnum* × *bodnantense* (Heiniger and Stadler, 2003). Most of the country is at risk.
Countries with introduced species	Found locally in UK, Netherlands, Germany, Spain, Belgium, Italy, Poland, Sweden and Switzerland.

Impacts

Damage on plant	The damage greatly depends on the host plant. Detailed symptoms are described in EPPO (2003) and Anon. (2003). The most susceptible hosts (e.g. oak species in the western USA) develop serious cankers on the stems. Cankered trees may survive for one to several years, but then crown dieback starts and the tree dies rapidly. Infected trees are also more susceptible to secondary attack by insects and diseases. In Europe, the fungus causes twig blight in *Rhododendron*, and wilting disease in *Viburnum*.
Environmental impact	In the USA, the fungus has already killed thousands of trees, and a serious negative impact can be expected on the biological diversity of forests together with major environmental problems (e.g. enhanced fire risk and damage to water catchments, erosion, etc.). In Europe, the disease has been found only on *Rhododendron* and *Viburnum* in nurseries. Its potential threat to native plants and their ecosystems is unknown, but should not be neglected, since many host genera (e.g. *Quercus*, *Rhododendron*, *Viburnum*, *Vaccinium*) are important parts of European ecosystems.
Economic impact	Most plant/tree species affected by the disease, including those attacked in Europe, are commercially grown as nursery stock. Oak species are also important timber trees. The nursery trade is also affected because of quarantine regulation. In the USA, the economic impact is expected to be huge. In Europe, too little is known regarding *P. ramorum*'s potential occurrence to evaluate properly its possible economic impact, but the damage on *Rhododendron* and *Viburnum* causes concern in nurseries (Werres, 2002; Heiniger and Stadler, 2003).

Management options There are no current management options for *P. ramorum*. In general, *Phytophthora* spp. are difficult to control. Studies are presently being carried out in the USA to test the susceptibility of *P. ramorum* to fungicides, high temperature and composting treatments.

Information gaps Very little is known about this pest. More data are needed on its taxonomic identity, biology, host range, geographical distribution and epidemiology, particularly in Europe.

References

Literature

Anon. (2003) Web site on sudden oak death: http://www.suddenoakdeath.org

Anon. (2004) UK forestry website on Piramorum: http://www.forestry.gov.uk/pramorum

EPPO (2003) Alert list, sudden oak death: http://www.eppo.org/QUARANTINE/Alert_List/Fungi/oak_death.html

Heiniger, U. and B. Stadler (2003) Gefährliche Quarantänekrankheit gefunden. *Phytophthora ramorum* jetzt erstmals auch in der Schweiz. Der Gartenbau 51/52/2003, pp. 10-12.

Rizzo, D. (2002) Sudden oak death. 13th USDA Interagency

Research Forum on Gypsy Moth and other Invasive Species, Annapolis, Maryland, USA, 2002-01-15/18, pp. 1-2.
Werres, S. (2002) *Phytophthora ramorum* – erste Ergebnisse zum Wirtspflanzenspektrum in Deutschland. Deutsche Baumschule 7, p. 46.
http://www.bba.de – Aktuelle Themen: Information on the species [in German].

10 Plants – Planta

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Introduction and terminology

The expansion of alien plants within Central Europe began with the introduction of agriculture about 7,000 years ago and the subsequent spread of weeds. In Europe, as in most regions of the world, the number of alien plant species has increased considerably in the past 200 years as a result of increasing trade, tourism and disturbance. The increasing number of naturalized alien plant species with negative impacts on plant communities is viewed as a major component of global change. Successful invaders can affect the invaded communities in various ways, e.g. reducing the local diversity, driving rare native species to extinction (e.g. by competition or hybridization), changing habitat structures and ecosystem functioning, or increasing erosion. Plants are particularly notorious invaders, since they are capable of changing the food web at the base, which can ripple through the entire ecosystem. In Switzerland, with the exception of the Alps, wildlife and areas of conservation value are usually restricted to small areas, surrounded by heavily disturbed habitats or urban areas. In such small areas, invasive plant species pose additional threats to the native plant and animal diversity. Moreover, new plant invaders in Switzerland and in Europe can also affect human health (e.g. *Ambrosia artemisiifolia* L. and *Heracleum mantegazzianum* Sommier et Levier) or are a potential threat to the agro-economy (e.g. *Senecio inaequidens* DC.). This report gives an overview of alien and invasive plant species with regard to the Swiss flora. Some of the ecological and biological characteristics of alien plants in Switzerland are discussed and a list of plant invaders or potential invaders is provided.

In this context, it is important to note that different original sources may cite different numbers of alien plant species. For example, Moser et al. (2002) list 350 neophytes. A number of these species are given a different status in Lauber and Wagner (1998). In addition, the species lists are not identical. For example, Moser et al. (2002) list two ferns as neophytes (*Cyrtomium falcatum* K. Presl, *C. fortunei* J. Sm.) which are not included in Lauber and Wagner (1998). The same holds for *Crataegus lindmanii* Hrabetova and *C. rhipidophylla* Gand. In contrast, species like *Cotoneaster bullata* Bois, *C. dammeri* Schneider, *Helianthus rigidus* (Cassini) and *Paspalum dilatatum* Poiret are not included in Moser et al. (2002). Excluding cultivated species that occur rarely as subspontaneous species ('C' plants in Moser et al. (2002)), we found in total over 70 alien species which are included in either one of the two lists but not in the other. Most of the variation originates from whether cultivated species are considered to be subspontaneous or not. In addition, another 60 species of European origin are controversial with regard to their alien status in Switzerland. Thus, different authors have different approaches to the treatment of species, and there is no ultimately correct source. However, either source can be used to seek general patterns in geographic origins, life form distribution, or the numbers of neophytes present. Because Moser et al. (2002) do not provide standardized information on plant status and plant origin, we used the information provided by Lauber and Wagner (1998) to seek these general patterns.

There is much variation in the definition of some of the terms presented below. In particular, there is controversy about the definition of 'invasive species' in the literature. The term 'invasive species' often refers exclusively to species penetrating into natural and semi-natural habitats although it is often difficult to clearly separate semi-natural from human-made habitats. The terms 'weeds' and 'weedy species' are consequently devoted to plants causing problems in managed areas. Some authors call any alien plant species that spreads spontaneously in the introduced range an invasive species, irrespective of whether the species has harmful effects or not. For practical reasons, such a broad definition is not useful.

In this chapter, the term 'invasive species' always refers to plants of alien origin, while the term 'weed' implies an indigenous species. Alien species may become invasive primarily in human-made habitats or agricultural land and thus have economic rather than ecological effects (e.g. *Ambrosia artemisiifolia* and *Cyperus esculentus* L.). It must be stressed however that most invasive plants are of greater concern in natural or semi-natural areas. It should be pointed out also that the spread of many naturalized species is primarily in highly disturbed areas of low ecological (or economic) value but this situation may change for many plant species in the future. In contrast, native species can pose problems by becoming abundant in conservation areas influenced by human activities, e.g. *Phragmites australis* (Cavanilles) or *Rubus* spp. This report does not consider native species that are weeds in agricultural land or may be of concern in natural or semi-natural areas.

The terminology presented below has been adapted from Richardson et al. (2000) and Weber (1999a).

- **Alien** (**non-native**, **non-indigenous**, **introduced**) **plants**: plant taxa (species, subspecies or lower taxon) in a given area whose presence there is due to intentional or accidental introduction as a result of human activity. Unless specified, cultivated plants that have not escaped from cultivation are not treated as alien species.
- **Native** (**indigenous**) **plants**: plant taxa occurring within their natural range and dispersal potential (i.e. within the range they occupy naturally or could occupy without direct or indirect introduction or care by humans).
- **Neophyte plants** (or **neophytes**): *alien* plants introduced during modern times (after 1500 A.D.) and which have become naturalized. **Archeophyte plants** (or **archeophytes**) are those that were introduced before 1500 A.D. This report does not treat the two groups separately.
- **Casual** (**transient**, **ephemeral**) **plants**: *alien* plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions or habitat disturbance for their persistence.
- **Adventive plants**: *casual alien* plants that have been accidentally introduced as a result of human activity.
- **Subspontaneous plants**: *casual alien* plants escaped from cultures.
- **Naturalized plants**: *Alien* plants that reproduce consistently and sustain populations over many life cycles without direct intervention by humans, (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade their habitat.
- **Invasive plants** (**plant invaders**): *Naturalized* plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants, and thus have the potential to spread over a considerable area. Invasive plants can affect the invaded natural or semi-natural communities in various ways. Invasive plants can also affect human-made habitats and have direct economic effects. The term environmental weeds is sometimes used for those *invasive plants* having an impact in natural areas and semi-natural areas; and the term alien weeds is sometimes used for those *alien plants* that are weedy in managed habitats, such as agriculture.
- **Weeds**: *native* plants that grow in sites where they are not wanted and which have detectable economic or environmental effects.

The native and alien flora of Switzerland

The list of alien species present in Switzerland (Table 10.6) includes both archaeophytes and neophytes. However, in this list, the neophytes of *Flora Helvetica* (Lauber and Wagner, 1998) are marked as such. A few species that have become naturalized recently (e.g. *Ludwigia grandiflora* (Michaux) and *Lysichiton americanus* Hultén & St. John) have been added to the alien species amongst the 3000 plant taxa listed in *Flora Helvetica*. The plant status and life form for each species have been extracted from the information provided by Lauber and Wagner (1998).

The Swiss flora of vascular plants includes some 162 families and over 3000 taxa (species, subspecies and lower taxa). Of these, 20 plant families and 84 plant taxa belong to the ferns and fern allies (Pteridophyta) while the other families and taxa belong to the flowering plants (Spermatophyta).

The Swiss flora comprises 2505 native species belonging to 136 families (Table 10.1; excluding subspecies and lower taxa). From the 470 taxa of alien origin recorded in Switzerland, over 100 species are cultivated species that are not, or rarely, found in the environment. The 362 remaining alien species have become subspontaneous, adventive or naturalized. These alien species, which represent about 12.6% of the flora of Switzerland, are discussed below.

This percentage is similar to that observed in neighbouring countries, e.g. 9.1% in Austria, 10.2% in France, but much less than in countries in North America, e.g. 28% in Canada, or on islands, e.g. 47% in New Zealand (Heywood, 1989). The density of alien species in Switzerland (i.e. the number of alien species per log country size in square kilometres) is 78.4 and slightly higher than in several other

European countries. This may be due to the topography and diversity of climates encountered in Switzerland which allow plant species as different as *Agave americana* L. and *Reynoutria japonica* Houttuyn to become naturalized (see also Weber, 1999a, b). France, which offers an even wider range of habitats and climates, has a density of alien species of 87.1 (Heywood, 1989), whereas in Austria, the density of alien species is 60.9.

According to Lauber and Wagner (1998), the group containing ferns and its allies does not include any alien species (Table 10.1). There is a high proportion of alien gymnosperm species (28.6%), i.e. four alien gymnosperm species out of 14 recorded. The frequency of alien species in the dicotyledons and monocotyledons is quite similar, i.e. 13.5% and 11.0%, respectively.

Table 10.1: Synopsis of the native and alien flora of Switzerland: number of species (% of total).

	Pteridophyta	Spermatophyta			Total
		Gymnosperms	Dicotyledons	Monocotyledons	
Native species*	84 (3.4)	10 (0.4)	1879 (75.0)	532 (21.2)	**2505 (100)**
Families	20 (14.7)	4 (2.9)	93 (68.4)	19 (14.0)	**136 (100)**
Alien species**	0	4 (1.1)	292 (80.7)	66 (18.2)	**362 (100)**
Families which include alien spp.	0	2 (2.5)	64 (80.0)	14 (17.5)	**80 (100)**
TOTAL no. species	**84 (2.9)**	**14 (0.5)**	**2171 (75.7)**	**598 (20.9)**	**2867 (100)**
% alien species / total no. species	0	28.6	13.5	11.0	12.6

* Excluding subspecies and varieties
** Excluding cultivated species which are not, or only rarely, found in the environment

The geographic origin of alien and naturalized species

About one-fifth of all alien plant species in Switzerland have been introduced from each of the following areas: North America, Asia and the Mediterranean (Fig. 10.1; Table 10.2). Some 15% have been introduced from the rest of Europe and Eurasia/the Caucasus. The distribution of the so-called Eurasian species usually extends from eastern and south-eastern Europe to Asia Minor. Approximately one-fifth of the species of Asian origin were restricted to western Asia and the other four-fifths to Central Asia, China and east Asia. Only three species originate from Africa, three from Central America and 14 from South America (Table 10.6). One species is native to Australia. Seven per cent of all alien species in Switzerland are of unknown origin.

One hundred and two alien species have become naturalized. Although 71 alien plant species in Switzerland have been introduced from North America and 76 from the Mediterranean region, only 18.4% from the Mediterranean region have become naturalized whereas 43.7% of those of North American origin have done so. Also, 31.1% of the alien species of European origin have become naturalized but only 25.8% of those of Asian/Eurasian origin. It should be noted that three out of five species introduced from the Caucasus have become naturalized and two of them are considered to be invasive (*Heracleum mantegazzianum* and *Rubus armeniacus* Focke).

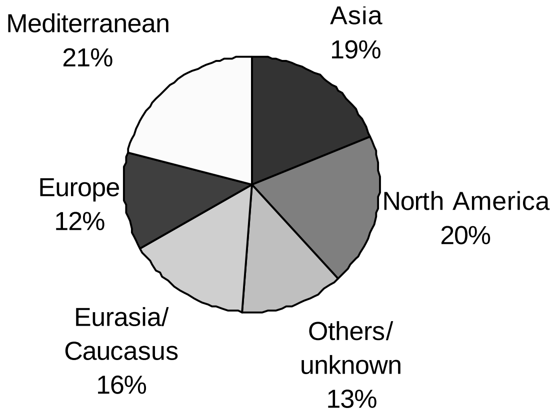

Figure 10.1: The origin of alien plants in Switzerland.

Table 10.2: The origin of the alien flora of Switzerland: number of species (%).

	North America	South America	Asia	Eurasia/ Caucasus	Europe	Mediter-ranean.	Others	Unknown	Total
Alien	71 (19.6)	14 (3.9)	68 (18.8)	56 (15.5)	45 (12.4)	76 (21.0)	7 (1.9)	25 (6.9)	362 (100)
Naturalized	31 (30.4)	3 (2.9)	17 (16.7)	15 (14.7)	14 (13.7)	14 (13.7)	3 (2.9)	5 (4.9)	102 (100)
Invasive	8 (40.0)	1 (5.0)	8 (40.0)	2 (10.0)	0	0	1 (5.0)	0	20 (100)

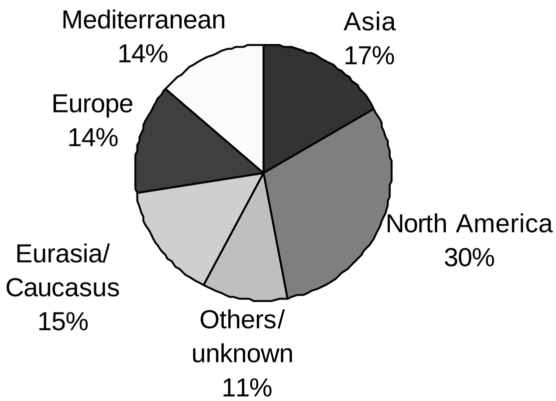

Figure 10.2: The origin of naturalized species in Switzerland.

In total, 30.4% of the naturalized flora originates from North America and 31.4% from Eurasia and the Caucasus (Fig. 10.2; Table 10.2).

Of the 20 species that are considered to be invasive in Switzerland (***http://www.cps-skew.ch/***), 40% originate each from North America and Asia (Table 10.2). With the exception of the Caucasian species, no Eurasian or Mediterranean species have become invasive. One might argue that Eurasian and Mediterranean species capable of being invasive in Switzerland will have arrived already. Thus, not surprisingly, the majority of naturalized and invasive species in Switzerland originate from temperate North America and Asia. Europe and the Mediterranean are a major source of alien species, but interestingly not of naturalized or invasive plants.

Pathways of introduction

From the 20 species on the Black List of invasive species (***http://www.cps-skew.ch/***), 15 (75%) have been deliberately introduced, usually as ornamentals. The pathway of introduction of the two aquatic species, *Elodea canadensis* Michaux and *E. nuttallii* (Planchon), is unknown but they might well have escaped from garden ponds or been released from aquariums and thus are likely to be deliberate introductions as well. Kowarik (2003) separates the pathways of the 25 problematic species in Germany into 21 deliberate (84%) and four accidental (16%) introductions. These figures are summarized in Table 10.3 together with the corresponding numbers of the total neophytes in Austria and the Czech Republic.

These two sets of data each give a similar picture for the Central European flora. The total numbers of neophytes in Austria and the Czech Republic are around 1,000 species and the numbers of problematic species in Germany and Switzerland are 25 and 27, respectively. It should be noted that the figure of 1,000 neophytes given by Essl and Rabitsch (2002) for Austria is much higher than the 300 introduced species given by Heywood (1989) for the same country.

The percentage of deliberate introductions that have become problematic is between 75% and 84%, while it is lower for all neophytes, i.e. between 55% and 59%. The comparison indicates that species selected for introduction are more likely to become problematic species than those arriving accidentally. These differences may be attributed to human dimensions in the success of invasions, in particular propagule pressure.

Table 10.3: Pathways of introductions into four European countries.

	Switzerland	Germany	Austria	Czech Republic
Total number	20	25	1110	924
Deliberate	15	21	652	504
Accidental	4	4	372	420
Unknown	1	-	86	-
Deliberate/Accidental as percentage of total	75 / 25	84 / 16	59 / 33	55 / 45

The numbers for Switzerland and Germany are based on problematic plants (authors’ data and Kowarik, 2003), while the numbers for Austria (Essl and Rabitsch, 2002) and Czech Republic (Pysek et al., 2002) are neophytes.

Status of the alien species of Switzerland

Of the 362 alien species recorded in Switzerland, 102 species (28.2%) have become naturalized and 20 species have become invasive (5.5%) (Fig. 10.3), which also means that a quarter of all naturalized species have become invasive. The remaining species are either adventive or subspontaneous, or of unknown status. Thus, 3.6% of the Swiss flora consists of naturalized species.

The 362 alien species belong to 80 plant families, i.e. about half of all plant families present in Switzerland (Table 10.1). The percentage of alien species per family ranges from 2.8% (Juncaceae) to 100% for 20 plant families which are represented by alien species only, usually by one or two species (Table 10.7). The percentage of alien species in the large families (>30 species) ranges from 2.8 (Juncaceae) to 25.6% (Polygonaceae). The largest family, Asteraceae, comprises 340 species of which some 12.4% are alien species. Thirty percent of all alien species belong to the Asteraceae, Brassicaceae and Poaceae.

Some 50 plant families in Switzerland include no alien species. Most of these are small or very small families. Exceptions are the Orchidaceae (62 species), Gentianaceae (34 species), Potamogetonaceae (21 species) and Orobanchaceae (20 species).

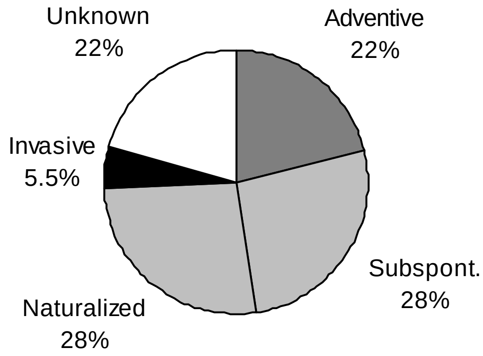

Figure 10.3: Status of alien species in Switzerland.

Naturalized species of Switzerland

Naturalized species are represented by 102 species belonging to 49 plant families, i.e. less than one-third of the total number of families in Switzerland (Table 10.7). The majority (30 families) include only one naturalized species. Eleven families include two naturalized species, and only eight families have more than two naturalized species. The Asteraceae alone includes ten naturalized species followed by the Rosaceae (nine), the Brassicaceae (seven) and the Fabaceae (six). Almost one-third of all naturalized species belong to one of these four families.

The percentage of naturalized species per family ranges from 0.8% (Caryophyllaceae) to 100% for eight families that are represented exclusively by their naturalized species (usually one species – with the exception of the Phytolaccaceae which is represented by two species) (Table 10.7). The percentage of naturalized species in the large families (>30 species) ranges from 0.8% (Caryophyllaceae) to 7.7% (Polygonaceae). The largest family, Asteraceae, comprises 2.9% naturalized species. The aquatic plant family Hydrocharitaceae comprises 71.4% naturalized species.

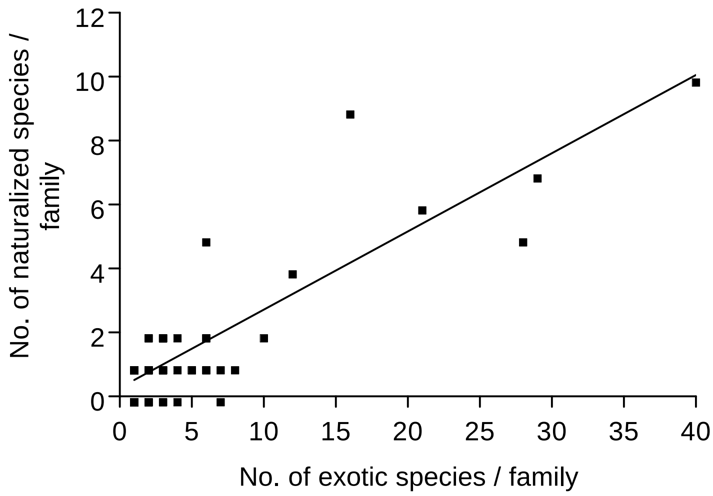

Figure 10.4: Number of established species as a function of the number of alien species (r^2=0.8).

In total, 28.2% of all alien species have become naturalized. No naturalization at all is observed in 31 families (comprising 55 alien species). The highest rate of failure is in the Amaranthaceae with nine alien but no naturalized species. In contrast, 100% naturalization is observed in 17 families accounting for 20 alien species. The number of naturalized species is correlated to the number of species introduced (Fig. 10.4).

Life form

The 11 life forms that are defined in *Flora Helvetica* (see also Table 10.6) have been pooled into eight different ones. The categories 'trees' and 'shrubs' include both deciduous and evergreen plants. The category 'small shrubs' includes both woody and herbaceous chamaephytic plants. Chamaephytic plants are perennial species with persistent stems and buds overwintering above ground level. Geophytic plants are perennial herbs with tubers, bulbs or rhizomes.

In all, 46.4% of the alien flora of Switzerland consists of annual and biennial species (n=168) but only 21.6% of the naturalized flora is in these groups (n=22) (Table 10.4). In contrast, perennial species form 53.6% of the alien flora but 78.4% of the naturalized flora. Thus, of the alien species present in Switzerland, relatively more aquatic plants (78%), small shrubs (55%) and trees (47%), and indeed perennial plants as a whole (41%) have become naturalised, compared to biennial plants (13%) and annual herbs (13%).

Table 10.4: The life form of vascular plants in Switzerland: number of species (% of total).

Life forms		Alien species	Naturalized species	Invasive species	Native species
Perennials	Trees	30 (8.3)	14 (13.7)	5 (25.0)	68 (2.7)
	Shrubs	25 (6.9)	8 (7.8)	2 (10.0)	103 (4.1)
	Small shrubs	22 (6.1)	12 (11.8)	0	238 (9.6)
	Geophytic plants	48 (13.3)	18 (17.6)	7 (35.0)	383 (15.4)
	Herbs	60 (16.6)	21 (20.6)	1 (5.0)	1120 (44.9)
	Aquatic plants	9 (2.5)	7 (6.9)	2 (10.0)	62 (2.5)
Perennials (total)		194 (53.6)	80 (78.4)	17 (85)	1974 (79.1)
Biennial herbs		54 (14.9)	7 (6.9)	1 (5.0)	239 (9.6)
Annual herbs		114 (31.5)	15 (14.7)	2 (10.0)	279 (11.2)
Total		362	102	20	2492

Woody and geophytic plants account for 70% of invasive species in Switzerland (Table 10.4). Perhaps surprisingly, no chamaephytic and only one herbaceous perennial have become invasive. The proportions of shrubs and aquatic plants in the invasive flora are similar, as are the proportions of these two life forms in the naturalized flora, i.e. 7-10%. Thus, there are again a disproportionate number of large woody perennials and geophytic species that have become invasive compared to those that have become naturalized. Only few short-lived species have become invasive.

In total, 85% of the invasive flora in Switzerland consists of perennial species of which more than two-thirds are trees and geophytic plants. The proportion of alien species that are trees is three times the proportion of native species that are trees (Table 10.4), but the proportion of invasive species that are trees is about ten times the figure for native species. For comparison, the proportion of short-lived plants that are alien is about twice the proportion for native species, but the proportions of short-lived species that are invasive and native are similar. In contrast, the proportion of herbaceous perennials that are native is almost three times higher than the figure for alien species and nearly ten times higher than for invasive species (Table 10.4). In summary, the life form composition of the alien flora is different from the native one and it changes during the process of naturalization and invasion. While the highest number of introduced species are annual plants, they do not naturalize well. The relatively small number of introduced trees and geophytic plants are successful in the naturalization process and are aggressive invaders. The introduction, naturalization and invasion of alien plant species results not only in a change in the floristic composition, but also in plant life form changes with probable consequences on habitat structure and ecosystem functioning.

The habitats of alien plants in Switzerland

The ecological plant groups used here have been taken from Lauber and Wagner (1998) to define plant habitats. Nine ecological groups have been defined:

- F = forest plant
- M = mountain plant
- P = (lowland) pioneer plant
- E = aquatic plant
- H = marsh plant
- S = dry grassland plant
- G = grassland plant
- R = ruderal plant

Table 10.5: The ecological groups of alien plants in Switzerland, excluding cultivated plants: number of species (%).

	Forest	Mountain	Pioneer	Aquatic	Marsh	Dry grassland	Grassland	Ruderal	Total
Alien	34 (11.3)	4 (1.3)	19 (6.3)	12 (4.1)	26 (8.6)	14 (4.7)	4 (1.3)	189 (62.6)	302
Naturalized	23 (23.5)	3 (3.1)	11 (11.2)	8 (8.2)	11 (11.2)	4 (4.1)	0	38 (38.8)	98
Invasive	3 (15.0)	0	7 (35.0)	2 (10.0)	3 (15.5)	0	0	5 (25.0)	20
Native	443 (17.9)	644 (26.0)	126 (5.1)	96 (3.9)	308 (12.4)	347 (14.0)	74 (3.0)	438 (17.7)	2476

The majority of alien species in Switzerland are ruderal plants (62.6%), followed by forest plants (11.3%) and marsh plants (8.6%) (Table 10.5). However, ruderal plants represent only 38.8% of all naturalized species. Forest species increase to 23.5% of all naturalized species, followed by pioneer and marsh species (11.2%), and aquatic species (8.2%). There are very few mountain and grassland species naturalized in Switzerland. Thus, it appears that forest and wetland habitats are more suited to plant naturalization since 42.9% of all naturalized species belong to these ecological groups (F, E, H). It should be noted, however, that three out of four mountain species have become naturalized. Only 20.2% of ruderal species have become naturalized.

Ruderal and pioneer species represent 60% of all invasive species, indicating perhaps less resistance of these habitats to invasion. Wetlands and forests seem to be more resistant to invasion. However, 40% of invasive species in Switzerland belong to either the forest, aquatic or marsh ecological plant groups (F, E, H) and thus are a potential threat to the most valuable ecosystems of Switzerland, i.e. forests and wetland habitats. Mountain and grassland habitats seem to be at less risk based on invasions to date.

About 50% of all naturalized and invasive species are ruderal and lowland pioneer species. These species are often not restricted to waste ground or urban areas, but are known to invade (sometimes after a long period) semi-natural habitats such as meadows, riverbanks, gravel shores, forest margins or clearings. Several of the worst invasive plants in Switzerland such as *Reynoutria japonica*, *Heracleum manteggazianum*, *Impatiens glandulifera* Royle, *Buddleja davidii* Franchet and *Solidago canadensis* L. are treated as ruderal or pioneer plants but are known to invade less disturbed places as well. *Solidago* spp. in particular have been recognized for over a decade as a threat to protected areas (Voser-Huber, 1992). *Impatiens parviflora* DC. was introduced from Asia into Central Europe in 1837 and was for many years a typical ruderal plant occurring only in towns, gardens, parks or cemeteries. A few decades ago, however, it started to penetrate into woods, at first only in badly degraded areas, but then becoming firmly established in relatively natural stands of deciduous forests in Central Europe (Kornas, 1990).

Weber (1999a) gives the number of alien plant species recorded in various habitats (s.str.) in Switzerland: 16% are known from forests and related habitats, 15% from lakes and wetland areas, and 8% from grassland habitats. Interestingly, 16% of alien plants are found in rocky sites and on walls. As compared to the 61% of ruderal species, some 35% of alien plants grow only in ruderal sites. The number of alien plants recorded in various habitats is relatively similar to the numbers that can be extrapolated from the ecological groups. The data suggest that many ruderal alien plants are not restricted to ruderal sites but grow mainly in open habitats or less disturbed sites such as rocky areas, walls, or forests subjected to some disturbance.

As shown above, the great majority of naturalized and invasive species in Switzerland are perennial species and most of them are forest, wetland and ruderal species. With very few exceptions (e.g. *Impatiens glandulifera*), naturalized and invasive short-lived species are uncommon in semi-natural or natural habitats.

With respect to plant life form, the composition of the ecological plant groups of the alien flora differs from the native one, and it changes during the process of naturalization and invasion. The proportion of ruderal species in the alien flora is much higher than in the native one but this discrepancy is reduced during the naturalization process. In contrast, the proportion of alien forest plant species is lower than that of native forest plant species but proportions of invasive and native forest plant species are fairly similar.

Invasive plant species in Europe

Up to 2003, only a few European countries had compiled data on their alien and invasive floras at a national level. However, information from several countries is quite informative about invasive species elsewhere in Europe that could be a threat to Switzerland. Countries usually make explicit distinctions between invasive species, moderately or potentially invasive species, and species for which special attention is needed (usually the so-called 'Watch List'). We had to interpret some data to a certain extent to obtain a more consistent result. Austria includes an assessment of economic impact, which we have reproduced in Table 10.8 (Essl and Rabitsch, 2002). Also, the European and Mediterranean Plant Protection Organization (EPPO) is preparing a list of invasive and potentially invasive alien plants for the EPPO region. This information is still partial and it has not been used for the present review.

Plant species declared invasive or potentially invasive in nine European countries and occurring in Switzerland are presented in Table 10.8. The list includes over 130 alien plant species of concern in Europe. Quite obviously, not all of them are sufficiently pre-adapted to the eco-climatic conditions of Switzerland to present a threat in this part of Europe. On the other hand, some invasive species in northern European countries, for example, which are not listed in Table 10.8, could become a problem in Switzerland. Unfortunately, no detailed list of alien plants in Germany for each of the three categories defined was available at the time of this review. In contrast, the detailed information on the status of alien plants in France is highly relevant to Switzerland (Muller, 2004).

The list of invasive species ('Black List') and 'Watch Species' in Switzerland is taken from the CPS-SKEW working group (***http://www.cps-skew.ch/index.htm)***. A few species in these two categories do not have this status in the other European countries from which information could be collected (Table 10.8). However, they are invasive on other continents, e.g. *Pueraria lobata* (Willd.), and *Lonicera japonica* Thunberg (Cronk and Fuller, 1995; Weber, 2003) or their taxonomy is complex and their invasive status may not yet have been recognized (e.g. *Rubus armeniacus*).

Fact Sheets have been prepared for 48 plant species. They include 19 invasive species and 11 'Watch Species' of the CPS-SKEW working group. In this report, another 18 species to which special attention should be given in the future are also presented in Fact Sheets. These species have been selected according to their status in neighbouring countries and a previous list of potentially invasive species prepared by the CPS-SKEW working group (Table 10.8).

Discussion

About 362 alien species are established in Switzerland and almost one third of these have become naturalized with certainty. With the exception of aquatic plants in the Hydrocharitaceae, no one plant family appears to be particularly successful in naturalization.

This review stresses the importance of establishing the biological and ecological characteristics of the naturalized flora for determining the potential invasiveness of alien species in Switzerland. The life form composition of the alien flora is different from that of the native one and changes during the process of naturalization from dominance by short-lived to perennial species. The flora of naturalized plants consists of almost 80% perennial species. There is a further shift during the process of invasion towards large woody perennial and geophytic plants. The invasion by herbaceous perennials and short-lived plants has been negligible so far. Invasive species come from geographically distant areas and no European or Mediterranean species is considered to be invasive or potentially invasive in Switzerland.

More than 40% of all naturalized and invasive species consist of either forest or wetland species, thus it appears that these habitats are at a higher risk of invasion. In Europe, over 50% of the naturalized flora occurs in river border communities (Sykora, 1990). This is because rivers are an effective means of transportation for many species, natural riverbank communities have been largely destroyed by human activities, and riverbanks are regularly disturbed by water movement. Alluvial zones and mires are therefore of primary concern with regard to invasive species. The typical vegetation of lowland alluvial zones such as riverine floodplains consists of a mosaic of pioneer communities, shrubs and alluvial forests. Invasion by pioneer or ruderal alien species is likely to occur and expand in such sites due to human activities or colonization from upstream or adjacent fields. Fenlands also are at risk because they are often used for agricultural purposes. In contrast, raised bogs are at a lower risk since only highly specialized plant species can flourish in such habitats, and there is less permanent natural disturbance.

To date, the invasibility of mountain and grassland habitats has been low and few alien species have become naturalized in these habitats. Because meadows and grasslands owe their existence almost exclusively to human management, the threat from alien species will increase with land-use changes and reduced grassland maintenance. In the absence of any management, most meadows and grasslands below the timberline degenerate to scrub and revert to woodland. Alien shrubs and trees may profit from such a situation.

The restoration of biological diversity in intensively used agricultural land has been supported for several years through various agri-environmental schemes. In many areas this involves the conversion of intensively managed arable land to extensive pastures or so-called areas of ecological compensation. The transition period from intensively to extensively managed land or semi-natural habitats is highly favourable to alien species. Alien plants are a threat to the areas of ecological compensation, the restoration of riverbanks and mires, abandoned grassland and forests, and all previously or currently disturbed natural areas in Switzerland. For example, the rehabilitation of riverbanks can be seriously handicapped by alien species. Many invasive species increase erosion (e.g. *Reynoutria japonica*, *Buddleja davidii*), which in turn accelerates the establishment of invasive species, thus preventing the restoration of native plant communities.

The problems caused by alien species in cultivated land are still relatively minor but may increase in the future because of newly naturalized species and because changes in land use may favour establishment of alien species in extensive agro-ecosystems. Weber (1999a) recorded 38 alien plants that are known to occur in arable land. For example, *Conyza canadensis* (L.) and *Epilobium ciliatum* Rafinesque are of increasing importance in arable land, gardens, orchards and tree nurseries. *Galinsoga parviflora* Cavanilles is known to be a serious problem in vegetable crops in other countries and *Cyperus esculentus* is considered to be one of the world's worst weeds. *Ambrosia artemisiifolia* is most abundant in sunflower crops owing to the botanical similarity between the weed and the crop itself, and therefore only a limited number of herbicides are available that are effective against *A. artemisiifolia* alone. *Senecio inaequidens* is a potential problem in pastures and meadows. Unlike those in a natural environment, most alien plants in arable land are ruderal species and the majority of them are short lived.

Alien species can also become a public health problem. *Ambrosia artemisiifolia* is a strongly allergenic plant. Exposure to the sap of *Heracleum manteggazianum* sensitizes the skin to sunlight and causes severe irritation and painful blisters. Contact with the sap of *Ailanthus altissima* (Miller) may also cause skin eruptions.

Most of the 20 declared invasive plants in Switzerland are also invasive in neighbouring countries. An analysis of the invasive flora of several European countries shows that over 130 alien plants are of concern in Europe. The status of alien plants in Europe should be one aspect considered in developing a dynamic 'Watch List' of alien plants in Switzerland. In addition to the known invasive species of Switzerland, over 30 alien plants should be monitored over time to predict their invasive potential.

In conclusion, a careful review of invasive and potentially invasive plants in Europe combined with some key biological and ecological traits associated with naturalized species rather than alien plants, as well as field observations, should contribute to assessing the invasiveness of alien plant species in Switzerland. More research is needed to understand the naturalization and invasion process and to evaluate the impact of invasive species on the environment and the agro-ecosystem. More research is also needed to establish long-term and environmentally friendly management tools for invasive plants in Switzerland.

References

Cronk, Q.C.B. and J.L. Fuller (1995) *Plant invaders*. Chapman & Hall, 241 pp.

Dana, E.D., Sanz-Elorza, M. and E. Sobrino (2001) Plant invaders in Spain. ***http://www.ual.es/personal/edana/alienplants/checklist.pdf***

De Almeida, J.D. (1999) *Flora exotica subespontanea de Portugal continental.* Universidade de Coimbra, 151 pp.

Essl, F. and W. Rabitsch (eds) (2002) *Neobiota in Österreich.* Federal Environment Agency, 432 pp.

Heywood, V.H. (1989) Patterns, extends and modes of invasions by terrestrial plants. In: Drake, J.A. et al. (eds) *Biological invasions: a global perspective*. SCOPE 37, John Wiley & Sons, pp. 31-55.

Kornas, J. (1990) Plant invasions in Central Europe: historical and ecological aspects. In: di Castri, F., Hansen, A.J. and M. Debussche (eds) *Biological invasions in Europe and the Mediterranean Basin*. Kluwer Academic Publishers, pp. 19-36.

Kowarik, I. (2003) *Biologische Invasionen: Neophyten und Neozoen in Mitteleuropa.* Verlag Eugen Ulmer GmbH, Stuttgart, 380 pp.

Lauber, K. and G. Wagner (1998) *Flora Helvetica*. Paul Haupt Publishers, 1616 pp.

Moser, D.M., Gygax, A., Bäumler. B., Wyler, N. and R. Palese (2002) Rote Liste der gefährdeten Farn- und Blütenpflanzen der Schweiz. BUWAL-Reihe "Vollzug Umwelt".

Muller, S. (2004) *Plantes invasives en France*. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Pyšek, P., Sádlo, J. and B. Mandák (2002) C*atalogue of alien plants of the Czech Republic*. Preslia, Praha, 97-186.

Richardson, D.M., Pyšek, P., Rejmanek, M., Barbour, M.G., Panetta, F.D. and C.J. West (2000) Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6, 93-107.

Sykora, K.V. (1990) History of the impact of man on the distribution of plant species. In: di Castri, F., Hansen, A.J. and M. Debussche (eds) *Biological invasions in Europe and the Mediterranean Basin*. Kluwer Academic Publishers, pp. 37-50.

Voser-Huber, M.-L. (1992) Verges d'or - problèmes dans les réserves naturelles. OFEFP, Cahier de l'environnement N° 167, 22 pp.

Weber, E. (1999a) Switzerland and the invasive plant issue. Bot Helv. 110, 11-24.

Weber, E (1999b) Gebietsfremde Arten der Schweizer Flora - Ausmass und Bedeutung. Bauhinia 13, 1-10.

Weber, E. (2003) *Invasive plant species of the world. A reference guide to environmental weeds.* CABI Publishing, Wallingford, 548 pp.

Welch, D. et al. (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Abutilon theophrasti Medic.	Malvaceae	Unknown	t	adventive	N	R
Acalypha virginica L.	Euphorbiaceae	North America	t	naturalized	N	R
Acer negundo L.	Aceraceae	North America	t	subspontaneous		F
Acorus calamus L.	Araceae	Unknown	g	unknown	N	E
Aegilops cylindrica Host	Poaceae	Mediterranean	t	adventive		R
Aegilops ovata L.	Poaceae	Mediterranean	t	adventive		R
Agave americana L.	Agavaceae	Central America	j	naturalized	N	R
Ailanthus altissima (Miller)	Simaroubaceae	Asia	p	naturalized	N	P
Aldrovanda vesiculosa L.	Droseraceae	Unknown	a	unknown	N	E
Allium scorodoprasum L.	Liliaceae	Europa	g	unknown	N	R
Alopecurus rendlei Eig	Poaceae	Mediterranean	t	adventive		H
Althaea officinalis L.	Malvaceae	Asia	h	subspontaneous		C
Amaranthus albus L.	Amaranthaceae	North America	t	unknown	N	R
Amaranthus blitum L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus cruentus L.	Amaranthaceae	North America	t	subspontaneous	N	R
Amaranthus deflexus L.	Amaranthaceae	South America	u	unknown	N	R
Amaranthus graecizans L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus hypochondriacus L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus retroflexus L.	Amaranthaceae	Unknown	t	unknown	N	R
Ambrosia artemisiifolia L.	Asteraceae	North America	t	adventive	N	R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Amorpha fructicosa L.	Fabaceae	North America	n	subspontaneous	N	H
Arabis rosea DC.	Brassicaceae	Europa	h	naturalized	N	P
Arabis caucasica (Willdenow)	Brassicaceae	Eurasia	c	naturalized	N	M
Aremonia agrimonioides (L.)	Rosaceae	Europa	h	naturalized	N	P
Armoracia rusticana P.Gaertn., B. Mey. & Scherb.	Brassicaceae	Eurasia	g	subspontaneous		C
Artemisia annua L.	Asteraceae	Eurasia	t	adventive		R
Artemisia biennis Willdenow	Asteraceae	Eurasia	u	adventive		R
Artemisia verlotiorum Lamotte	Asteraceae	Asia	g	unknown	N	R
Arum italicum Miller	Araceae	Mediterranean	g	naturalized		R
Asarina procumbens Mill.	Scrophulariaceae	Mediterranean	c	naturalized	N	P
Asclepias syriaca L.	Asclepiadaceae	North America	g	subspontaneous	N	CR
Aster novae-angliae L.	Asteraceae	North America	g	subspontaneous	N	H
Aster novi-belgii L.	Asteraceae	North America	c	subspontaneous	N	H
Aster tradescantii L.	Asteraceae	North America	g	subspontaneous		C
Aubrieta deltoidea (L.)	Brassicaceae	Mediterranean	c	naturalized	N	S
Avena barbata Pott	Poaceae	Mediterranean	t	adventive		R
Avena sativa L.	Poaceae	Eurasia	t	subspontaneous		C
Bidens bipinnata L.	Asteraceae	North America	t	naturalized	N	R
Bidens connata Willdenow	Asteraceae	North America	t	naturalized	N	H
Bidens frondosa L.	Asteraceae	North America	t	naturalized	N	R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Bidens subalternans DC.	Asteraceae	South America	t	adventive		R
Brassica juncea (L.)	Brassicaceae	Asia	t	adventive		R
Brassica nigra (L.)	Brassicaceae	Unknown	t	naturalized		R
Brassica rapa L.	Brassicaceae	Europa	u	subspontaneous		C
Bromus diandrus Roth	Poaceae	Europa	t	adventive		R
Bromus inermis Leysser	Poaceae	Eurasia	h	unknown	N	R
Bromus madritensis L.	Poaceae	Mediterranean	t	adventive		R
Bromus rigidus Roth	Poaceae	Mediterranean	t	adventive		R
Buddleja davidii Franchet	Buddlejaceae	Asia	n	naturalized	N	P
Bunias orientalis L.	Brassicaceae	Eurasia	h	unknown	N	R
Calla palustris L.	Araceae	Unknown	g	naturalized	N	E
Cannabis sativa L.	Cannabaceae	Asia	t	subspontaneous		C
Carex vulpinoidea Michaux	Cyperaceae	North America	h	naturalized	N	H
Centaurea diffusa Lamarck	Asteraceae	Mediterranean	t	adventive		R
Centranthus ruber (L.)	Valerianaceae	Mediterranean	h	naturalized	N	P
Cerastium dubium (Bastard)	Caryophyllaceae	Mediterranean	t	adventive		H
Cerastium ligusticum Viviani	Caryophyllaceae	Mediterranean	t	adventive		R
Cerastium tomentosum L.	Caryophyllaceae	Europa	c	subspontaneous		C
Cerinthe major L.	Boraginaceae	Eurasia	t	adventive		R
Cerinthe minor L.	Boraginaceae	Eurasia	u	adventive		R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Chenopodium ambrosioides L.	Chenopodiaceae	South America	t	adventive		R
Chenopodium pratericola Rydberg	Chenopodiaceae	North America	t	adventive		R
Chrysanthemum segetum L.	Asteraceae	Mediterranean	t	unknown	N	R
Commelina communis L.	Commelinaceae	Asia	c	naturalized	N	R
Consolida ajacis (L.)	Ranunculaceae	Eurasia	t	subspontaneous		C
Conyza canadensis (L.)	Asteraceae	North America	u	unknown	N	P
Cornus sericea L.	Cornaceae	North America	n	naturalized	N	F
Coronopus didymus (L.)	Brassicaceae	South America	u	adventive	N	R
Crepis nemauensis Gouan	Asteraceae	Mediterranean	t	naturalized	N	R
Crepis nicaeensis Persoon	Asteraceae	Mediterranean	u	adventive		R
Crepis pulchra L.	Asteraceae	Mediterranean	t	unknown	N	R
Cuscuta campestris Yuncker	Cuscutaceae	North America	t	adventive	N	R
Cuscuta cesatiana Bertoloni	Cuscutaceae	Eurasia	t	unknown	N	R
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	Scrophulariaceae	Europa	c	unknown	N	P
Cynodon dactylon (L.)	Poaceae	Mediterranean	g	naturalized	N	R
Cyperus eragrostis Lamarck	Cyperaceae	South America	h	unknown		H
Cyperus esculentus L.	Cyperaceae	Unknown	g	unknown	N	H
Cyperus rotundus L.	Cyperaceae	Eurasia	g	naturalized		H
Datura stramonium L.	Solanaceae	Central America	t	unknown	N	R
Dianthus barbatus L.	Caryophyllaceae	Europa	h	subspontaneous		C

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Diplotaxis erucoides (Torner)	Brassicaceae	Mediterranean	u	adventive		R
Dipsacus laciniatus L.	Dipsacaceae	Mediterranean	u	unknown	N	R
Duchesnea indica (Andrews)	Rosaceae	Asia	h	naturalized	N	F
Eleusine indica (L.)	Poaceae	Unknown	t	naturalized	N	R
Elodea canadensis Michaux	Hydrocharitaceae	North America	a	unknown	N	E
Elodea densa (Planchon)	Hydrocharitaceae	South America	a	naturalized	N	E
Elodea nuttallii (Planchon)	Hydrocharitaceae	North America	a	naturalized	N	E
Epilobium ciliatum Rafinesque	Onagraceae	North America	h	unknown	N	R
Epimedium alpinum L.	Berberidaceae	Europa	g	naturalized	N	F
Eragrostis cilianensis (Allioni)	Poaceae	Mediterranean	t	unknown	N	R
Eragrostis multicaulis Steudel	Poaceae	Asia	t	adventive		R
Eranthis hyemalis (L.)	Ranunculaceae	Europa	g	subspontaneous	N	F
Erica tetralix L.	Ericaceae	Europa	z	naturalized	N	H
Erigeron annuus (L.)	Asteraceae	North America	u	naturalized	N	R
Erigeron karvinskianus DC.	Asteraceae	Central America	h	unknown	N	P
Erodium ciconium (L.)	Geraniaceae	Mediterranean	t	adventive		R
Erodium moschatum (L.)	Geraniaceae	Mediterranean	u	unknown	N	R
Erysimum cheiri (L.)	Brassicaceae	Mediterranean	c	naturalized		C
Erysimum hieraciifolium L.	Brassicaceae	Eurasia	u	unknown	N	R
Erysimum repandum L.	Brassicaceae	Europa	t	adventive		R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Euclidium syriacum (L.)	Brassicaceae	Eurasia	t	adventive		R
Euphorbia chamaesyce L.	Euphorbiaceae	Eurasia	t	adventive		R
Euphorbia humifusa Willdenow	Euphorbiaceae	Asia	t	unknown	N	R
Euphorbia lathyris L.	Euphorbiaceae	Eurasia	u	subspontaneous	N	R
Euphorbia maculata L.	Euphorbiaceae	North America	t	unknown	N	R
Euphorbia nutans Lagasca	Euphorbiaceae	North America	t	unknown	N	R
Euphorbia prostrata Aiton	Euphorbiaceae	North America	t	adventive		R
Euphorbia virgata Waldstein et Kitaibel	Euphorbiaceae	Eurasia	h	unknown	N	R
Fagopyrum esculentum Moench	Polygonaceae	Asia	t	subspontaneous		RC
Fagopyrum tataricum (L.)	Polygonaceae	Asia	t	unknown		R
Ficus carica L.	Moraceae	Mediterranean	p	subspontaneous		C
Foeniculum vulgare Miller	Apiaceae	Mediterranean	u	naturalized	N	R
Galega officinalis L.	Fabaceae	Mediterranean	h	subspontaneous	N	G
Galinsoga ciliata (Rafinesque)	Asteraceae	South America	t	unknown	N	R
Galinsoga parviflora Cavanilles	Asteraceae	South America	t	unknown	N	R
Galium saxatile L.	Rubiaceae	Europa	c	unknown	N	H
Galium verrucosum Hudson	Rubiaceae	Mediterranean	t	adventive		S
Geranium sibiricum L.	Geraniaceae	Asia	u	unknown	N	F
Glaucium corniculatum (L.)	Papaveraceae	Mediterranean	t	adventive		P
Glaucium flavum Crantz	Papaveraceae	Europa	u	adventive		P

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Glyceria striata (Lamarck)	Poaceae	North America	g	unknown	N	H
Gypsophila paniculata L.	Caryophyllaceae	Eurasia	c	naturalized	N	P
Helianthus annuus L.	Asteraceae	North America	t	subspontaneous		C
Helianthus rigidus (Cassini)	Asteraceae	North America	g	subspontaneous		C
Helianthus tuberosus L.	Asteraceae	North America	g	subspontaneous	N	R
Hemerocallis fulva (L.)	Liliaceae	Asia	g	naturalized	N	R
Heracleum mantegazzianum Sommier & Levier	Apiaceae	Caucasus	h	naturalized	N	R
Hibiscus trionum L.	Malvaceae	Asia	t	subspontaneous		C
Hordeum distichon L.	Poaceae	Western Asia	t	subspontaneous		C
Hordeum vulgare L.	Poaceae	Africa	u	subspontaneous		C
Hypericum calycinum L.	Hypericaceae	Eurasia	z	subspontaneous		C
Iberis umbellata L.	Brassicaceae	Mediterranean	u	subspontaneous		PC
Impatiens balfourii Hooker F.	Balsaminaceae	Asia	t	unknown	N	R
Impatiens glandulifera Royle	Balsaminaceae	Asia	t	naturalized	N	R
Impatiens parviflora DC.	Balsaminaceae	Asia	t	naturalized	N	F
Inula helenium L.	Asteraceae	Europa	h	subspontaneous		C
Iris foetidissima L.	Iridaceae	Europa	g	subspontaneous	N	S
Iris germanica L.	Iridaceae	Mediterranean	g	naturalized		C
Iris lutescens Lamarck	Iridaceae	Eurasia	g	subspontaneous	N	S
Iris sambucina L.	Iridaceae	Unknown	g	unknown	N	S

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Iris squalens L.	Iridaceae	Unknown	g	subspontaneous	N	S
Juncus tenuis Willdenow	Juncaceae	North America	h	unknown	N	R
Lagarosiphon major (Ridley)	Hydrocharitaceae	South Africa	a	naturalized	N	E
Laurus nobilis L.	Lauraceae	Mediterranean	i	naturalized	N	F
Legousia hybrida (L.)	Campanulaceae	Mediterranean	t	adventive		R
Lemna minuta Humboldt et al.	Lemnaceae	North America	a	naturalized	N	E
Lepidium densiflorum Schrader	Brassicaceae	North America	u	unknown	N	R
Lepidium neglectum Thellung	Brassicaceae	North America	u	unknown	N	R
Lepidium sativum L.	Brassicaceae	Western Asia	t	subspontaneous		RC
Lepidium virginicum L.	Brassicaceae	North America	u	unknown	N	R
Lepidium latifolium L.	Brassicaceae	Europa	h	subspontaneous		RC
Leucanthemum gaudinii Della Torre	Asteraceae	Unknown	h	unknown	N	R
Ligustrum lucidum Aiton	Oleaceae	Asia	i	subspontaneous		C
Linaria arvensis (L.)	Scrophulariaceae	Europa	t	adventive		R
Linaria repens (L.)	Scrophulariaceae	Europa	h	naturalized	N	R
Linaria simplex (Willdenow)	Scrophulariaceae	Europa	t	adventive		R
Linaria dalmatica (L.)	Scrophulariaceae	Europa	h	naturalized	N	R
Linum bienne Miller	Linaceae	Europa	u	adventive		S
Linum narbonense L.	Linaceae	Mediterranean	h	naturalized	N	S
Lonicera japonica Thunberg	Caprifoliaceae	Asia	i	naturalized	N	F

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Lonicera henryi Hemsley	Caprifoliaceae	Asia	i	subspontaneous	N	F
Ludwigia grandiflora (Michaux)	Onagraceae	South America	a	naturalized	N	E
Lunaria annua L.	Brassicaceae	Europa	u	naturalized	N	R
Lupinus polyphyllus Lindley	Fabaceae	North America	h	subspontaneous	N	F
Mahonia aquifolium (Pursh)	Berberidaceae	North America	j	subspontaneous	N	FR
Malus domestica Borkhausen	Rosaceae	Western Asia	p	subspontaneous		C
Matricaria discoidea DC.	Asteraceae	Asia	t	unknown	N	R
Meconopsis cambrica (L.)	Papaveraceae	Europa	h	unknown	N	R
Medicago polymorpha L.	Fabaceae	Mediterranean	u	unknown	N	R
Medicago sativa L.	Fabaceae	Mediterranean	h	subspontaneous		C
Melilotus indicus (L.)	Fabaceae	Eurasia	t	unknown	N	R
Melilotus sulcatus Desfontaines	Fabaceae	Mediterranean	t	unknown	N	R
Mespilus germanica L.	Rosaceae	Eurasia	p	naturalized		C
Mimulus guttatus DC.	Scrophulariaceae	North America	g	naturalized	N	H
Muhlenbergia schreberi Gmelin	Poaceae	North America	h	unknown	N	R
Narcissus incomparabilis Miller	Amaryllidaceae	Europa	g	subspontaneous		C
Narcissus medioluteus Miller	Amaryllidaceae	Unknown	g	naturalized	N	R
Nigella damascena L.	Ranunculaceae	Mediterranean	t	subspontaneous		C
Nonea erecta Bernhardi	Boraginaceae	Asia	h	unknown	N	R
Nonea lutea (Desrousseaux)	Boraginaceae	Eurasia	u	unknown	N	R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Nymphoides peltata (Gmelin)	Menyanthaceae	Eurasia	a	naturalized	N	E
Oenothera biennis L.	Onagraceae	North America	u	unknown	N	R
Oenothera glazioviana Micheli	Onagraceae	Unknown	u	unknown	N	R
Oenothera parviflora L.	Onagraceae	North America	u	unknown	N	R
Oplismenus undulatifolius (Arduino)	Poaceae	Eurasia	c	naturalized		F
Opuntia humifusa (Rafinesque)	Cactaceae	North America	c	unknown	N	S
Opuntia imbricata (Haworth)	Cactaceae	North America	c	unknown	N	S
Ornithogalum nutans L.	Liliaceae	Eurasia	g	unknown	N	R
Oxalis fontana Bunge	Oxalidaceae	Unknown	u	unknown	N	R
Panicum capillare L.	Poaceae	North America	t	naturalized	N	R
Panicum dichotomiflorum Michaux	Poaceae	North America	t	naturalized	N	R
Papaver apulum Tenore	Papaveraceae	Mediterranean	u	adventive		R
Papaver croceum Ledebour	Papaveraceae	Asia	h	naturalized	N	M
Papaver somniferum L.	Papaveraceae	Unknown	t	subspontaneous	N	R
Parthenocissus quinquefolia (L.)	Vitaceae	North America	p	naturalized	N	F
Parthenocissus tricuspidata (Siebold et Zuccarini)	Vitaceae	Western Asia	p	subspontaneous	N	C
Paspalum dilatatum Poiret	Poaceae	South America	g	adventive		H
Paulownia tomentosa (Thunberg)	Bignoniaceae	Asia	p	subspontaneous	N	F
Phacelia tanacetifolia Bentham	Hydrophyllaceae	North America	t	subspontaneous	N	R
Phalaris canariensis L.	Poaceae	Mediterranean	t	adventive		R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Philadelphus coronarius L.	Philadelphaceae	Europa	n	naturalized	N	F
Physalis alkekengi L.	Solanaceae	Eurasia	g	naturalized	N	R
Physocarpus opulifolius (L.)	Rosaceae	North America	n	naturalized	N	F
Phyteuma nigrum F.W. Schmidt	Campanulaceae	Europa	h	adventive		F
Phytolacca americana L.	Phytolaccaceae	North America	h	naturalized	N	R
Phytolacca esculenta Van Houtte	Phytolaccaceae	Western Asia	h	naturalized	N	R
Pimpinella peregrina L.	Apiaceae	Mediterranean	t	adventive		R
Pisum sativum L.	Fabaceae	Eurasia	t	naturalized	N	R
Plantago arenaria Waldstein et Kitaibel	Plantaginaceae	Eurasia	t	unknown	N	R
Polygonum orientale L.	Polygonaceae	Asia	t	subspontaneous		R
Polygonum polystachyum Meissner	Polygonaceae	Asia	g	naturalized	N	R
Polypogon monspeliensis (L.)	Poaceae	Eurasia	t	adventive		R
Pontederia cordata L.	Pontederiaceae	North America	g	adventive		E
Potentilla intermedia L.	Rosaceae	Europa	h	adventive		R
Potentilla recta L.	Rosaceae	Eurasia	h	unknown	N	R
Prunus cerasus L.	Rosaceae	Western Asia	p	naturalized	N	F
Prunus dulcis (Miller)	Rosaceae	Western Asia	p	naturalized	N	F
Prunus laurocerasus L.	Rosaceae	Eurasia	i	naturalized	N	F
Prunus serotina Ehrhart	Rosaceae	North America	p	naturalized	N	F
Pseudotsuga menziesii (Mirbel)	Pinaceae	North America	i	naturalized	N	F

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Pueraria hirsuta (Thunberg)	Fabaceae	Western Asia	p	subspontaneous	N	FR
Punica granatum L.	Punicaceae	Western Asia	n	subspontaneous		C
Pyrus pyraster (L.)	Rosaceae	Eurasia	p	subspontaneous		FC
Quercus rubra L.	Fagaceae	North America	p	naturalized	N	F
Ranunculus muricatus L.	Ranunculaceae	Mediterranean	t	adventive		H
Raphanus sativus L.	Brassicaceae	Mediterranean	u	subspontaneous		C
Rapistrum perenne (L.)	Brassicaceae	Europa	h	adventive		R
Reynoutria japonica Houttuyn	Polygonaceae	Asia	g	naturalized	N	R
Reynoutria sachalinensis (F. Schmidt)	Polygonaceae	Asia	g	subspontaneous	N	R
Rhus typhina L.	Anacardiaceae	North America	p	naturalized	N	P
Robinia pseudoacacia L.	Fabaceae	North America	p	naturalized	N	F
Rorippa austriaca (Crantz)	Brassicaceae	Europa	h	adventive		H
Rosa rugosa Thunberg	Rosaceae	Western Asia	n	subspontaneous	N	R
Rostraria cristata (L.)	Poaceae	Mediterranean	h	adventive		R
Rubia tinctorum L.	Rubiaceae	Eurasia	h	naturalized	N	R
Rubus armeniacus Focke	Rosaceae	Caucasus	n	naturalized	N	F
Rudbeckia hirta L.	Asteraceae	North America	u	subspontaneous		C
Rudbeckia laciniata L.	Asteraceae	North America	g	subspontaneous	N	R
Rumex longifolius DC.	Polygonaceae	Eurasia	h	unknown	N	P
Rumex palustris J.E. Smith	Polygonaceae	Eurasia	u	adventive		R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Rumex thyrsiflorus Fingerhuth	Polygonaceae	Eurasia	h	unknown	N	R
Rumex confertus Willdenow	Polygonaceae	Asia	h	naturalized	N	P
Salvia sylvestris L.	Lamiaceae	Eurasia	h	naturalized	N	R
Salvia verbenaca L.	Lamiaceae	Mediterranean	h	adventive		S
Salvia verticillata L.	Lamiaceae	Mediterranean	h	unknown	N	R
Sarracenia purpurea L.	Sarraceniaceae	North America	h	naturalized		H
Saxifraga hirsuta L.	Saxifragaceae	Europa	h	subspontaneous		C
Saxifraga stolonifera Meerburgh	Saxifragaceae	Western Asia	h	naturalized	N	P
Saxifraga umbrosa L.	Saxifragaceae	Europa	c	subspontaneous		C
Scabiosa ochroleuca L.	Dipsacaceae	Europa	h	naturalized	N	S
Scilla non-scripta (L.)	Liliaceae	Europa	g	naturalized	N	F
Scrophularia vernalis L.	Scrophulariaceae	Mediterranean	u	adventive	N	R
Sedum sarmentosum Bunge	Crassulaceae	Asia	c	naturalized		C
Sedum sediforme (Jacquin)	Crassulaceae	Mediterranean	c	adventive		P
Sedum spurium M. Bieberstein	Crassulaceae	Western Asia	c	subspontaneous	N	R
Sedum hispanicum L.	Crassulaceae	Europa	u	unknown		P
Senecio inaequidens DC.	Asteraceae	South Africa	u	naturalized	N	R
Senecio rupestris Waldstein et Kitaibel	Asteraceae	Europa	u	unknown	N	R
Setaria italica (L.)	Poaceae	Unknown	t	subspontaneous		RC
Silene conica L.	Caryophyllaceae	Mediterranean	t	adventive		R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Silene dichotoma Ehrhart	Caryophyllaceae	Europa	u	adventive		R
Sinapis alba L.	Brassicaceae	Mediterranean	t	subspontaneous		RC
Sisymbrium altissimum L.	Brassicaceae	Eurasia	u	unknown	N	R
Sisymbrium irio L.	Brassicaceae	Mediterranean	u	unknown	N	R
Sisymbrium loeselii L.	Brassicaceae	Eurasia	u	unknown	N	R
Sisyrinchium montanum Greene	Iridaceae	North America	h	unknown	N	H
Solanum sublobatum Roemer et Schultes	Solanaceae	South America	t	naturalized	N	R
Solidago canadensis L.	Asteraceae	North America	g	naturalized	N	R
Solidago gigantea Aiton	Asteraceae	North America	g	naturalized	N	H
Solidago graminifolia (L.)	Asteraceae	North America	g	naturalized	N	R
Sorghum halepense (L.)	Poaceae	Unknown	h	unknown	N	R
Sorghum vulgare Persoon	Poaceae	Western Asia	t	adventive		C
Spiraea salicifolia L.	Rosaceae	Eurasia	n	subspontaneous	N	R
Spiraea ulmifolia Scopoli	Rosaceae	Eurasia	n	subspontaneous	N	R
Staphylea pinnata L.	Staphyleaceae	Eurasia	n	subspontaneous		FC
Stratiotes aloides L.	Hydrocharitaceae	Eurasia	a	naturalized	N	H
Symphoricarpos albus (L.)	Caprifoliaceae	North America	n	naturalized	N	F
Symphytum asperum Lepechin	Boraginaceae	Caucasus	h	naturalized	N	R
Tanacetum cinerariifolium (Treviranus)	Asteraceae	Europa	h	naturalized	N	P
Thlaspi alliaceum L.	Brassicaceae	Europa	u	naturalized	N	R

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Tolpis barbata (L.)	Asteraceae	Mediterranean	t	adventive		R
Tordylium maximum L.	Apiaceae	Mediterranean	u	adventive		R
Torilis leptophylla (L.)	Apiaceae	Mediterranean	t	adventive		R
Torilis nodosa (L.)	Apiaceae	Europa	t	unknown	N	R
Trachycarpus fortunei (Hooker)	Palmae	Asia	i	subspontaneous	N	F
Tragopogon crocifolius L.	Asteraceae	Mediterranean	u	adventive		S
Tribulus terrestris L.	Zygophyllaceae	Mediterranean	t	adventive		R
Trifolium alexandrinum L.	Fabaceae	Mediterranean	t	subspontaneous	N	R
Trifolium hybridum L.	Fabaceae	Europa	u	naturalized	N	R
Trifolium incarnatum L.	Fabaceae	Europa	u	subspontaneous	N	G
Trifolium resupinatum L.	Fabaceae	Mediterranean	u	naturalized	N	R
Trifolium suaveolens Willdenow	Fabaceae	Mediterranean	t	naturalized	N	R
Tulipa didieri Jordan	Liliaceae	Western Asia	g	unknown	N	R
Tulipa grengiolensis Thommen	Liliaceae	Unknown	g	unknown	N	R
Typha laxmannii Lepechin	Typhaceae	Eurasia	g	adventive		H
Ulex europaeus L.	Fabaceae	Europa	n	naturalized	N	F
Ulmus laevis Pallas	Ulmaceae	Europa	p	subspontaneous		C
Vaccinium macrocarpon Aiton	Ericaceae	North America	z	naturalized	N	H
Valerianella eriocarpa Desvaux	Valerianaceae	Mediterranean	t	adventive		R
Vallisneria spiralis L.	Hydrocharitaceae	Unknown	a	naturalized	N	E

Table 10.6: Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Veronica filiformis Smith	Scrophulariaceae	Eurasia	h	unknown	N	G
Veronica peregrina L.	Scrophulariaceae	North America	t	unknown	N	R
Veronica persica Poiret	Scrophulariaceae	Western Asia	u	unknown	N	R
Vicia hybrida L.	Fabaceae	Europa	u	unknown	N	R
Vicia lutea L.	Fabaceae	Mediterranean	u	adventive	N	R
Vicia pannonica Crantz	Fabaceae	Europa	u	adventive	N	R
Vicia peregrina L.	Fabaceae	Mediterranean	t	adventive		R
Vicia sativa L.	Fabaceae	Mediterranean	u	subspontaneous	N	R
Vinca major L.	Apocynaceae	Eurasia	z	naturalized	N	M
Viola obliqua Hill	Violaceae	North America	g	naturalized	N	F
Vitis vinifera L.	Vitaceae	Europa	p	subspontaneous		C
Vulpia ciliata Dumortier	Poaceae	Mediterranean	t	adventive		R
Xanthium italicum Moretti	Asteraceae	North America	t	subspontaneous	N	G
Xanthium spinosum L.	Asteraceae	South America	t	unknown	N	R
Xeranthemum annuum L.	Asteraceae	Mediterranean	t	adventive		R

* Excluding cultivated plants which have not escaped in the environment

Life form: p, deciduous tree; i, evergreen tree; n, deciduous shrub; j, evergreen shrub; z, woody chamaephytic plant (small shrub); c, herbaceous chamaephytic plant; hhemicryptophytic plant (perennial herb); g, geophytic plant (perennial herb with tubers, bulbs or rhizomes); t, annual plant; u, biennal plant; a, aquatic plant.

Ecological group: R, ruderal plant; P, pioneer plant; F, forest plant; M, mountain plant; E, aquatic plant; H, marsh plant; S, dry meadow plant; G, meadow plant; C, cultivated plant; N, neophyte (according to Lauber and Wagner, 1998).

Table 10.7: Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Aceraceae	Dicot	4	1	0	5	20.0	0.0	0.0
Agavaceae	Monoc	0	1	1	1	100.0	100.0	100.0
Aizoaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Alismataceae	Monoc	5	1	1	6	16.7	16.7	100.0
Amarantaceae	Dicot	0	9	0	9	100.0	0.0	0.0
Amaryllidaceae	Monoc	7	2	1	9	22.2	11.1	50.0
Anacardiaceae	Dicot	1	1	1	2	50.0	50.0	100.0
Apiaceae	Dicot	85	7	2	92	7.6	2.2	28.6
Apocynaceae	Dicot	1	1	1	2	50.0	50.0	100.0
Araceae	Monoc	3	3	2	6	50.0	33.3	66.7
Asclepiadaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Asteraceae	Dicot	298	42	10	340	12.4	2.9	23.8
Balsaminaceae	Dicot	1	3	2	4	75.0	50.0	66.7
Berberidaceae	Dicot	1	2	1	3	66.7	33.3	50.0
Bignoniaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Boraginaceae	Dicot	35	6	1	41	14.6	2.4	16.7
Brassicaceae	Dicot	129	35	7	164	21.3	4.3	20.0
Buddlejaceae	Dicot	0	1	1	1	100.0	100.0	100.0

Table 10.7: Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Cactaceae	Dicot	0	2	0	2	100.0	0.0	0.0
Campanulaceae	Dicot	34	2	0	36	5.6	0.0	0.0
Cannabaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Caprifoliaceae	Dicot	12	6	2	18	33.3	11.1	33.3
Caryophyllaceae	Dicot	117	6	1	123	4.9	0.8	16.7
Chenopodiaceae	Dicot	21	6	1	27	22.2	3.7	16.7
Commelinaceae	Monoc	0	1	1	1	100.0	100.0	100.0
Cornaceae	Dicot	2	1	1	3	33.3	33.3	100.0
Crassulaceae	Dicot	26	3	1	29	10.3	3.4	33.3
Cupressaceae	Gymnosperm	2	2	0	4	50.0	0.0	0.0
Cuscutaceae	Dicot	2	2	0	4	50.0	0.0	0.0
Cyperaceae	Monoc	131	4	2	135	3.0	1.5	50.0
Dipsacaceae	Dicot	15	2	1	17	11.8	5.9	50.0
Droseraceae	Dicot	4	1	0	5	20.0	0.0	0.0
Elaeagnaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Ericaceae	Dicot	15	2	2	17	11.8	11.8	100.0
Euphorbiaceae	Dicot	17	8	1	25	32.0	4.0	12.5
Fabaceae	Dicot	135	25	6	160	15.6	3.8	24.0

Table 10.7: Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Fagaceae	Dicot	7	1	1	8	12.5	12.5	100.0
Fumariaceae	Dicot	8	1	0	9	11.1	0.0	0.0
Geraniaceae	Dicot	20	4	0	24	16.7	0.0	0.0
Hydrocharitaceae	Monoc	1	6	5	7	85.7	71.4	83.3
Hydrophyllaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Hypericaceae	Dicot	12	1	0	13	7.7	0.0	0.0
Iridaceae	Monoc	8	6	1	14	42.9	7.1	16.7
Juncaceae	Monoc	35	1	0	36	2.8	0.0	0.0
Lamiaceae	Dicot	82	4	2	86	4.7	2.3	50.0
Lauraceae	Dicot	0	1	1	1	100.0	100.0	100.0
Lemnaceae	Monoc	4	1	1	5	20.0	20.0	100.0
Liliaceae	Monoc	54	9	2	63	14.3	3.2	22.2
Linaceae	Dicot	4	2	1	6	33.3	16.7	50.0
Malvaceae	Dicot	4	4	0	8	50.0	0.0	0.0
Mimosaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Moraceae	Dicot	1	1	0	2	50.0	0.0	0.0
Oleaceae	Dicot	3	2	0	5	40.0	0.0	0.0
Onagraceae	Dicot	21	5	1	26	19.2	3.8	20.0

Table 10.7: Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Oxalidaceae	Dicot	2	1	0	3	33.3	0.0	0.0
Palmae	Monoc	0	1	0	1	100.0	0.0	0.0
Papaveraceae	Dicot	10	5	1	15	33.3	6.7	20.0
Philadelphaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Phytolaccaceae	Dicot	0	2	2	2	100.0	100.0	100.0
Pinaceae	Gymnosperm	7	2	2	9	22.2	22.2	100.0
Plantaginaceae	Dicot	8	2	0	10	20.0	0.0	0.0
Poaceae	Monoc	189	31	5	220	14.1	2.3	16.1
Polygonaceae	Dicot	29	10	3	39	25.6	7.7	30.0
Pontederiaceae	Monoc	0	1	0	1	100.0	0.0	0.0
Punicaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Ranunculaceae	Dicot	93	5	0	98	5.1	0.0	0.0
Rosaceae	Dicot	126	20	9	146	13.7	6.2	45.0
Rubiaceae	Dicot	34	3	1	37	8.1	2.7	33.3
Salicaceae	Dicot	33	1	0	34	2.9	0.0	0.0
Sarraceniaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Saxifragaceae	Dicot	30	4	1	34	11.8	2.9	25.0
Scrophulariaceae	Dicot	106	12	5	118	10.2	4.2	41.7

Table 10.7: Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Simourabaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Solanaceae	Dicot	5	5	2	10	50.0	20.0	40.0
Staphyleaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Ulmaceae	Dicot	3	1	0	4	25.0	0.0	0.0
Valerianaceae	Dicot	18	2	1	20	10.0	5.0	50.0
Violaceae	Dicot	25	1	1	26	3.8	3.8	100.0
Vitaceae	Dicot	0	3	1	3	100.0	33.3	33.3
Zygopphyllaceae	Dicot	0	1	0	1	100.0	0.0	0.0

*Excluding cultivated plants which have not escaped into the environment

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Abutilon theophrasti Medik.	R	t	adventive		(econ.)	x	xx	xx				x
yes	*Acer negundo* L.	F	p	subspont.		xxx; (econ.)	xxx	x			xxx		
	Aesculus hippocastanum L.	C	p	subspont.						xxx			
	Agave americana L.	R	j	naturalized			+ M	xxx	xx				
yes	*Ailanthus altissima* (Miller)	P	p	naturalized	xxx	xxx	xxx	xxx	xxx		xxx	xxx	
	Allium paradoxum (M. v. Bieberstein)	C	g	subspont.						xx			
	Amaranthus albus L.	R	t	unknown				x	xxx				
	Amaranthus blitum L.	R	t	unknown				x	x				
	Amaranthus cruentus L.	R	t	subspont.								xxx	
	Amaranthus deflexus L.	R	u	unknown			x		xxx			xxx	xxx
	Amaranthus retroflexus L.	R	t	unknown		econ.	x		xxx			xxx	xxx
yes	*Ambrosia artemisiifolia* L.	R	t	adventive	xxx	xx; econ.	xxx	x	x		xxx	xxx	
yes	*Amorpha fruticosa* L.	H	n	subspont.	x	xx	++ M				xxx	xxx	
	Artemisia annua L.	R	t	adventive			x						
yes	*Artemisia verlotiorum* Lamotte	R	g	unknown	xxx		xxx	x	x			xxx	
	Arundo donax L.	H	g	subspont.				xxx	xx				
yes	*Asclepias syriaca* L.	C R	g	subspont.		xx	+ M				xxx		

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
yes	*Aster lanceolatus* Willdenow	C	g	subspont.		xxx	++ M		xx		xxx *Aster* spp.		
	Aster novae-angliae L.	H	g	subspont.									
yes	*Aster novi-belgii* L.	H	c	subspont.		xxx	xxx						
	Aubrieta deltoidea (L.)	S	c	naturalized									
	Avena sativa L.	C	t	subspont.						x			
	Bidens bipinnata L.	R	t	naturalized								xxx	
	Bidens connata Willdenow	H	t	naturalized			+++ A						
yes	*Bidens frondosa* L.	R	t	naturalized		xxx	xxx	xx	xxx			xxx	
	Bidens subalternans DC.	R	t	adventive				xx					
	Brassica napus L.	C	u	subspont.					x	xx			
yes	*Buddleja davidii* Franchet	P	n	naturalized	xxx	xx	xxx	xxx		xx			
yes	*Bunias orientalis* L.	R	h	unknown	x		++ C						xxx
	Cerastium tomentosum L.	C	c	subspont.						xx			
	Chenopodium ambrosioides L.	R	t	adventive			+++ M		x			xxx	
	Chrysanthemum Segetum L.	R	t	unknown					xx				
	Cicerbita macrophylla (Willdenow)	C	g	subspont.						xx			
yes	*Conyza canadensis* (L.)	P	u	unknown			+++ C	xxx	xxx		xxx	xxx	xxx
yes	*Cornus sericea* L.	F	n	naturalized	x								
	Coronopus didymus (L.)	R	u	adventive			x		xxx				

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Cotoneaster horizontalis Decne	C	j	subspont.						xx			
	Crepis nemauensis Gouan	R	t	naturalized									
	Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	P	c	unknown						xx			
yes	*Cyperus eragrostis* Lamarck	H	h	unknown			xxx	xxx	xx				
yes	*Cyperus esculentus* L.	H	g	unknown	x								xxx
	Cyperus rotundus L.	H	g	naturalized									
	Datura stramonium L.	R	t	unknown			x	x	xxx			xxx	xxx
yes	*Duchesnea indica* (Andrews)	F	h	naturalized		xx							
	Eleusine indica (L.)	R	t	naturalized				xx	x			xxx	
yes	*Elodea canadensis* Michaux	E	a	unknown	x	xxx	+++ C	xxx	xx	xx		xxx	
yes	*Elodea nuttallii* (Planchon)	E	a	naturalized	xxx	xx	++ C			xx			
yes	*Epilobium ciliatum* Rafinesque	R	h	unknown		xxx	xxx			x			
	Erigeron annuus (L.)	R	u	naturalized			xx				xxx	xxx	
	Erigeron karvinskianus DC.	P	h	unknown			+ A		xx				
	Euphorbia maculata L.	R	t	unknown			x		x				
	Euphorbia prostrata Aiton	R	t	adventive					x				
	Ficus carica L.	C	p	subspont.					x				
	Galega officinalis L.	G	h	subspont.			++ C						
yes	*Galinsoga ciliata* (Rafinesque)	R	t	unknown		econ.	x		x			xxx	xxx

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
yes	*Galinsoga parviflora* Cavanilles	R	t	unknown		econ.	x		xx			xxx	xxx
	Gleditsia triacanthos L.	C	p	subspont.				xx					
	Glyceria striata (Lamarck)	H	g	unknown		xx							
yes	*Helianthus tuberosus* L.	R	g	subspont.	x	xxx	xxx	xx			xxx	xxx	xxx
yes	*Heracleum mantegazzianum* Sommier & Levier	R	h	naturalized	xxx	xx; econ.	xxx			xxx	xxx		xxx
yes	*Impatiens balfourii* Hooker F.	R	t	unknown			+ C						
yes	*Impatiens glandulifera* Royle	R	t	naturalized	xxx	xxx	xxx			xx	xxx	xxx	xxx
yes	*Impatiens parviflora* DC.	F	t	naturalized			xxx				xxx		xxx
	Juncus tenuis Willdenow	R	h	unknown			++ C						
	Lagarosiphon major (Ridley)	E	a	naturalized			+++ A						
	Lemna minuta Humboldt et al.	E	a	naturalized			xxx						
	Lepidium virginicum L.	R	u	unknown			x		x				
	Ligustrum lucidum Aiton	C	i	subspont.			xx						
yes	*Lonicera henryi* Hemsley	F	i	subspont.	x		xx						
yes	*Lonicera japonica* Thunberg	F	i	naturalized	xxx								
yes	*Ludwigia grandiflora* (Michaux)	E	a	naturalized	xxx		xxx						
yes	*Lupinus polyphyllus* Lindley	F	h	subspont.	x	xx							
	Lycium barbarum L.	C	n	subspont.			++ A						
	Lysichiton americanus Hultén & H.	H	g	naturalized	xxx								

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	St. John												
	Lysimachia punctata L.	C H	h	subspont.						xx			
yes	*Mahonia aquifolium* (Pursh)	F R	j	subspont.	x	xx							
	Matricaria discoidea DC.	R	t	unknown			+ C			xx			xxx
	Meconopsis cambrica (L.)	R	h	unknown						xx			
	Medicago sativa L.	C	h	subspont.					x				
	Mimulus guttatus DC.	H	g	naturalized						xx			
	Morus alba L.	C	p	subspont.			++ C						
	Nicandra physalodes (L.)	C R	t	subspont.									xxx
yes	*Oenothera biennis* L.	R	u	unknown			xxx	x		x		xxx	
	Oenothera glazioviana Micheli	R	u	unknown				x		x			
	Opuntia imbricata (Haworth)	S	c	unknown				xxx					
	Oxalis fontana Bunge	R	u	unknown			x						
	Panicum capillare L.	R	t	naturalized			x		x				
	Panicum dichotomiflorum Michaux	R	t	naturalized			x						xxx
	Parthenocissus quinquefolia (L.)	F	p	naturalized									
	Parthenocissus tricuspidata (Siebold et Zuccarini)	C	p	subspont.			xx				xxx *Parthen.* spp.		
yes	*Paspalum dilatatum* Poiret	H	g	adventive			xxx	xxx	xxx				
	Paulownia tomentosa (Thunberg)	F	p	subspont.									

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]	
	Phalaris canariensis L.	R	t	adventive					x					
yes	*Phytolacca americana* L.	R	h	naturalized			x		xx		xxx	xxx		
	Phytolacca esculenta Van Houtte	R	h	naturalized										
	Polygonum orientale L.	R	t	subspont.					x					
yes	*Polygonum polystachyum* Meissner	R	g	naturalized	xxx									
yes	*Prunus laurocerasus* L.	F	i	naturalized	x		xx							
yes	*Prunus serotina* Ehrhart	F	p	naturalized	xxx	xx								xxx
	Pseudotsuga menziesii (Mirbel)	F	i	naturalized						xx				
yes	*Pueraria lobata* (Willdenow)	F R	p	subspont.	x									
yes	*Reynoutria japonica* Houttuyn	R	g	naturalized	xxx	xxx; econ.	xxx	xxx	x	xxx	xxx			xxx
yes	*Reynoutria sachalinensis* (F. Schmidt)	R	g	subspont.	xxx	xx; (econ.)	xxx			xx	xxx			xxx
yes	*Rhus typhina* L.	P	p	naturalized	xxx									
	Ribes rubrum L.	C	n	subspont.						x				
yes	*Robinia pseudoacacia* L.	F	p	naturalized	xxx	xxx; econ.	xxx	xxx	xx		xxx	xxx		
	Rorippa austriaca (Crantz)	H	h	adventive			+ C							
yes	*Rosa rugosa* Thunberg	R	n	subspont.						xxx				
	Rubia tinctorum L.	R	h	naturalized					x					

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]	
yes	*Rubus armeniacus* Focke	F	n	naturalized	xxx									
	Rudbeckia hirta L.	C	u	subspont.							xxx			
yes	*Rudbeckia laciniata* L.	C	g	subspont.		xxx					xxx			
	Rumex longifolius DC.	P	h	unknown										
	Rumex patientia L.	C R	h	subspont.			+ C							
	Rumex thyrsiflorus Fingerhuth	R	h	unknown			++ C							
	Rumex confertus Willdenow	P	h	naturalized										
	Sedum spurium M. Bieberstein	R	c	subspont.	x									
	Sedum hispanicum L.	P	u	unknown										
yes	*Senecio inaequidens* DC.	R	u	naturalized	xxx	x	xxx	xxx				xxx		
	Senecio rupestris Waldstein et Kitaibel	R	u	unknown	x									
	Solanum sublobatum Roemer et Schultes	R	t	naturalized			++ M							
yes	*Solidago canadensis* L.	R	g	naturalized	xxx	xxx	+++ C				xxx			xxx
yes	*Solidago gigantea* Aiton	H	g	naturalized	xxx	xxx; econ)	+++ C			x	xxx	xxx		xxx
	Sorghum halepense (L.)	R	h	unknown			x	xx	x					
	Symphoricarpos albus (L.)	F	n	naturalized						xxx				
	Symphytum asperum Lepechin	R	h	naturalized			+++ C			xx				

Table 10.8: Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Syringa vulgaris L.	C	n	subspont.		xx							
	Tanacetum parthenium (L.)	C	h	subspont.					xx				
	Tetragonia tetragonioides (Pallas)	C	t	subspont.			++ M		x				
	Trachycarpus fortunei (Hooker)	F	i	subspont.	x								
	Trifolium incarnatum L.	G	u	subspont.					x				
	Trifolium resupinatum L.	R	u	naturalized					x				
	Ulex europaeus L.	F	n	naturalized			++ A						
	Vaccinium macrocarpon Aiton	H	z	naturalized									
	Veronica filiformis Smith	G	h	unknown						xx			
	Veronica peregrina L.	R	t	unknown			+ C			x			
	Veronica persica Poiret	R	u	unknown			xx		xxx	xx			
	Xanthium spinosum L.	R	t	unknown			+ M	xx	xx				

xxx, invasive species (black list); xx, potentially or moderately invasive species; species in expansion, locally invasive; x, species present; need to be followed up (watch list).

+++ - For France: invasive species in one sector only: M (Mediterranean area); A (Atlantic area); C (continental area); ++ - For France: potentially invasive in one sector only: M, A or C; + - For France: species present, which need to be followed up (Watch List), in one sector only: M, A or C.

[1] Switzerland: CPS-SKEW (http://www.cps-skew.ch/)

[2] Austria: Essl, F. and W. Rabitsch (eds) (2002) Neobiota in Österreich. Federal Environment Agency, 432 pp.

[3] France: Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels; 62, 176 pp.

[4] Germany: From a preliminary EPPO list of invasive alien plants for the EPPO region (plants from Germany include mostly species in the category xxx)

[5] Hungary: Invasive alien species in Hungary. National Ecological Network No. 6 (the list includes only invasive plant species in Hungarian protected areas)

[6] Italy: Laura Celesti, pers. comm. (2003). The species given for Italy are those most frequent in northern Italy

[7] Portugal: De Almeida, J.D. (1999) Flora exotica subespontanea de Portugal continental. Universidade de Coimbra, 151 pp.

[8] Spain: Dana, E.D., Sanz-Elorza, M. & E. Sobrino (2001) Plant invaders in Spain, http://www.ual.es/personal/edana/alienplants/checklist.pdf

[9] Scotland: Welch, D. et al., (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

Fact Sheets

Acer negundo

Taxonomic status

Scientific name	*Acer negundo* L.
Synonyms	*Negundo aceroides* (L.) Moench, *N. negundo* (L.) Karst.
Family	Aceraceae
English name	Inland boxelder, western boxelder, ashleaf maple
German name	Eschen-Ahorn
French name	Erable à feuille de frêne
Italian name	Acero americano

Description and identification

Life form	Deciduous tree.
Description	Deciduous tree growing up to 20 m tall with twigs usually drooping. Variable pale green leaves, 5-10 cm long, with 3-5 (7) elliptic to lance-shaped leaflets, glabrous, shallowly lobed or coarsely toothed. *A. negundo* is the only maple species with divided leaves. Dioecious. Pale green apetalous flowers pendulous in narrow clusters, opening before the leaves. Male flowers with 4-6 stamens, at first stalkless but later with long slender pubescent stalks. Female flowers with an ovary only. Flowers appear with or before the leaves. Fruits in long clusters up to 25 cm in length. Samaras wings diverging at an acute angle.
Similar species	Four congeneric native species in Switzerland: *A. pseudoplatanus* L., *A. platanoides* L., *A. campestre* L., *A. opalus* Miller.

Biology and ecology

Invaded habitats	Forests, riverbanks and stream edges, floodplains.
Ecology and spread	Young trees prefer moist sites, but become drought tolerant once well established. Reproduction is by seeds. Winged pods are dispersed by wind or water, or by birds and squirrels. Vegetative reproduction is also common by stump or root sprouting and allows recovery of established stands. The species is still planted, thus favouring its spread.

Origin Eastern North America.

Introduction and dispersal First introduced into Europe in 1688. Planted as a fast-growing tree in recreation areas and on riverbanks.

Current status

Distribution in CH	Present in the Jura and north-eastern Switzerland.
Distribution in Europe	Austria, Bulgaria, Czech Republic, France, Germany, Spain, Hungary, Russia. *A. negundo* is an invasive species in France and Austria. It is on a Watch List in Spain.

Impacts

Environmental	Dense clones create deep-shaded areas with little ground vegetation and thus have a negative impact on native vegetation.
Economic	Unknown

Management options Hand-pull seedlings. Cut and paint, stem injection, and basal bark treatment in younger plants. Cut trees will resprout without painting.

Information gaps Potential spread. Potential environmental and economic impacts.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Medrzycki, P. and P. Pabjanek (2001) Linking land use and invading species features: a case study of *Acer negundo* in Bialowieza village (NE Poland). In: Brundu, G. et al. (eds) Plant invasions. Species ecology and ecosystem management. Backhuys Publishers, Leiden, pp. 123-132.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Sachse, U. (1992) Invasion patterns of box elder on sites with different levels of disturbance. Verhandlungen der Gesellschaft für Ökologie 21, pp.103-111.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbgweb2.rbge.org.uk/FE/fe.html*

http://www.fs.fed.us/database/feis/plants/tree/aceneg/

Ailanthus altissima

Taxonomic status

Scientific name	*Ailanthus altissima* (Miller) Swingle
Synonyms	*A. glandulosa* Desfontaines, *Rhus cacodendron* Ehrh.
Family	Simaroubaceae
English name	Tree of heaven, varnishtree
German name	Götterbaum
French name	Ailante
Italian name	Ailanto

Description and identification

Life form	Deciduous tree.
Description	A rapid-growing tree that is 5-25 m in height, with pale-striped, smooth bark, often suckering extensively from underground roots. Leaves 30-100 cm long, alternate, pinnately compound with 10-40 leaflets. Leaflets lanceolate, 4-13 cm long and 2.5-5.0 cm wide, each with 2-4 coarse glandular teeth near the base. The numerous small, greenish-yellow and strong-smelling flowers are borne in panicles of 6-12 cm in length at the end of branches. Fruits usually in clusters of 1-4, winged, 4 cm long and 0.5-1 cm wide, light reddish brown or pinkish red, with the seed in the center. Flowering period: July-August.
Similar species	There is no other species in the genus or family in Switzerland. *A. altissima* can be confused with another alien species, *Rhus typhina* L. (see Fact Sheet).

Biology and ecology

Invaded habitats	Waste grounds, railway embankments, vacant lots, grassland, forest gaps, riparian habitats, flood plains, rock outcrops.
Ecology and dispersal	**Pioneer species estimated to range from subtropical dry to wet to temperate dry to wet forest life zones. It is a fast-growing, light-demanding pioneer tree forming extensive thickets due to root suckering and stump sprouting, thereby displacing native vegetation. It tolerates drought and airborne salt, and grows well on dry poor soils. It does not tolerate flooded soils. Older trees are resistant to freezing temperatures. The tree produces up to one million wind-dispersed seeds per year. Seedlings and ramets may persist in the forest waiting for a gap, and then rapidly grow into the canopy.**

Origin	Central China.
Introduction and mode of spread	Missionaries who brought it from Nanking, China to England introduced the tree of heaven in 1751 as an ornamental.

Current status and distribution

Distribution in CH	The plant is present in most of the country. It is invasive south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Present in most European countries, except northern Europe. Known to be invasive in countries such as Austria, France, Italy, Spain and Portugal. Also invasive in North America.

Impacts

Environmental

A. altissima by its rapid growth and root suckering successfully competes and displaces the native vegetation. It also produces a toxin in its bark and leaves. As these accumulate in the soil, the toxin inhibits the growth of other plants.

Economic

The toxin in the bark and leaves is allergenic and can create skin irritations. The root system is capable of damaging to sewers and foundations.

Management options

Tree of heaven is very difficult to remove once it has established a taproot. Therefore, seedlings and saplings must be hand-pulled, root fragments must be removed and carefully disposed. Cutting induces root suckering and resprouting and must be combined with herbicide treatments. Girdling is done when trees are growing, followed by herbicide application. Effective herbicides include glyphosate applied to foliage or stem cuttings, triclopyr applied to barks of young stems and stem cuttings, and picloram for treating cut stumps.

Information gaps

Environmental and economic impacts.

References

Selected literature

Kowarik, I. and R. Böcker, (1984) Zur Verbreitung, Vergesellschaftung und Einbürgerung des Götterbaumes (*Ailanthus altissima* [Mill.] Swingle) in Mitteleuropa. Tuexenia 4, 9-29.

Kowarik, I. (1983) Zur Einbürgerung und zum pflanzensoziologischen Verhalten des Götterbaumes (*Ailanthus altissima* (Mill.) Swingle) im französischen Mittelmeergebiet (Bas-Languedoc). Phytocoenologia 11, 389-405.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

http://www.cps-skew.ch/
Info sheet on *Ailanthus altissima*

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://tncweeds.ucdavis.edu/esadocs/documnts/ailaalt.pdf
The Nature Conservancy Element Stewardship Abstract (1988) for *Ailanthus altissima* (1988)

Ambrosia artemisiifolia

Taxonomic status

Scientific name	*Ambrosia artemisiifolia* L.
Synonyms	*A. elatior* L.
Family	Asteraceae
English name	Common ragweed
German name	Aufrechtes Traubenkraut
French name	Ambroisie à feuilles d'armoise
Italian name	Ambrosia con foglie di artemisia

Description and identification

Life form	Annual herb.
Description	An erect, sometimes branched, leafy annual with a grooved, often reddish, hairy stem, 20-120 cm tall. Leaves compound, divided in oblong, toothed segments, green and hairy above, and with dense, white adpressed hairs beneath. Male flowerheads, 4-5 mm, involucre cup-like, (composed of 5-12 flowers) in slender, bractless, terminal spikes. Female flowerheads, few, each usually one-flowered, sessile, inconspicuous in small clusters or single in the axils of the upper leaves. Achenes, 4-5 mm, hairy, with 5-6 spines. Pappus lacking. Flowering period: late summer (August-October).
Similar species	No congeneric species. Should not be mistaken with species in the genus *Artemisia*, like *A. vulgaris* L. or *A. verlotiorum* Lamotte (see Fact Sheet).

Biology and ecology

Invaded habitats	Ruderal and disturbed sites, roadsides, vacant lots, field margins, crops.
Ecology and spread	Pioneer plant. The plant prefers warm areas and rather light, nutrient-rich soils, slightly acid or neutral. Reproduction is by seeds. Seed dispersal is by water, birds, contaminated seed stocks or human activities. Ragweed seeds can remain viable for 40 years or more. Temperature is the most important factor affecting the germination of common ragweed seeds.

Origin	North America
Introduction and dispersal	It was first recorded in Europe in the mid 1800s, but has only begun to spread since the early 1940s. It first spread in Hungary and Serbia and then continued in the 1960s into Austria, south-eastern France and northern Italy.

Current status

Distribution in CH	Occasionally present in Switzerland, but is becoming more frequent in the areas of Genève and Basel. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Mostly in continental Europe; in recent years spreading quickly in south-eastern France and northern Italy.

Impacts

Environmental	The environmental impact of *A. artemisiifolia* is negligible.
Economic	Common ragweed is a public health hazard. It has become the major cause of summer hay fever in areas now being invaded by

the plant. Patients allergic to ragweed pollen are affected by rhinitis, oculorhinitis and, less frequently, asthma. In France (Lyon) in 1993, the prevalence of ragweed pollinosis was about 3%. Direct contact with the plant and its fruits can result in skin allergy.
A. artemisiifolia is a weed in crops such as maize, cereals, potato and sugarbeet where it can be controlled by the traditional herbicides used in such crops. However, common ragweed is prevalent in sunflower crops owing to the botanical similarity between the weed and the crop itself, and therefore there is a limited number of herbicides effective against ragweed whilst protecting sunflower.

Management options

Control is best achieved by crop rotation and by taking action on crops where control can more easily be carried out and also between seasons by implementing mechanical measures and non-selective herbicides. Isolated plants or small populations should be eradicated by hand-pulling or mowing just before seed production.

Information gaps

Potential spread of common ragweed in Switzerland. Monitoring of ragweed populations and potential for an eradication programme. Assessment of pre-emergence control methods. Prevalence of ragweed pollinosis in relation to local pollen production and long-distance pollen transport.

References

Selected literature

Basset, I.J. and C.W. Crompton (1975) The biology of Canadian weeds. 11. *Ambrosia artemisiifolia* L. and *A. psilostachya* DC. Canadian Journal of Plant Science 55, 463-476.
Chollet, D., Mircovich, C. and E. Pilorgé (1998) La lutte contre l’ambroisie dans les cultures de tournesol. Phytoma – La Défense des Végétaux 504, 30-32.
Déchamp, C. (1995) L’ambroise, un nouveau fléau. Editions Verso, 94 pp.
Delabays, N., Lambelet, C., Jeanmonod, D. Keimer, Ch. and B. Clot (2002) L’ambroise à feuilles d’armoise (*Ambrosia artemisiifolia*): Une espèce à surveiller en Suisse. Revue Suisse Agric 34.
Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d’Histoire Naturelle. Patrimoines naturels, 62, 176 pp.
Polunin, O (1997) Flowers of Europe. A field guide. Oxford University Press.

Other sources

http://www.cps-skew.ch/
Info sheet on *Ambrosia artemisiifolia*
http://wwwcjb.unige.ch/
Groupe AMBROSIA: Conservatoire et jardin botanique de Genève
http://perso.wanadoo.fr/afeda/revue.html
Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Amorpha fructicosa

Taxonomic status

Scientific name	*Amorpha fructicosa* L.
Synonyms	-
Family	Fabaceae
English name	False indigo
German name	Bastardindigo
French name	Indigo bâtard, amorphe buissonnante
Italian name	Indaco bastardo

Description and identification

Life form	Deciduous shrub.
Descritption	Deciduous shrub, up to 4 m tall. Leaves compound with 6-17 pairs of leaflets, elliptic to lanceolate, mucronate, with scattered glands beneath, 1-6 cm long; petiole short. Short-stalked flowers are born in 10-15 cm long, dense, erect panicles. The flower has a dark violet corolla, 4-6 mm long, composed of one unique petal (banner), and 10 yellow-orange erect stamens. The capsule is 6-9 mm, glandulous. The leaves and fruits are aromatic. Flowering period: April-June.
Similar species	No congeneric species. The only species in the family without any wings and spur on the flower.

Biology and ecology

Invaded habitats	Riverbeds, gravel shores, floodplains, humid sites.
Ecology and spread	*A. fructicosa* is a marsh plant. It prefers fairly moist and warm conditions. The plant has very effective vegetative reproduction by root and stem suckering. Dispersal is by seeds that can be transported by water. Seed germination and seedling growth require moderate light.

Origin North America

Introduction and dispersal Introduced for commercial purposes in the 18thcentury. *A. fructicosa* has been used for fencing, has been planted to consolidate subsiding and degraded soil, and was used to produce baskets and demijohn coverings.

Current status

Distribution in CH	Present in the Jura and north-eastern Switzerland. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Naturalized in many countries in particular in south and south-eastern Europe. *A. fructicosa* is considered to be a potentially invasive species in France and also in Austria.

Impacts

Environmental	*A. fructicosa* is becoming a dominant species in secondary succession, where the disturbance is attenuated. It is also becoming dominant in more natural situations such as in moderately hygrophilous scrub. *A. fructicosa* can interfere with the regeneration of native floodplain woods.
Economic	Unknown

Management options Whatever mechanical control is used, all cut material must be removed and disposed of safely to prevent vegetative regrowth. Populations can be reduced temporarily by mowing or burning. Locally, repeated mowing can be effective. The most effective control method to date is the use of glyphosate.

Information gaps Potential spread and abundance. Environmental and economic impacts.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Szentesi, Á. (1999) Predispersal seed predation of the introduced false indigo, *Amorpha fruticosa* L. in Hungary. Acta Zoologica Academiae Scientiarum Hungaricae 45, 125-141.

Tremp, H. (2002) Integration von Arteigenschaften invasiver Pflanzen mit Umweltfaktoren zur Erstellung von Risiko-Szenarien. Beispiel: Bastardindigo (*Amorpha fructicosa* L., Fabaceae). In: Kowarik, I. & Starfinger, U. (eds) Biologische Invasionen. Herausforderung zum Handeln? Neobiota 1, 67-89.

Zavagno, F. and G. D'Auria (2001) Synecology and dynamics of *Amorpha fructicosa* communities in the Po Plain (Italy). In: G. Brundu, J. Brock, I. Camara, L. Child and M. Wade (eds) Plant invasions: species, ecology, and ecosystem management. Backhuys Publishers, Leiden, pp. 175-182.

Other sources *http://www.cps-skew.ch/*

Artemisia verlotiorum

Taxonomic status

Scientific name	*Artemisia verlotiorum* Lamotte
Synonyms	*A. selengensis* auct.
Family	Asteraceae
English name	Chinese mugwort
German name	Verlot'scher Beifuss
French name	Armoise des frères Verlot, armoise de Chine
Italian name	Assenzio dei fratelli Verlot

Description and identification

Life form	Perennial herb.
Description	A tall, erect, unbranched, perennial herb, with deeply lobed, greyish-green leaves spread up the stems. The underside of the leaf is white. Lobes narrowly lanceolate. Flowers are very small, in elongated branched terminal spikes. Flowering is in late summer. Can be distinguished from *A. vulgaris* by the presence of stolons.
Similar species	Nine native species: *A. vulgaris* L., *A. absinthium* L., *A. vallesiaca* Allioni, *A. campestris* L., *A. borealis* Pallas, *A. umbelliformis* Lamarck, *A. glacialis* L., *A. nivalis* Braun-Blaquet, *A. genipi* Weber; 5 alien subspontaneous species: *A. abrotanum* L., *A. pontica* L., *A. annua* L., *A. biennis* Willdenow, *A. dracunculus* L.. Could also be confused with *Ambrosia artemisiifolia* L. (see Fact Sheet).

Biology and ecology

Invaded habitats	Waste ground, crops, fields and sandy riverbanks.
Ecology and spread	Ruderal species. Local spread of clumps is by rhizomes. Seeds are spread by the wind in contaminated soil.

Origin East Asia

Introduction and dispersal Unknown

Current status

Distribution in CH	Most of the country. More common on the Plateau and south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Present in most European countries. The species is recorded as an invasive species in France. It is on the Watch Lists of Spain and Portugal.

Impacts

Environmental	Likely negative effects on native vegetation because of its dense root systems; outcompeting other plants for soil moisture.
Economic	Unknown

Management options Small plants can be hand-pulled, established infestations will need to be sprayed.

Information gaps Environmental and economic impacts. Control methods.

References

Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition.

Paul Haupt (ed).
Smital, A., Markovic, L. and M. Ruscic (1996) The spread of the species *Artemisia verlotiorum* Lamote in Croatia. Acta Botanica Croatica 55, 53-63.

Other sources

http://www.cps-skew.ch/
Flora Europaea, web version: *http://rbg-web2.rbge.org.uk /FE/ fe.html*

Asclepias syriaca

Taxonomic status

Scientific name	*Asclepias syriaca* L.
Synonyms	*A. cornuti* Decaisne
Family	Asclepiadaceae
English name	Common milkweed
German name	Syrische Seidenpflanze
French name	Asclépiade de Syrie, plante à la ouate
Italian name	Albero della seta, Lino d'India

Description and identification

Life form	Rizomatous perennial herb with milky latex.
Description	Stem stout, unbranched, 1-2 m tall. Leaves lanceolate, conspicuously veined, tomentose beneath, 10-20 cm long. Petiole 0.5-1 cm long. Large, dense, terminal and axillary umbels of numerous sweet-scented, pale purple flowers. Corolla 5-lobed, lobes reflexed, 5-10 mm long. Follicle oblong-oval, 10-15 cm long, 3 cm wide, white-woolly, and with a few short, soft spines, 1-3 mm. Seed brown, flat, oval, with a silky pappus. Flowering period: June-August.
Similar species	In Switzerland, only one other species occur in the family Asclepiadaceae, i.e. *Vincetoxicum hirundinaria* Medikus.

Biology and ecology

Invaded habitats	Common along roads, railroads, wastelands and perennial grass areas. The species is also found in wooded areas. Common milkweed dispersion is increasing, most rapidly in dry areas. In North America, it has become an increasingly troublesome weed in cultivated fields.
Ecology and dispersal	The distribution of *A. syriaca* in North America is limited by lower and upper mean July temperatures of 18°C and 32°C in the North and South, respectively. The plant grows over a wide range of soil moisture, although it is most prevalent in well-drained soils. Fully grown plants withstand drought well. The plant is not limited by soil type, soil pH or altitude. Common milkweed propagates vegetatively by its creeping root system. Cutting generally increases sprouting activity. Size, length and maturity of root fragments also play an important role in relation to the time needed for sprouting. Seed pods mature and split open in early autumn and the seeds are dispersed by wind, carried by the tufts of floss. Seeds may remain viable for years in the soil.

Origin	Eastern North America
Introduction and mode of spread	Introduced as a medicinal plant (?) to Europe before Linnaeus' time.

Current status and distribution

Distribution in CH	No distribution map is available for common milkweed.
Distribution in Europe	Southern, Central and eastern Europe. Invasive in dry sandy grassland in Hungary. Potentially invasive in Austria. A Watch Species in southern France. Common milkweed is also a serious economic weed problem in crops in north-central states in the USA and southern parts of Ontario and Quebec in Canada.

Impacts

Environmental — Unknown

Economic — Unknown for Europe, but see above for North America.

Management options — Cultivation chops the underground root system into small fragments and spreads these fragments, leading to the establishment of additional plants. Mowing induces lateral root buds to sprout. Therefore, mechanical control such as clipping or cultivation can lead to the creation of a large colony of common milkweed plants, unless the tillage or mowing is repeated enough to deplete stored carbohydrate reserves in the root system. Crop rotations involving forage grasses or legumes, small grains and irrigated maize help control common milkweed. The weed can be controlled by a number of soil- or foliar-applied herbicides.

Information gaps — Potential spread and potential habitats prone to invasion.

References

Selected literature

Bhowmik, P.C. (1994) Biology and control of common milkweed (*Asclepias syriaca*). Reviews of Weed Science 6, 227-250.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Polunin, O (1997) Flowers of Europe. A field guide. Oxford University Press.

Other sources

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Aster lanceolatus

Taxonomic status

Scientific name	*Aster lanceolatus* Willd. s. str.
Synonyms	*A. paniculatus* Lam., *A. salicifolius* Aiton, *A. recurvatus* Willd., *A. simplex* Willd.,
Family	Asteraceae
English name	**Panicled Aster, eastern lined Aster**
German name	Lanzettblättrige Aster
French name	Aster lancéolé
Italian name	Astro lanceolato

Description and identification

Life form	Rhizomatous perennial herb.
Description	*A. lanceolatus* can be distinguished from *A. novi-belgii* L. by the sessile leaves with rounded bases (rarely half-clasping the stem). Involucre 4-6 mm long, shorter than that of *A. novi-belgii* (5-9 mm) Outer involucral bracts whitish and coriaceous, = half the length of the inner bracts (= half the length in *A. novi-belgii*). Inner bracts acuminate (in *A. novi-belgii* the inner bract is oblong, apiculate). The capitula is smaller with usually white ray florets and narrow (usually < 1 mm) ligules. Flowering period: autumn.
Similar species	See Fact Sheet for *A. novi-belgii.*

Biology and ecology

Invaded habitats	Moist meadows, riverbanks, openings and edges of floodplain forests, damp thickets and fields, roadside ditches. Also grows in mesic to humid neglected fields and poorly managed pastures.
Ecology and dispersal	*A. lanceolatus* prefers full or partial sun and moist habitats, but it can also grow in relatively dry ruderal sites. It also prefers soils with a pH > 7. Panicle aster is a rhizomatous species propagating clonally. Vegetative spread from the original introduction is probably of the utmost importance. Long-distance dispersal is by seeds.

Origin North America

Introduction and mode of spread North American *Aster* spp. were introduced as ornamentals in Europe in the early 1800s. Human-mediated dispersal is through commercial trade and probably in rubbish, including rhizomes of *A. lanceolatus* from house gardens.

Current status and distribution

Distribution in CH	A few records in northern and eastern Switzerland.
Distribution in Europe	Present in most of Europe. *A. lanceolatus* is recorded as an invasive species in Austria, and a potentially invasive species in France and Portugal.

Impacts

Environmental	Dense populations will have a negative impact on native species. It has to be noted that in North America panicled aster is an important source of pollen and nectar for insects because it is one of the last wildflowers to bloom during autumn.
Economic	Unknown

Management options No specific Management options are described for this species.

Information gaps Distribution and potential spread. Invasiveness in Switzerland.

References

Selected literature

Chmielewski, J.G. and J.C. Semple (2001) The biology of Canadian weeds. 113. *Symphyotrichum lanceolatum* (Willd.) Nesom (*Aster lanceolatus* Willd.) and *S. lateriflorum* (L.) Love & Love (*Aster lateriflorus* (L.) Britt.). Canadian Journal of Plant Science 81, 829-849.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Aster novi-belgii

Taxonomic status

Scientific name	*Aster novi-belgii* L.
Synonyms	*A. brumalis* Nees; *A. floribundus* Willd.; *A. longifolius* Lam. First recorded as *A. salignus* Willd.
Family	Asteraceae
English name	Michaelmas daisy
German name	Neubelgische Aster
French name	Aster de la Nouvelle-Belgique
Italian name	Astro americano

Description and identification

Life form	Perennial herb.
Description	An erect herb, 50-100 (150) cm tall, upper stem branched, often pubescent but without glandular hairs. Leaves ± hairless, oval-lance-shaped, entire or finely toothed, sessile, the upper narrower, half-clasping the stem, with sharp lobes. Flower heads violet, 2-3 cm across, in a broad, much-branched, pyramidal cluster. Disk-florets yellow, ray-florets violet, rarely rose or white; involucre long, 5-9 mm, involucral bracts unequal, spreading, acute. Achenes hairless, 2-3 mm, pappus white. Flowering period: autumn.
Similar species	Numerous species have become naturalized in Europe. The taxonomy and identification can be difficult owing to hybridization, and the occurrence of subspecies and various cultivars. *A.* x *salignus* Willdenow, *A. tradescantii* L., *A. novae-angliae* L., *A. x versicolor* Willdenow, *A. lanceolatus* Willdenow are of North American origin. Native species: *A. bellidiastrum* (L.), *A alpinus* L., *A. linosyris* (L.) and *A. amellus* L.. See also Fact Sheet for *A. lanceolatus* Willdenow.

Biology and ecology

Invaded habitats	Riverbanks, shores, marshes, damp woods, moist meadow thickets and ruderal habitats.
Ecology and spread	*A. novi-belgii* is a marsh plant. It prefers relatively humid and rich soils. It is a rhizomatous species, propagating clonally. Vegetative spread from the original introduction is probably of the utmost importance. Long-distance dispersal is by seeds.

Origin	North America
Introduction and dispersal	The plant was probably introduced in the 1860s in the UK as an ornamental, but the earliest possible date could be about 1710. Human-mediated dispersal is through commercial trade and probably in rubbish, including rhizomes of *A. novi-belgii* from house gardens.

Current status

Distribution in CH	The species is present throughout the country.
Distribution in Europe	Present in most of Europe. The species is considered as an invasive species in Austria and France.

Impacts

Environmental	Dense populations will have a negative impact on native species.
Economic	Unknown

Management options	Specific Management options for *A. novi-belgii* are unknown.
Information gaps	Spread and abundance. Invasiveness in Switzerland.
References	
Selected literature	Briggs D., Block, M. and S. Jennings (1989) The possibility of determining the age of colonies of clonally propagating herbaceous species from historic records: the case of *Aster novi-belgii* L. (first recorded as *A. salignus* Willd.) at Wicken Fen Nature Reserve, Cambridgeshire. New Phytologist 112, 577-584. Labrecque, J. and L. Brouillet (1996) Biosystematics of the *Aster novi-belgii* complex (Asteraceae: Asteracea) in Quebec. Canadian Journal of Botany 74, 162-188. Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed) Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press. Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.
Other sources	*http://www.cps-skew.ch/index.htm*

Bidens frondosa

Taxonomic status

Scientific name	*Bidens frondosa* L.
Synonyms	*B. melanocarpa* Wiegand
Family	Asteraceae
English name	Beggarticks
German name	Dichtbelaubter Zweizahn
French name	Bident feuillu, bident à fruits noirs
Italian name	Forbicina peduncolata

Description and identification

Life form	Annual herb.
Description	Stout, erect, annual herb, up to 1 (-2) m tall. Stem branching, red-brownish, essentially glabrous. Leaves opposite, petiolate, the basal simple and lanceolate, the other divided in 3(-5) lanceolate leaflets with dentate margin and sharp apex. Lateral leaflets with petiolules 5-6 mm long, terminal leaflet with petiolule up to 2.5 cm long, larger than lateral leaflets. Capitula erect, 1-2 cm in diameter, with or without ray flowers. Disc flowers yellow-brownish. Outer bracts spreading, 5-8 in number, 5-20 mm long and 1-3 mm wide, ciliate-margined. Inner bracts erect, brown, 5-9 mm long. Achenes 6-10 mm long, blackish with two scabrid awns, and erect bristles on the edge. Flowering period: August to September.
Similar species	Native species: *B. tripartita* L. and *B. radiata* Thuillier*.* Alien species (native in the Americas): *B. connata* Willdenow, *B. cernua* L., *B. bipinnata* L. and *B. subalternans* DC.. *B. frondosa* can be distinguished from *B. tripartita* by the presence of petiolules on the leaflets.

Biology and ecology

Invaded habitats	Riverbanks, alluvial soils, ditches, waste ground and roadsides.
Ecology and spread	Pioneer species in moist ground, reproducing by seeds. Seeds dispersed by water current or aquatic birds.

Origin	North America
Introduction and dispersal	Accidentally introduced and naturalized in Central Europe by the end of the 19th century.

Current status

Distribution in CH	Jura, Plateau, south of the Alps. The number of populations is increasing. Probably more common but confused with the native species *B. tripartita*.
Distribution in Europe	Most of Europe. *B. frondosa* is an invasive species e.g. in France, Austria, Portugal and a potentially invasive species in Spain.

Impacts

Environmental	Dense stands will likely have negative effects on the native pioneer vegetation. Outcompetes the native species *B. tripartita.*
Economic	Unknown.

Management options	Hand-pulling, mowing before fructification.
Information gaps	Distribution, invasiveness and environmental impacts.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Keil, P. (1999) Ökologie der gewässerbegleitenden Agriophyten *Angelica archangelica* ssp. *litoralis*, *Bidens frondosa* und *Rorippa austriaca* im Ruhrgebiet. Dissertationes Botanicae. Cramer Verlag, Berlin.

Koeck, U.V. (1988) Ecological aspects of spreading of *Bidens frondosa* L. in Central Europe: Is it displacing *Bidens tripartita* L.? Flora (Jena) 180, 177-190.

Ludwig, W. (1994) *Bidens frondosa* var. *anomala* in Hessen. Hessische Floristische Briefe 43, 17-19.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://wwwcjb.unige.ch/
Info sheet on *Bidens frondosa*

Buddleja davidii

Taxonomic status

Scientific name	*Buddleja davidii* Franchet
Synonyms	*B. variabilis* Hemsley
Family	Buddlejaceae
English name	Butterfly bush, summer lilac
German name	Schmetterlingsstrauch, Sommerflieder
French name	Buddléa de David, arbre aux papillons
Italian name	Buddleja

Description and identification

Life form	Deciduous shrub.
Description	A much-branched deciduous shrub up to 5 m tall with long, arching branches and opposite leaves. Leaves lanceolate to narrowly ovate, 10-25 cm long, white tomentose beneath, with serrate margins and petioles 2-5 mm long. Inflorescences are long pyramidal and dense panicles of 10-25 cm length. The pale lilac to deep violet flowers are 8-13 mm long and have corollas with four lobes and an orange center. Fruits are capsules of c. 10 mm length that contain numerous seeds. Seeds are long-winged at both ends and 2-4 mm long. The shrub is short-lived with individuals up to the age of 37 years having been recorded. Flowering period: July-August.
Similar species	No other species in the genus or family in Switzerland.

Biology and ecology

Invaded habitats	Riparian habitats, gravel shores, railway embankments, quarries, forest edges, vacant lots in urban areas.
Ecology and spread	*B. davidii* is a highly successful colonizer. The plant prefers poor and well-drained soils and is resistant to drought. *B. davidii* also likes full sun, but it can tolerate some shade. In China *B. davidii* grows at a much higher altitude than in any of the invaded regions in the world. When cut back, *B. davidii* sprouts vigorously. It also tolerates burial by alluvial deposition by producing adventitious roots and shoots. Dispersal and colonization are by seeds. Each shrub can produce up to 3 million seeds. One-year old plants can flower and produce seeds that are dispersed by wind and water. Colonization of disturbed areas is very quick, within 1-2 years.

Origin	South-western China.
Introduction and dispersal	Introduced to Britain as an ornamental in the 1890s. *B. davidii* is sold by horticulturists. It is appreciated by the public because of the beautiful flowers that attract a number of butterflies.

Current status

Distribution in CH	Present in the lowlands of most of the country. More common south of the Alps and around Genève and Basel. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Widespread in most western European countries. Invasive, e.g. in the UK, France and Spain. Also a potential invasive species in Austria. It is regarded as invasive in North America and New Zealand, too.

Impacts

Environmental	Because of its high dispersal potential by seeds, it tends to colonize modified or disturbed habitats before any native species. Initial growth rate is high, and this also suppresses native pioneer species. In Britain, *B. davidii* spreads into areas usually colonized by *Betula* spp. In New Zealand, it is invasive because it quickly displaces primary native colonizers on fresh alluvial plains and accelerates succession to forests.
Economic	Unknown
Management options	If established plants are removed, the stumps should be either removed as well or treated with a glyphosate herbicide, because the shrub can regrow from cut roots. Seedlings and smaller plants can be hand-pulled or dug out. A biological control programme has started in New Zealand.
Information gaps	Environmental and economic impacts.

References

Selected literature

Brockerhoff, E.G., Withers, T.M., Kay, M. and W. Faulds (1999) Impact of the defoliator *Cleopus japonicus* (Coleoptera: Curculionidae) on *Buddleja davidii* in the laboratory. Proceedings 52nd New Zealand Plant Protection Conference, pp. 13-118.

Godefroid, S. (1996) A propos de l'extension spectaculaire de *Fallopia japonica*, *F. sachalinensis*, *Buddleja davidii* et *Senecio inaequidens* en Région bruxelloise. Dumortia 63, 9-16.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

http://www.cps-skew.ch/
Info sheet on *Buddleja davidii*

http://wwwcjb.unige.ch/
Info sheet on *Buddleja davidii*

Flora Europaea, web version :
http://rbg-web2.rbge.org.uk/FE/fe.html

http://members.lycos.co.uk/WoodyPlantEcology/docs/web-bud.htm

Bunias orientalis

Taxonomic status

Scientific name	*Bunias orientalis* L.
Synonyms	-
Family	Brassicaceae
English name	Turkish wartycabbage
German name	Östliches Zackenschötchen
French name	Bunias d´Órient
Italian name	Cascellore orientale

Description and identification

Life form	Perennial herb.
Description	Polycarpic perennial herb 30-120 cm tall. Stem branched, glabrous or sparsely hairy. Lower leaves up to 40 cm long, deeply pinnately cut into narrow lobes. Upper leaves much smaller, leaf divisions less pronounced. Petals 5-6 mm, yellow, rounded. Pedicel 12-15 mm long. Silicula 6-10 mm long, ovoid, and covered with irregular protuberances, divided into two loculi containing one seed each. Flowering period: May-June.
Similar species	*B. erucago* can be distinguished by the lower leaves deeply pinnately cut into triangular lobes, maximum 15 cm long, and the heart-shaped yellow petals 7-10 mm long.

Biology and ecology

Invaded habitats	Roadsides, verges of country lanes or channels. Recently, in Germany, *B. orientalis* has colonized meadows, orchards, vineyards and even thermophilous grassland in nature reserves.
Ecology and dispersal	*B. orientalis* performs best in open sites with a medium to high nitrogen supply and medium disturbance regimes. The formation and persistence of large *B. orientalis* stands result from the high growth rate of the species, the large rosettes and a second growth period of rosettes in late summer. Long-distance dispersal is mostly along roads by means of highly regenerative root fragments and seeds carried in soil. Short-distance propagation is promoted by a high fruit set and high germination rates.

Origin	South-western Russia, western Asia.
Introduction and mode of spread	Introduced to Central Europe in the 18th century. Over the last 200 years the species has spread through Central Europe to the continental parts of western and northern Europe.

Current status and distribution

Distribution in CH	Present throughout the country. More common in the west and in the Rhone valley, rare south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Most of Europe. Not present in the Iberian peninsula and in Greece. Considered a potentially invasive species in France.

Impacts

Environmental	Dense stands are likely to impact the native vegetation of ruderal or semi-natural communities.
Economic	Unknown

Management options No specific management options are described for *B. orientalis*. A moderate mowing regime does not significantly alter *B. orientalis*. Field observations indicate that frequent mowing (> twice a year) may prevent any seed setting. At rarely mown sites (less than once in 3 years), increased competition by taller successional species may displace *B. orientalis* in the long run. Vegetative regeneration by root fragments is frequent under elevated disturbance (e.g. cultivation) because the probability of root fragmentation increases.

Information gaps Environmental and economic impacts.

References

Selected literature

Dietz, H., and T. Steinlein (1998) The impact of anthropogenic disturbance on life stage transitions and stand regeneration of the invasive alien plant *Bunias orientalis* L. In: U. Starfinger, K. Edwards, I. Kowarik and M. Williamson (eds) Plant invasions: ecological mechanisms and human responses. Backhuys Publishers, Leiden, pp. 169-184.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Steinlein, T., Dietz, H. and I. Ullmann (1996) Growth patterns of the alien perennial *Bunias orientalis* L. (Brassicaceae) underlying its rising dominance in some native plant assemblages. Vegetatio 125, 73-82.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Conyza canadensis

Taxonomic status

Scientific name	*Conyza canadensis* (L.) Cronquist
Synonyms	*Erigeron canadensis* L.
Family	Asteraceae
English name	Canadian fleabane
German name	Kanadisches Berufkraut
French name	Vergerette du Canada
Italian name	Saeppola canadese

Description and identification

Life form	A summer- or winter-annual herb.
Description	Stiff, erect, ± hispid herb, 20-100 cm tall. Cauline leaves 1-4 cm, lanceolate, entire, or slightly serrate, the upper leaves smaller, often linear, sessile. Much branched above and bearing very numerous tiny whitish flower heads in long, dense, branched clusters. Capitula 3-5 mm in diameter, cylindrical. Ray flowers slightly longer than the disk flowers and the involucre. Achenes 1-1.5 mm long, pappus brownish-white, 3× longer than the achene. Most seeds emerge in autumn and individuals overwinter as a rosette. Flowering period: July-September.
Similar species	Four other species of the genus have been recognized in Europe based on subtle differences in floral and vegetative characteristics. *C. sumatrensis* (Retz.) E. Walker and *C. bonariensis* (L.) Cronq. are, together with *C. canadensis*, by far the most widespread taxa throughout western Europe. *C. blakei* (Cabr.) Cabrera and *C. floribunda* H.B.K. have only recently begun to spread in France.

Biology and ecology

Invaded habitats	Orchards, vineyards, other perennial crops, waste areas, fallow fields, fence rows, along roadsides and railways and irrigation channels, but also in disturbed areas of native vegetation, and in natural sand dunes or grasslands.
Ecology and spread	*C. canadensis* grows best in relatively dry conditions and basic soils. Seeds are dispersed mainly by wind. The species is self-compatible, and apparently is not actively pollinated by insects, suggesting either autogamy or wind-pollination. *C. canadensis* does not compete well under conditions of high plant densities and cover, but is recruited and becomes well established under disturbed conditions.

Origin	Eastern North America
Introduction and dispersal	Accidentally introduced into Europe within the past 350 years.

Current status

Distribution in CH	Whole country.
Distribution in Europe	Whole of Europe. Invasive e.g. in France, Spain and Portugal. Probably one of the most widely introduced species in the world.

Impacts

Environmental	Can dominate natural vegetation and increases fire risk.
Economic	Can reduce the yields of various crops such as grapes and

sugarbeet.

Management options The weed survives herbicide treatments in untilled crop fields. Several researchers have reported evolution of strains resistant to triazine and paraquat. Using mulch and reduced tilling produces varying results in controlling the plant.

Information gaps Economic impacts and control methods.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Prieur-Richard, A.H., Lavorel, Se., Grigulis, K. and A. Dos-Santos (2000) Plant community diversity and invasibility by exotics: Invasion of Mediterranean old fields by *Conyza bonariensis* and *Conyza canadensis*. Ecology Letters 3, 412-422.

Thebaud, C. and R. Abbott (1995) Characterization of invasive *Conyza* species (Asteraceae) in Europe: quantitative trait and isozyme analysis. American Journal of Botany 82, 360-368.

Thebaud, C., Finzi, A., Affre, L., Debussche, M. and J. Escarre (1996) Assessing why two introduced *Conyza* differ in their ability to invade Mediterranean old fields. Ecology 77, 791-804.

Weaver, S.E. (2001) The biology of Canadian weeds. 115. *Conyza canadensis*. Canadian Journal of Plant Science 81, 867-875.

Other sources

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://usgssrv1.usgs.nau.edu/swepic/factsheets/Conyza_canadensis.pdf

Cornus sericea

Taxonomic status

Scientific name	*Cornus sericea* L.
Synonyms	*Cornus stolonifera* Michaux
Family	Cornaceae
English name	Red-osier dogwood
German name	Seidiger Hornstrauch
French name	Cornouiller soyeux
Italian name	Corniolo serico

Description and identification

Life form	Deciduous shrub.
Description	Deciduous shrub up to 4 m. Young stems and twigs green-yellowish. Leaves opposite, broadly elliptical or ovate, entire, accuminate, up to 14 cm long, greyish-green below, with prominent lateral veins (5-7 pairs) that curve toward the tip and smooth edges. Petals only 2-4 mm long, berry-like fruits whitish or light grey. Flowering period: May-June.
Similar species	Similar to the native species, *C. sanguinea* L., but with numerous stolons. Alien species: *C. mas* L. (native to the Mediterranean).

Biology and ecology

Invaded habitats	In its native habitat, a characteristic species of swamps, low meadows and riparian zones; also found in forest openings, forest margins, hedges, thickets. The plant can live with the roots submerged in water for most of the growing season.
Ecology and spread	Seeds that are dispersed primarily by birds, need cold stratification for 1-3 months. The plant spreads also by layering when the lower stems touch or lie along the ground and root at the nodes. New plants are also produced from roots and stolons in moist situations.

Origin North America

Introduction and dispersal Probably introduced as an ornamental. Commercialized.

Current status

Distribution in CH	Jura, Plateau, north-eastern Switzerland. Potential expansion mostly in humid areas, riverbanks, forested areas. Southern limits appear to be determined by high temperatures. On the Watch List of of the CPS-SKEW working group.
Distribution in Europe	Known from British Isles, Germany, Finland. Potentially invasive in Austria.

Impacts

Environmental	This shrub has negative effects on the native vegetation because of its thick, extensive root system and dense canopy.
Economic	Unknown

Management options No specific **Management options** known. Cutting generally increases sprouting from roots and stems.

Information gaps Distribution, potential spread, invasiveness. Environmental impacts.

References

Selected literature

Kelly, D.L. (1990) *Cornus sericea* L. in Ireland: An incipient weed of wetlands. Watsonia 18, 33-35.

Middleton, B. (2002) Winter burning and the reduction of *Cornus sericea* in sedge meadows in southern Wisconsin. Restoration Ecology 10, 723-730.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.rook.org/earl/bwca/nature/shrubs/cornusser.html

http://www.fs.fed.us/database/feis/plants/shrub/corser/

Cyperus eragrostis

Taxonomic status

Scientific name	*Cyperus eragrostis* Lamarck
Synonyms	*C. depressus* Moench, *C. monandrus* Roth, *C. vegetus* Wild.
Family	Cyperaceae
English name	Pale galingale, umbrella sedge
German name	Frischgrünes Zypergras, Liebesgrasartiges Zypergras
French name	Souchet robuste, souchet fausse éragrostide
Italian name	Zigolo false panicella

Description and identification

Life form	Perennial grass-like herb.
Description	Perennial herb up to 20-70 cm tall, stem triangular in cross section, leaves 4-8 mm wide, arising from near the stem base, length is up to the length of the stem. Inflorescence is arranged in a simple to compound umbel of dense heads; rays 8-10, up to 10 cm long, ending each in a dense cluster of yellow-green to reddish coloured spikelets up to 10-15 mm long, each with 10-40 flowers. Rachilla not winged. The umbel is surrounded by 4-6 involucral leaves, longer than the inflorescence. The rhizomes are short and thick.
Similar species	Several alien congeneric species occur in Switzerland, i.e. *C. flavescens* L., *C. rotundus* L., *C. microiria* Steudel and *C. esculentus* L. (see Fact Sheet). Other species are *C. fuscus* L., *C. longus* L. and *C. glomeratus* L..

Biology and ecology

Invaded habitats	Wet areas, waterways, ditches and roadsides.
Ecology and dispersal	A marsh plant. *C. eragrostis* tolerates full sun, part sun, clay, no drainage and seasonal flooding, but it does not tolerate very cold temperature. *C. eragrostis* reproduces by seeds and rhizomes. It has no underground tubers. Seeds are dispersed over long distances by water currents. Even small plants can produce large quantities of viable seed. Once established, umbrella sedge can grow to form large tussocks.

Origin	Tropical America.
Introduction and mode of spread	The history of introduction to Europe is unknown. The plant is spread by seeds dispersed with agricultural and nursery activities, machinery and soil movement. It is also commercialized.

Current status and distribution

Distribution in CH	The species is present south of the Alps.
Distribution in Europe	Present in south-western Europe. *C. eragrostis* is an invasive species in France (Mediterranean and Atlantic sectors) and in Spain and a potentially invasive species in Portugal.

Impacts

Environmental	Large tussocks can displace native vegetation.
Economic	*C. eragrostis* can be a problem in water storage and irrigation channels.

Management options	Plants should be dug up. Removing flowers will help to reduce spread.

Information gaps	Potential spread and abundance. Prevention/eradication methods.
References	
Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Other sources	Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html* *http://cotton.crc.org.au/Assets/PDFFiles/WEEDpak/WPh3.pdf*

Cyperus esculentus

Taxonomic status

Scientific name	*Cyperus esculentus* L. There are four wild varieties worldwide and one cultivated (var. *sativus*) with the most weedy variety being possibly var. *esculentus*.
Synonyms	*C. aureus* Ten., non Georgi, *C. melanorhizus* Delile
Family	Cyperaceae
English name	Yellow nutsedge, yellow nutgrass, chufa (edible variety)
German name	Essbares Zypergras
French name	Souchet comestible
Italian name	Zigolo dolce

Description and identification

Life form	Perennial grass-like herb.
Description	Robust perennial, 10-50 (90) cm tall, thread-like weak rhizomes ending in edible underground globular tubers (1-2 cm long). Leaves pale green, stiff, 5-10 mm wide and 20-90 cm long, arising from near the stem base. The inflorescence is arranged in an umbel of 4-10 rays, up to 10 cm long ending each in a lax cluster of straw-coloured or golden spikelets up to 6-12 mm long. Rhachilla broadly winged. The umbel is surrounded with 2-9 involucral leaves of which 2-4 are longer than the inflorescence. The achenes are yellowish-brown, three-angled, and 1.2-1.5 mm long.
Similar species	Several alien congeneric species occur in Switzerland, i.e. *C. flavescens* L., *C. rotundus* L., *C. microiria* Steudel and *C. eragrostis* Lamarck (see Fact Sheet). Other species are *C. fuscus* L., *C. longus* L. and *C. glomeratus* L..

Biology and ecology

Invaded habitats	Yellow nutsedge occurs in disturbed habitats, ditches, margins of lakes, rivers and marshes. It also occurs as a weed in cultivated fields especially those irrigated in the summer: orchards, gardens and turfgrass.
Ecology and dispersal	A marsh plant and ruderal species. *C. esculentus* can tolerate a wide range of soil types, but production is often greatest on silty clay soils and lowest on sand. It is adapted to seasonally flooded environments and can tolerate periods of drought. It is also cold tolerant. The species competes poorly with other plants because of its light requirements. The quick emergence and rapid growth of yellow nutsedge allow plants to mature before being subjected to shading by other plants. Tubers contain many phenolic compounds known to have allelopathic properties. Yellow nutsedge reproduces vegetatively and by seeds. The species spreads locally primarily by corm-like solid basal bulbs, rhizomes that extend from the bulbs, and by hard tubers, 1-2 cm long, at the rhizome terminals. During the growing season, the rhizome terminal may develop into either a new bulb with a shoot and rhizomes or a dormant tuber. Tubers store starch and generally produce 1-3 sprouts the following spring. Tubers are the only part of the plant that overwinter. One plant can produce thousands of tubers in one season. Seeds disperse naturally with wind and in water, especially through flooding. Seed viability is usually low. The cultivated variety chufa (var. *sativus*) does not have the overwintering capability of the variety *esculentus*. Chufa tubers are also known to be larger.

Origin	Eurasia, Africa

Introduction and mode of spread

The use of yellow nutsedge has its origin in ancient Egypt and chufa was one of the first domesticated crops. It was introduced into Spain in the Middle Age where a drink was made out of the tubers. Today chufa is also used as a flavouring agent for roast nuts, ice cream and biscuits. When and where different varieties were introduced is unclear. Tubers and seeds are dispersed with agricultural and nursery activities, machinery and soil movement.

Current status and distribution

Distribution in CH

Present in the Plateau and south of the Alps. On the Watch List of the CPS-SKEW working group.

Distribution in Europe

Mostly Mediterranean Europe and Portugal, but also spreading in colder climates in Europe. It is considered one of the world's worst weeds in warm and temperate zones.

Impacts

Environmental

Dense stands are likely to have an impact on the native vegetation. Early and rapid growth of yellow nutsedge create shade and prevent the growth of other species.

Economic

Extent unknown, but the economic impact can be important. For example, the weedy variety var. *esculentus* was introduced to the Netherlands in the late 1970s concealed in a *Gladiolus* shipment and it was so invasive that in 1984 a regulation was introduced that prohibits the harvest of any root crop in a field infested with yellow nutsedge.

Management options

The plant is resistant to many herbicides and its spread may correspond to the increased use of selective herbicide. Most herbicides used affect only the shoots and/or roots and do not kill the tubers. In addition, yellow and purple nutsedge (*C. rotundus*) require different herbicides. Shading and solarization can reduce infestations by weakening shoots and decreasing new tuber formation, but mature tubers may not be eliminated. Cultivation can worsen an infestation if not repeated enough to exhaust tubers and prevent new tuber formation. Crop competition can be used effectively. The potential of biological control, especially the use of a fungus-based bioherbicide, is being investigated.

Information gaps

Potential spread and abundance. Taxonomy of the most weedy varieties and prevention/eradication methods.

References

Selected literature

De Vries, F.T (1991) Chufa (*Cyperus esculentus*, Cyperaceae): a weedy cultivar or a cultivated weed? Economic Botany 45, 27-37.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Pascual, B. et al. (2000) Chufa (*Cyperus esculentus* L. var. *sativus* Boeck.): an unconventional crop. Studies related to applications and cultivation. Economic Botany 54, 439-448.

Polunin, O (1997) Flowers of Europe. A field guide. Oxford University Press.

Schmitt, R. and A. Sahli (1992) Eine in der Schweiz als Unkraut neu auftretende Unterart des *Cyperus esculentus* L. Landwirtschaft Schweiz 5, 273-278.

Schmitt, R. (1993) Das "neue" Unkraut Knöllchen-Zypergrass. Erste Ergänzung. Landwirtschaft Schweiz 6, 376-378.

Schmitt, R. (1995) Die "neuen" Unkräuter Knöllchen-Zypergrass und Aleppo-Hirse. Agrarforschung 2, 276-278.

Stoller, E.W. and R.D. Sweet (1987) Biology and life cycle of purple and yellow nutsedges (*Cyperus rotundus* and *C. esculentus*). Weed Technology 1, 66-73

Wills, G.D. (1987) Description of purple and yellow nutsedge (*Cyperus rotundus* and *C. esculentus*). Weed Technology 1, 2-9.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.siu.edu/~ebl/leaflets/nutsedge.htm

http://www.wa.gov/agr/weedboard/weed_info/yellownutsedge.html

http://threeissues.sdsu.edu/three_issues_coquillofacts01.html **(***http://threeissues.sdsu.edu/***).**

Duchesnea indica

Taxonomic status

Scientific name	*Duchesnea indica* (Andrews) Focke
Synonyms	*Fragaria indica* Andrews, *Potentilla indica* (Andr.) Wolf
Family	Rosaceae
English name	Indian strawberry
German name	Scheinerdbeere
French name	Fraisier des Indes
Italian name	Fragola matta

Description and identification

Life form	Perennial herb.
Description	Herb with short stock, somewhat flaccid, up to 10 cm tall at flowering. Runners greenish, slender, pilose, up to 20-50 cm long and rooting at nodes and tips to form new rosettes. Basal leaves in rosette; leaves alternate, divided into 3 toothed leaflets like those of wild strawberries. Petiole long and hairy. Single flowers on long stalks that arise from the leaf axils. Flowers consist of 5 yellow petals with large ovate-triangular sepals beneath. Segments of the calicle broadly obovate, pilose, deflexed at fruiting, with 3-5 purple-tipped teeth. Fruits erect, fleshy, tasteless. Flowering period: April-July.
Similar species	No other congeneric species. Native wild strawberries have white flowers.

Biology and ecology

Invaded habitats	Woods, grassy slopes, ravines in low mountain areas.
Ecology and dispersal	A fairly thermophilous wood species which prefers relatively moist, nitrophilous, shaded habitats. Spreads and multiplies rapidly by runners.

Origin East Asia

Introduction and mode of spread Unknown

Current status and distribution

Distribution in CH	Plateau, Jura, more common south of the Alps.
Distribution in Europe	Particularly present in France, Italy and Austria. Listed as a potentially invasive species in Austria. Also invasive in south-eastern USA.

Impacts

Environmental	Likely to have negative impacts on native vegetation.
Economic	Unknown

Management options No specific control methods described.

Information gaps Invasiveness. Environmental impact.

References

Selected literature

Gray, E. and N.M. Call (1993) Fertilization and mowing on persistence of Indian mockstrawberry (*Duchesnea indica*) and common blue violet (*Viola papilionacea*) in a tall fescue

(Festuca arundinacea) lawn. Weed Science 41, 548-550.
Jackowiak, B. (1992) On the distribution of *Duchesnea indica* (Rosaceae) in Vienna. Fragmenta Floristica et Geobotanica 37, 593-547.
Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition, Paul Haupt (ed).

Other sources

http://www.cps-skew.ch/
Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Elodea canadensis

Taxonomic status

Scientific name	*Elodea canadensis* Michaux
Synonyms	*Anacharis canadensis* Planch.
Family	Hydrocharitaceae
English name	Canadian waterweed, American waterweed
German name	Gemeine Wasserpest
French name	Elodée du Canada
Italian name	Peste d'aqua comune

Description and identification

Life form	Submerged aquatic herb.
Description	*E. canadensis* is a submerged, rather densely bushy, aquatic perennial, 30-300 cm, with numerous overlapping, dark green, translucent, oblong and minutely toothed leaves, c. 1 cm long, 2-3 mm wide, usually in whorls of 3. Dioecious. Flowers c. 5 mm across, rose-white, carried to the surface on a long slender stalk 2-15 cm, with a sheathing, two-lobed spathe. Fruit oblong, 6 mm long and 3 mm wide. Roots white, unbranched and thread-like.
Similar species	Alien species: *E. nuttallii* (Planchon) (see Fact Sheet) and *E. densa* (Planchon).

Biology and ecology

Invaded habitats	Invades still or slow-flowing water. In the latter half of the 19th century and the first half of the 20th century it spread rapidly throughout Europe and caused major environmental problems. Since the 1950s, it has become less problematic and is now considered preferable to the more invasive *E. nuttallii* and *Lagarosiphon major* (Ridley).
Ecology and spread	American waterweed grows in a wide range of conditions, from very shallow to deep water, in slightly mineralized and acid water in siliceous sediments to heavily mineralized water in calcareous sediments. Prefers mesotrophic waters. Seeds are seldom produced because of a shortage of male plants. Reproduction and dispersal are essentially vegetative by fragmentation of the stems that float away, root, and start new plants. *E. canadensis* also produces winter buds from the stem tips that overwinter on the lake bottom.

Origin	North America
Introduction and dispersal	First recorded in Ireland in 1836, then in 1845 on the continent.

Current status

Distribution in CH	Widespread almost throughout the country, except the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Most of Europe. Invasive in several European countries such as Austria, France and Spain. Potentially invasive in Portugal and Scotland.

Impacts

Environmental	The proliferation of *E. canadensis* can have a general negative impact on the functioning of the aquatic ecosystem and it will

	outcompete native aquatic plants. The plant can also impede water flow and adversely affect recreation activities.
Economic	Unknown
Management options	Mechanical removal of the biomass will temporarily reduce the populations and their proliferation. However it is essential to prevent the spread of plant fragments by creating filters downstream before any mechanical treatment is carried out. All plants removed must be carefully disposed of to prevent dissemination of fragments.
Information gaps	Environmental and economic impacts.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Bowmer, K.H., Jacobs, S.W.L. and G.R. Sainty (1995) Identification, biology and management of *Elodea canadensis*, Hydrocharitaceae. Journal of Aquatic Plant Management 33, 13-19.

James, C., Eaton, J.W. and K. Hardwick (1998) Competition between three submerged macrophytes *Elodea canadensis*, *Elodea nuttallii* and *Lagarosiphon major*. In: Monteiro A., T. Vasconcelos and L. Catarino (eds) Proceedings 10th EWRS International Symposium on Aquatic Weeds. Lisbon. 21-25 September 1998, pp. 79-82.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Pieterse, A., and K.J. Murphy (eds) (1990) Aquatic weeds. The ecology and management of nuisance aquatic vegetation. Oxford University Press, 593 pp.

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Simpson, D.A. (1984) A short history of the introduction and spread of *Elodea* Michx. in the British Isles. Watsonia 15, 1-9.

Simpson, D.A. (1990) Displacement of *Elodea canadensis* Michx by *Elodea nuttallii* (Planch.) H. St. John in the British Isles. Watsonia 18, 173-177.

Spicer, K.W. and Catling, P.M. (1988) The biology of Canadian weeds 88. *Elodea canadensis* Michx. Canadian Journal of Plant Science 68, 1035-1051.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Elodea nuttallii

Taxonomic status

Scientific name	*Elodea nuttallii* (Planchon) St. John
Synonyms	*Anacharis nuttallii* Planch
Family	Hydrocharitaceae
English name	Nuttall's pondweed, western waterweed
German name	Nuttalls Wasserpest
French name	Elodée de Nuttall
Italian name	Peste d'acqua di Nuttall

Description and identification

Life form	Submerged aquatic herb.
Description	Very similar to *E. canadensis* Michaux, but leaves linear, not more than 2 mm wide, acuminate. Dioecious. Flowers pale purple, 3-5 mm wide.
Similar species	Alien species: *E. canadensis* (see Fact Sheet) and *E. densa* (Planchon).

Biology and ecology

Invaded habitats	Invades still or slow flowing eutrophic waters. In UK, it is often found in poor macrophyte communities subject to boat traffic as well as in eutrophic drainage ditches. Due to increased eutrophication it has replaced *E. canadensis* at many sites and in turn is being replaced by *Lagarosiphon major* (Ridley).
Ecology and spread	Like *E. canadensis*, *E. nuttallii* grows in a wide range of conditions. The plant prefers eutrophic waters where it grows faster than Canadian waterweed. Like *E. canadensis*, seeds are seldom produced because of a shortage of male plants. Reproduction and dispersal is essentially vegetative by fragmentation of the stems and the production of winter buds from stem tips.

Origin	North America
Introduction and dispersal	First recorded in Belgium in 1939.

Current status

Distribution in CH	Jura, Plateau. Less common than *E. canadensis*. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Western Europe. Potentially invasive in Austria, France, Scotland. Undergoing strong expansion.

Impacts

Environmental	As for *E. canadensis*.
Economic	No information.

Management options	As for *Elodea canadensis*.
Information gaps	Potential spread. Invasiveness. Environmental and economic impacts.

References

Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

James, C., Eaton, J.W. and K. Hardwick (1998) Competition between three submerged macrophytes *Elodea canadensis*, *Elodea nuttallii* and *Lagarosiphon major*. In: Monteiro A., T. Vasconcelos and L. Catarino (eds) Proceedings 10th EWRS International Symposium on Aquatic Weeds, Lisbon, 21-25 September 1998, pp. 79-82.
Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.
Pieterse, A., and K.J. Murphy (eds) (1990) Aquatic weeds. The ecology and management of nuisance aquatic vegetation. Oxford University Press, 593 pp.

Other sources

http://www.cps-skew.ch/
Flora Europaea, web version *http://rbg-web2.rbge.org.uk/FE/fe.html*

Epilobium ciliatum

Taxonomic status

Scientific name	*Epilobium ciliatum Rafinesque*
Synonyms	*E. adenocaulon* Haussknecht
Family	Onagraceae
English name	Fringed willowherb
German name	Bewimpertes Weidenröschen
French name	Epilobe cilié
Italian name	Garofanino ciliato

Description and identification

Life form	Perennial herb.
Description	Simple to branched erect perennial, producing overwintering above-ground leafy rosettes or subterranean fleshy turions at the base in autumn, up to 140 cm tall. Stems glabrous below, with dense glandular hairs above. Leaves usually alternate above, at least in the inflorescence, sessile or with short petioles up to 6 mm long, lanceolate, rounded at the base, serrate. Flowers white to light pink, with 4 bifid petals. Stigmas 4, gathered in a club. Capsules linear, 3-10 cm long, pubescent. Seeds mostly 0.8-1.6 mm long, longitudinally ridged, the pappus attached to a short, broad, flattened beak at the tip of the seed. Several subspecies in its native range in North America.
Similar species	Native species: *E. dodonaei* Villars, *E. fleischeri* Hochstetter, *E. angustifolium* L., *E. hirsitum* L., *E. duriaei* Godron, *E. lanceolatum* Sebastiani et Mauri, *E. montanum* L., *E. collinum* Gmelin, *E. obscurum* Schreber, *E. palustre* L., *E. roseum* Schreber, *E. alpestre* (Jacquin), *E. parviflorum* Schreber, *E. tetragonum* s.l. L., *E. anagallifolium* Lamarck, *E. nutans* Schmidt, *E. alsinifolium* Villars. The most similar species is *E. obscurum* from which fringed willowherb can be distinguished by a large stem, glandular on top and white flowers.

Biology and ecology

Invaded habitats	In its native area, the species grows in marshes, ditches, riverbanks and other wetlands. In Europe, the plant invades relatively moist waste and cultivated ground, such as gardens, tree nurseries, rivers and railways where there is disturbance, and sometimes damp woods. It grows also in arable land under organic or integrated management.
Ecology and dispersal	Vegetative and sexual reproduction. A plant can produce up to 60,000 seeds that are dispersed by wind. *E. ciliatum* is one of the arable weed species with the highest rate of increase in Central Europe.

Origin	North America
Introduction and mode of spread	It was first collected in Britain in 1891; reached Scotland by 1957. Possibly was first introduced to England in timber, and has doubtlessly since been moved in soil and attached to animals, vehicles, etc.

Current status and distribution

Distribution in CH	Present in the Jura and Plateau. Expanding.
Distribution in Europe	Most of Europe except the Mediterranean region, e.g. Belgium,

Czech Republic, England, Germany. Listed as an invasive species in Austria and France. Also on a Watch List in Scotland.

Impacts

Environmental — In Scotland, the plant is considered benign from a conservation point of view, but this opinion would change if the species became more capable of invading dense vegetation. Hybridization is reported with 7 of the other 13 British species, e.g. with *E. palustre* and *E. montanum.* If these hybrids become capable of producing fertile seeds, they may successfully invade other vegetation types.

Economic — In Europe, the species is known to spread also in tree nurseries, fruit plantations and maize crops.

Management options — Herbicide resistance has been observed in areas where total weed control is applied. No specific control methods are described.

Information gaps — Potential spread and invasiveness. Environmental and economic impacts. Control methods.

References

Selected literature

Belde, M., Mattheis, A., Sprenger, B. and H. Albrecht (2000) Long-term development of yield affecting weeds after the change from conventional to integrated and organic farming. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz. Sonderheft 17, 291-301.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Oredsson, A. (1986) *Epilobium ciliatum* ssp. *ciliatum* naturalized and common in north-western Poland. Fragmenta Floristica et Geobotanica 31, 287-294.

Preston, C.D. (1989) The spread of *Epilobium ciliatum* Raf. in the British Isles. Watsonia 17, 279-288.

Welch, D. et al. (2000) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.habitas.org.uk/flora/default.htm?item=3557

http://www.npwrc.usgs.gov/resource/1999/vascplnt/species/ecil.htm

http://www.weedscience.org/Case/Reference.asp?ReferenceID=965

http://www.weedscience.org/Case/Reference.asp?ReferenceID=651

Galinsoga ciliata

Taxonomic status

Scientific name	*Galinsoga ciliata* (Raf.) S.F.Blake
Synonyms	*G. quadriradiata* auct. non Ruiz & Pavon, *G. caracasana* auct., non (DC.) Sch.Bip., *G. aristulata*
Family	Asteraceae
English name	Hairy galinsoga
German name	Bewimpertes Knopfkraut
French name	Galinsoga velu, Galingosa cilié
Italian name	Galinsoga ispida

Description and identification

Life form	Annual herb
Description	Summer annual, 10-60 cm tall. Stems erect to spreading, much branched, the branches opposite. Plant sparsely pilose below to densely pilose above, often with red, glandular trichomes intermixed on the younger branches and peduncles. Leaves opposite, ovate to lanceolate, serrate, hairy on both sides, with a short petiole. Capitula 4-7 mm in diameter, solitary or in loose clusters. Peduncle with glandular hairs. Ray flowers (4)-5, white, 1-2 mm. Disc flowers many, yellow. Involucre with sparse glandular hairs, involucral bracts on two rows. Receptacle conical. Inner receptacular scales entire or dentate. Achenes 1 mm long, black. Pappus scales scarious. Flowering period: from spring until end of autumn.
Similar species	*G. parviflora* Cavanilles (native to South America) is almost glabrous; inner receptacular scales 3-fid (see Fact Sheet).

Biology and ecology

Invaded habitats	Waste places, disturbed ground, vegetable gardens, cultivated fields with low-growing crops, railway yards and refuse dumps. Rarely present in established grasslands or other dense crop stands.
Ecology and spread	The plant occurs on a variety of soil types, but prefers damp, rich soil with high levels of N, P, and K. *G. ciliata* prefers open communities, where there is little competition for light. The plant is not hardy and is among the first species to succumb to frost in autumn. Seeds are not dormant and can germinate immediately upon contact with warm moist soil, so that it is possible to have several generations in 1 year. The species produces large quantities of small, lightweight seeds that can be blown by the wind, or transported by streams.

Origin	Central and South America
Introduction and dispersal	Possibly multiple independent introductions. *G. ciliata* is known to have been in the Kew Botanical Garden in England. The species is easily dispersed by wind and streams, in the fur of animals, on human clothes, in contaminated soil or on machinery. Observations made in the USA suggest that long-distance dispersal is accomplished mostly through human activities.

Current status

Distribution in CH	Common throughout the country.
Distribution in Europe	Most of Europe. Treated as an economic invasive species in

Austria. On the Watch Lists of invasive species in France and Portugal. Also invasive in north-eastern USA and eastern Canada. Considered as a sub-cosmopolitan weed, *G. ciliata* has also become established in Japan, India, parts of eastern Asia and Africa.

Impacts

Environmental — Potential negative impacts on ruderal communities.

Economic — The plant is a troublesome weed in low-growing vegetable crops such as beans, cabbages, and tomatoes, as well as in horticultural crops (USA). *G. ciliata* serves as alternate host for many insects and nematodes that affect crop species.

Management options — *G. ciliata* is best controlled when in early bloom to prevent seed production. Several herbicides provide good control. Black plastic mulch is a good control in intensive agricultural production or in home horticulture.

Information gaps — Economic impact.

References

Selected literature

Ivany, J.A. and R.D. Sweet (1973) Germination, growth, development and control of *Galinsoga*. Weed Science 21, 41-45.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Warwick, S.I. and R.D. Sweet (1983) The biology of Canadian weeds. 58. *Galinsoga parviflora* and *G. quadriradiata* (= *G. ciliata*). Canadian Journal of Plant Science 63, 695-709.

Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Other sources

Flora Europaea, web version: http://rbg-web2.rbge.org.uk/FE/fe.html

http://www.agron.iastate.edu/~weeds/WeedBiolLibrary/517%20student%20pages/2000/Galinsogad..htm

Galinsoga parviflora

Taxonomic status

Scientific name	*Galinsoga parviflora* Cavanilles
Synonyms	*G. quinquiradiata* Ruiz & Pav.
Family	Asteraceae
English name	Small flowered galinsoga
German name	Kleinblütiges Knopfkraut
French name	Galinsoga à petites fleurs
Italian name	Galinsoga comune

Description and identification

Life form	Annual herb
Description	Similar to *G. ciliata* (Rafinesque) (see Fact Sheet), but plant glabrous to sparsely pilose, usually becoming almost glabrous below. Leaves glabrous or sparsely pilose especially on margins and veins of undersurface, petiolate, usually ovate, sometime elliptic, acuminate and serrate. Capitula maximum 5 mm in diameter. Inner receptacular scales 3-fid. Flowering period: July-October.
Similar species	*Galinsoga ciliata* (see Fact Sheet).

Biology and ecology

Invaded habitats	Waste sites, gardens, fields and freshly disturbed soil. Rarely present in established grasslands or other dense crop stands.
Ecology and spread	Same as for *G. ciliata*, but *G. parviflora* can grow on slightly more acid soils.

Origin	South America
Introduction and dispersal	As for *G. ciliata*.

Current status

Distribution in CH	The plant occurs throughout the country but it is less common than *G*. *ciliata*, particularly in the west.
Distribution in Europe	Throughout Europe. Treated as an economic invasive species in Austria. A potential invasive species in Portugal. On the Watch List of invasive species in France. Also invasive in the eastern USA. Considered as a sub-cosmopolitan weed, *G. parviflora* has also become established in India, eastern Asia, Africa and Australia. It is more abundant than *G. ciliata* in these regions.

Impacts

Environmental	Potential negative impacts on ruderal communities.
Economic	The plant is a troublesome weed in low-growing vegetable crops such as beans, cabbages, onions, potatoes and tomatoes, as well as in horticultural crops, tobacco and maize (USA). *G. parviflora* is a reservoir for wilt virus that attacks tomatoes, for cucumber mosaic virus and other viruses. It is also an alternate host for many insects and nematodes that affect crop species.

Management options	As for *G. ciliata*.
Information gaps	Economic impact.

References

Selected literature

Ivany, J.A. and R.D. Sweet (1973) Germination, growth, development and control of *Galinsoga*. Weed Science 21, 41-45.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Warwick, S.I. and R.D. Sweet (1983) The biology of Canadian weeds. 58. *Galinsoga parviflora* and *G. quadriradiata* (= *G. ciliata*). Canadian Journal of Plant Science 63, 695-709.

Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Other sources

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.agron.iastate.edu/~weeds/WeedBiolLibrary/517%20student%20pages/2000/Galinsogad..htm

Helianthus tuberosus and Helianthus × laetifolius

Taxonomic status

Scientific name	*Helianthus tuberosus* F. and *Helianthus* × *laetifolius* Pers
Synonyms	*H. serotinus* Tausch
Family	Asteraceae
English name	Jerusalem artichoke
German name	Topinambur
French name	Topinambour
Italian name	Topinambur, Girasole del Canada

Description and identification

Life form	Perennial herb
Description	Stems stout, erect, 1-2.5 m. Rhizomes with numerous swollen potato-like tubers (*H. tuberosus*) or not (*H.* × *laetifolius*) which persist throughout winter. Leaves mostly opposite, broadly lanceolate long-pointed, narrowed to a winged stalk, coarsely toothed, rough-hairy, 6-20 cm long, 3-8 cm wide. Flower heads with a long pedicel, 4-8 cm across, solitary, erect; ray-florets yellow 2.4-4 cm long, 1 cm wide; disk florets yellow 1-2.5 cm wide. Achenes flat, 4-6 cm long, 1.5 mm wide. Flowering period: April-May.
Similar species	Two other North American species are subspontaneous in Switzerland: *H. annuus* L. and *H. rigidus* (Cassini). The distribution of *H. rigidus* is expanding.

Biology and ecology

Invaded habitats	Riverbanks, alluvial soils, waste sites.
Ecology and spread	The plant prefers full sun and moist nutrient-rich habitats. Dispersal is mainly vegetative by the rhizomes. Seed maturation is usually interrupted by frost in autumn and the plant produces few seeds.

Origin North America

Introduction and dispersal *H. tuberosus* was introduced to Europe in the 16th century and cultivated before potatoes in Britain. The identity of the invasive taxon is uncertain. The ornamental polymorphic hybrid *H*. × *laetiflorus* (*H. tuberosus* × *H. pauciflorus*) has been cultivated only recently and could be the species causing problems on Corsica.

Current status

Distribution in CH	Present in the Jura, Plateau, and south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Mostly Central Europe. Invasive in Austria and France. Potentially invasive in Spain.

Impacts

Environmental	Dense stands will likely have negative effects on native vegetation along riverbanks. The species could be as competitive as *Reynoutria japonica* Houttuyn in alluvial habitats.
Economic	No information.

Management options Single plants and smaller infestations can be hand-pulled. All tubers and rhizomes must be carefully removed and destroyed. Repeated mowing can eventually kill the plants.

Information gaps Identification of the invasive taxon. Distribution and potential spread. Invasiveness. Environmental impact.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Swanton, C.J., Cavers, P.B., Clements, D.R. and M.J. Moore (1992) The biology of Canadian weeds. 1001. *Helianthus tuberosus* L. Canadian Journal of Plant Science 72, 1367-1382.

Other sources

http://www.cps-skew.ch/

http://wwwcjb.unige.ch/

Info sheet on *Helianthus tuberosus*

Heracleum mantegazzianum

Taxonomic status

Scientific name	*Heracleum mantegazzianum* Sommier et Levier
Synonyms	*H. giganteum* Fisch. ex Hornem.
Family	Apiaceae
English name	Giant hogweed
German name	Riesenbärenklau
French name	Berce de Mantegazzi, Berce du Caucase
Italian name	Panace di Mantegazzi

Description and identification

Life form	Short-lived perennial herb.
Description	A large, stout herb with hollow stems of 2-5 m in height and up to 10 cm diameter, usually softly pubescent and with conspicuous purple blotches. Leaves are up to 3 m long, pinnately divided or lobed, with lateral segments up to 1.3 m long. Flowers appear in large umbels up to 50 cm in diameter, which have 50-150 rays. The white or pinkish petals are 10-12 mm long. Fruits are glabrous or pubescent, 8-14 mm long and 6-8 mm wide, flattened, with broad lateral wings. The plant has a thick taproot. Flowering period: July-September.
Similar species	Native species: *H. sphondylium* L. and *H. austriacum* L. *H. mantegazzianum* should not be mistaken for *H. sphondylium* which is much smaller than *H. mantegazzianum*, and the umbel has no involucre or only 1-3 bracts.

Biology and ecology

Invaded habitats	Riparian habitats, grassland, along railways, roadsides, forest edges, disturbed sites, waste land and near houses.
Ecology and spread	Giant hogweed prefers moist soils. It grows in fairly shady sites to full sun but does best in partial shade. Plants do not flower until the second, third or even fourth year. The plants are monocarpic, thus die after flowering in the second or third year. Reproduction is mainly through seeds. Abundant seed production of about 30,000 seeds, a persistent rootstalk, and vegetative reproduction from perennating buds can explain its capability to colonize rapidly and expand populations. Seeds are dispersed by water, soil movement and human activities, such as bee-keeping.

Origin	Caucasus (south-west Russia and northern Georgia)
Introduction and dispersal	Giant hogweed was introduced to Britain in the 19th century for ornamental reasons. The dried fruits are used as a spice in some countries.

Current status

Distribution in CH	Present in the Jura, Plateau, Alps (Vaud), south of the Alps. Locally invasive. Spreading. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Most of western, Central and northern Europe. It is invasive e.g. in France, Scotland and many areas in Central Europe (e.g. Czech Republic). Potentially invasive in Austria. Also a serious invasive species in North America.

Impacts

Environmental — The species forms extensive populations whose large rosettes crowd out native species and increase soil erosion along riverbanks. Giant hogweed increases the dead biomass in rivers and can produce hybrids with the native species *H. sphondylium*.

Economic — Proliferating populations in urban and suburban areas represents an increasing public health hazard. Exposure to the sap sensitizes the skin to sunlight and results in swelling, blisters and eruptions of affected parts. Recovery can take a long time, sometimes several years. The active principles are furanocoumarins. Giant hogweed may hinder access to water areas and be detrimental in recreational areas.

Management options — Control must aim at depleting the soil seed bank. Repeated cutting before flowering may reduce the plant's vigour. Plants can be killed if the taproot is cut 8-12 cm below ground level and much of the root stalk removed. Seedlings and young plants can be hand-pulled. Effective herbicides are glyphosate, triclopyr or imazapyr applied in spring. Always wear protective clothing and avoid getting the sap on the skin. Investigations for phytophagous insects and pathogens are being conducted in the native range of giant hogweed.

Information gaps — Potential spread. Environmental and economic impacts.

References

Selected literature

Caffrey, J.M. (1999) Phenology and long-term control of *Heracleum mantegazzianum*. Hydrobiologia 415, 223-228.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Pysek, P. and A. Pysek (1995) Invasion by *Heracleum mantegazzianum* in different habitats in the Czech Republic. Journal of Vegetation Science 6, 711-718.

Otte, A. and R. Franke (1998) The ecology of the Caucasian herbaceous perennial *Heracleum mantegazzianum* Somm. et Lev. (giant hogweed) in cultural ecosystems of Central Europe. Phytocoenologia 28, 205-232.

Tiley, G.E.D. and B. Philp (1997) Observations on flowering and seed production in *Heracleum mantegazzianum* in relation to control. In: Brock, J.H., M. Wade, P. Pysek, and D. Green (eds*)* Plant invasions: Studies from North America and Europe. Backhuys Publishers, Leiden, pp. 115-121.

Other sources

http://www.cps-skew.ch/
Info sheet on *H. mantegazzianum*

http://wwwcjb.unige.ch/
Info sheet on *H. mantegazzianum*

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua012.html

http://www.flec.kvl.dk/giant%2Dalien/
Information on research and management of giant hogweed

Impatiens balfourii

Taxonomic status

Scientific name	*Impatiens balfourii* Hooker F.
Synonym	*I. mathildae* Chiovenda, *I. insubrica* Beauvois
Family	Balsaminaceae
English name	Balfour's impatiens
German name	Balfours Springkraut
French name	Impatiente de Balfour
Italian name	Balsamina di Balfour

Description and identification

Life form	Annual herb.
Description	Similar to *I. glandulifera* but only 1 m tall or less. Leaves alternate, 5-10 cm long, glabrous, oval-lanceolate, with serrate margins. Stalks not glandulous. Inflorescences are axillary racemes with 10 or more pink-white zygomorphic flowers. Lower sepal narrows gradually to a long, slender, straight or slightly arched spur. Flowering period: July-September.
Similar species	*I. balfourii* can be distinguished from *I. glandulifera* Royle (see Fact Sheet) by its alternate leaves, smaller bicoloured flowers and the non-glandulous flower stalks. The neophyte species *I. parviflora* DC. (see Fact Sheet) and the native species *I. noli-tangere* L. have yellow flowers.

Biology and ecology

Invaded habitats	Waste sites and abandoned gardens.
Ecology and spread	More frost intolerant than *I. glandulifera*. Ruderal species. Disperses by seeds.

Origin	Himalayas
Introduction and dispersal	The mode of introduction into Europe is unknown.

Current status

Distribution in CH	Locally present throughout the country, more common south of the Alps. Expanding.
Distribution in Europe	Central and southern Europe. On the Watch List of invasive species in France (continental sector).

Impacts

Environmental	Likely to have a negative impact on the natural vegetation of ruderal or semi-natural communities.
Economic	Unknown

Management options	As for *I. glandulifera* and *I. parviflora*.
Information gaps	Invasiveness. Environmental impacts.

References

Selected literature

Ilijanic, L., Markovic, L. and Z. Stancic (1994) *Impatiens balfourii* Hooker fil. in Croatia. Acta Botanica Croatica 53, 115-119.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.
Beerling, D.J. and J.M. Perrins. (1993) *Impatiens glandulifera* Royle (*Impatiens roylei* Walp.). Journal of Ecology 81, 367-382.
Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources *http://www.cps-skew.ch/*

Impatiens glandulifera

Taxonomic status

Scientific name	*Impatiens glandulifera* Royle
Synonym	*I. roylei* Walp.
Family	Balsaminaceae
English name	Himalayan balsam
German name	Drüsiges Springkraut
French name	Impatiente glanduleuse
Italian name	Balsamina ghiandolosa

Description and identification

Life form	Annual herb
Description	A large, glabrous, annual, up to 50-200 cm in height, with stout and purplish hollow stems, 5-50 mm in diameter, simple, but branched above. Leaves opposite or in whorls of 3.5-18 cm long and 2.5-7 cm wide, lanceolate to elliptical, with serrate margins. Stalks and base of leaves glandular. Inflorescences are axillary racemes with 5-12 deep to pale purplish-pink, rarely white flowers. These are 2.5-4 cm long, zygomorphic, with a sepal sac 12-20 mm long that is abruptly contracted to a very narrow spur, 2-8 mm long. Fruits are capsules of 15-35 mm length, dehiscing elastically and coiling. They release 4-16 black seeds of 2-3 mm length. Flowering period: July-September.
Similar species	Native species: *I. noli-tangere* L. (yellow flowers). Alien species: *I. parviflora* DC. (yellow flowers) and *I. balfourii* Hooker F. (flowers smaller and bicoloured) (see Fact Sheets).

Biology and ecology

Invaded habitats	Riparian habitats, moist woods and forest edges.
Ecology and spread	Native habitats include moist sites in deciduous and mixed forest openings, shrubland, and hedges from 1800-3200 m elevation. In Europe, *I. glandulifera* tolerates a wide variety of soil types but requires high soil moistures and favours half-shaded and nutrient-rich conditions. Seeds are ejected explosively up to several metres and easily dispersed by streams over long distances. A single plant can produce up to 10,000 seeds. No persistent seed bank is regularly formed, but seeds can survive 2 years. Seeds require chilling in order to germinate in spring. Shoots are sensitive to frost although field local topography and individual plant size play a major role in determining the severity of frost damage to plants.

Origin	Western Himalayas
Introduction and dispersal	Introduced into Europe as a garden ornamental and nectar-producing plant in the first half of the 19th century. It was first recorded as a naturalized alien in 1855 in England.

Current status

Distribution in CH	Present in most of the country. Locally invasive in the Jura, Plateau and south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Present in almost all European countries. Common throughout northern Europe. Recorded as an invasive species e.g. in France and Austria. A potentially invasive species in Scotland. Also invasive in North America.

Impacts

Environmental	Where invasive, this large and fast-growing herb forms dense infestations that support few native species. Outcompetes the native species *I. noli-tangere* and probably other riparian vegetation.
Economic	Unknown

Management options Single plants and smaller infestations can be hand-pulled. Larger infestations are mown close to the ground, ideally shortly before flowering. Plants damaged early in the season are able to resprout and still produce new seeds. Cut plants with flowers must be carefully disposed of to prevent dissemination of seeds. The species can be tentatively contained by sowing native plants. An interesting target plant for biological control.

Information gaps Environmental impacts.

References

Selected literature

Drescher, A. and B. Prots (2000) Warum breitet sich das Drüsen-Springkraut (*Impatiens glandulifera* Royle) in den Alpen aus? Wulfenia 7, 5-26.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Beerling, D.J. and J.M. Perrins. (1993) Biological flora of the British Isles. *Impatiens glandulifera* Royle (*Impatiens roylei* Walp.). Journal of Ecology 81, 367-382.

Csontos, P. (1986) Phytosociological description of a hilly country stand of *Impatiens parviflora* DC. Studia Botanica Hungarica 19, 115-118.

Prowse, A. (1998) Patterns of early growth and mortality in *Impatiens glandulifera*. In: Starfinger, U., K. Edwards, I. Kowarik, and M. Williamson (eds) Plant invasions. Ecological mechanisms and human responses. Backhuys Publishers, Leiden, pp. 245-252.

Pysek, P. and K. Prachel (1995) Invasion dynamics of *Impatiens glandulifera* - a century of spreading reconstructed. Biological Conservation 74, 41-48.

Schmitz, G. (1991) The use of the neophytes *Impatiens glandulifera* Royle and *Impatiens parviflora* D.C. by phytophagous insects in the area of Bonn. Entomologische Nachrichten und Berichte 35, 260-264.

Schmitz, G. (1998) Alien plant-herbivore systems and their importance for predatory and parasitic arthropods: The example of *Impatiens parviflora* D.C. (Balsaminaceae) and *Impatientinum asiaticum* Nevsky (Hom.: Aphididae). In: Starfinger, U., K. Edwards, I. Kowarik, and M. Williamson (eds) Plant invasions. Ecological mechanisms and human responses. Backhuys Publishers, Leiden, pp. 335-345.

Schmitz. G. (1999) *Impatiens parviflora* D.C. (Balsaminaceae) as a neophyte species of Central European forests: Analysis of biocenoses. Zeitschrift für Oekologie und Naturschutz 7, 193-206.

Other sources

http://www.cps-skew.ch/
See info sheet on *Impatiens glandulifera*

http://wwwcjb.unige.ch/conservation/impatiens.html

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Impatiens parviflora

Taxonomic status

Scientific name	*Impatiens parviflora D.C.*
Synonyms	-
Family	Balsaminaceae
English name	Smallflower touchmenot, small balsam
German name	Kleines Springkraut
French name	Impatiente à petites fleurs
Italian name	Balsamina minore

Description and identification

Life form	Annual herb
Description	Erect annual herb, 30-70 cm tall. Leaves 5-15 cm, spirally arranged, oval-lanceolate, acuminate, tapered at the base into a winged stalk, serrate, with 20 or more forwardly-directed acute teeth on each side. Flowers 5-15 mm overall, in axillary 4-10 flowered racemes, pale yellow, not spotted. Spur straight, lower sepal ± conical. Capsule club-shaped, 1.5-2 cm long. Flowering period: June-October.
Similar species	*I. parviflora* can be distinguished from the native *I. noli-tangere* L. by its smaller unspotted pale yellow flowers, and the higher number of acute teeth on the leaves. Two other species are naturalized in Switzerland: *I. balfourii* Hooker F. and *I. glandulifera* Royle (see Fact Sheets).

Biology and ecology

Invaded habitats	Woods, waste ground, shady sites, hedgerows, gardens, parks, riverbanks.
Ecology and dispersal	Small balsam prefers relatively moist, nutrient-rich and shady habitats. Intolerant to late frost. The species disperses by seeds that are ejected explosively up to several metres.

Origin	Central Asia
Introduction and mode of spread	Since 1837 in Germany and later in a number of European countries. Escaped from several botanical gardens.

Current status and distribution

Distribution in CH	Present in most of the country below 800 m altitude Naturalized since the early 19th century. Expanding.
Distribution in Europe	Naturalized in most European countries except the Mediterranean region. On the list of invasive species in France.

Impacts

Environmental	Where invasive, *I. parviflora* forms dense populations that support few native species. It outcompetes the native species *I. noli-tangere*.
Economic	Unknown

Management options	No specific control methods are known. As for *I. glandulifera*, single plants and smaller infestations can be hand-pulled. Larger infestations are mown close to the ground, preferably shortly before flowering. Plants damaged early in the season are able to resprout and still produce new seeds. Cut plants with flowers must be

carefully disposed of to prevent dissemination of seeds.

Information gaps Environmental impacts.

References

Selected literature

Coombe, D.E (1956) *Impatiens parviflora* DC. Journal of Ecology 44, 701-713.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Lonicera henryi

Taxonomic status

Scientific name	*Lonicera henryi* Hemsl.
Synonym	*L. acuminata* Wall.
Family	Caprifoliaceae
English name	Henry's honeysuckle
German name	Immergrünes Geissblatt
French name	Chèvrefeuille Henryi
Italian name	Caprifoglio Henryi

Description and identification

Life form	Evergreen climber.
Description	Young shoots hairy, growing up to 5 m, climbing or creeping. Leaves oblong-lanceolate, 4-10 cm long, 1.5-3.5 cm wide, dark green and glabrous above, hairy on the margin and the midrib, paler and glossy green beneath. Base often cordate, apex acuminate. Inflorescence in terminal clusters in June. Flowers paired, purplish-red-orange, 2 cm long with two reflexed tips. Fruits black, pruinose. Flowering period: June-August.
Similar species	11 congeneric species. Native: *L. periclymenum* L., *L. xylosteum* L., *L. nigra* L., *L. alpigena* L. and *L. caerulea* L. Alien: *L. tatarica* L., *L. pileata* Oliver, *L. japonica* Thunberg (see Fact Sheet) and *L. nitida* Wilson. The origin of *L. etrusca* Santi and *L. caprifolium* L. is uncertain.

Biology and ecology

Invaded habitats	Forests, forest margins.
Ecology and spread	The plant prefers slightly moist and acidic soils in half-shaded habitats. It spreads vegetatively by stem layering in autumn and dispersal of seeds. Seeds require a stratification period of 2 months.

Origin China

Introduction and dispersal Imported as an ornamental.

Current status

Distribution in CH	Present in the Jura, Plateau, and south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Not in Flora Europaea. Cultivated in France and Germany.

Impacts

Environmental	Likely to have negative impacts on native vegetation.
Economic	No information available.

Management options No information available. Likely to be identical to *L. japonica.*

Information gaps Potential spread and distribution. Potential environmental and economic impact.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Other sources	*http://www.cps-skew.ch/* Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html* *http://www.biologie.uni-ulm.de/systax/dendrologie/lonichenryfw.htm*

Lonicera japonica

Taxonomic status

Scientific name	*Lonicera japonica* Thunberg
Synonym	-
Family	Caprifoliaceae
English name	Japanese honeysuckle
German name	Japanisches Geissblatt
French name	Chèvrefeuille du Japon
Italian name	Caprifoglio giapponese

Description and identification

Life form	Semi-evergreen climber.
Description	A woody vine or twining shrub climbing up to 10 m tall, or creeping on the ground. Branchlets pubescent. Leaves in opposite pairs, short-stalked, ovate to oblong-ovate, sometimes lobed, 3-8 cm long and 2-4 cm wide, pubescent when young, a lighter green on the underneath than on the upper surface, and with ciliate margins. Fragrant white flowers grow in pairs and turn yellow with age. The peduncles are 5-10 mm long, the corollas 3-5 cm long. The corolla is white tinged with purple and has a narrow tube. Fruits are black to purple berries of 5-7 mm diameter, containing a few seeds of c. 2 mm in diameter. Flowering period: June-September.
Similar species	Native species: *L. periclymenum* L., *L. xylosteum* L., *L. nigra* L., *L. alpigena* L., and *L. caerulea* L. Alien: *L. tatarica* L., *L. pileata* Oliver, *L. henryi* Hemsley (see Fact Sheet) and *L. nitida* Wilson. The origin of *L. etrusca* Santi and *L. caprifolium* L. is uncertain.

Biology and ecology

Invaded habitats	Riparian forests, grassland, heathland, forest openings, edges of wetlands, fencerows.
Ecology and spread	In its native habitat in Korea, *L. japonica* is part of the understorey in later successional forests. It grows most vigorously in full sun and on rich soil, but is shade tolerant and drought tolerant and therefore able to grow in a wide variety of habitats. *L. japonica* invades disturbed communities. The vine spreads rapidly, and grows over and smothers small trees and shrubs. It grows as a ground layer on forest floors and quickly climbs into canopies in tree gaps where light is increased. It often forms a curtain of vines on forest edges and displaces the understorey shrub layer. Stems easily root at nodes. Seeds are dispersed by fruit-eating birds.

Origin	Temperate east Asia, including Japan and Korea.
Introduction and dispersal	Introduced as an ornamental species in the 19th century. Several cultivars have become naturalized.

Current status

Distribution in CH	Plateau, but most common and invasive south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Known from Britain, France, Germany, Spain, Italy. *L. japonica* is a serious invasive species in eastern USA, Australia and New Zealand, banned for sale in the last-named country.

Impacts

Environmental	Once established, the dense canopy of *L. japonica* inhibits establishment of later successional species and has a negative impact on native shrubs and trees.
Economic	Unknown

Management options

Whereas small plants can be hand-pulled, established vines are effectively controlled by a foliar application of glyphosate shortly after the first severe frost. Other effective herbicides are bromacil, hexazinone or picloram. Pulling, cutting or mowing may stimulate dense resprouting. If plants are dug out, all crowns and rooting stems must be removed and destroyed.

Information gaps

Environmental and economic impact.

References

Selected literature

Barden, L.S. and J.F. Matthews (1980) Change in abundance of honeysuckle (*Lonicera japonica*) and other ground flora after prescribed burning of a Piedmont pine forest. Castanea 45, 257-260.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Williams, P.A. and S.M. Timmins (1999) Biology and ecology of Japanese honeysuckle (*Lonicera japonica*) and its impact in New Zealand. Science for Conservation No. 99. New Zealand Department of Conservation. Wellington.

Williams, P.A., Timmins, S.M., Smith, J.M.B., and P.O. Downey (2001) The biology of Australian weeds. 38. *Lonicera japonica* Thunb. Plant Protection Quaterly 16, 90-100.

Other sources

http://www.cps-skew.ch/
Info sheet on *Lonicera japonica*

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://tncweeds.ucdavis.edu/esadocs/documnts/lonijap.html
The Nature Conservancy (1997) *Lonicera japonica*. Element Stewardship Abstract.

Ludwigia grandiflora

Taxonomic status

Scientific name	*Ludwigia grandiflora* (M. Micheli) Greuter & Burdet
Synonyms	There are 22 known synonyms, e.g. *L. hexapetala* (Hook. & Arn.) Zardini, Gu & Raven*, L. uruguayensis* (Camb.) Hara, *Jussiaea grandiflora* Michx., *J. michauxiana* Fern., *J. repens* L. var. *grandiflora* M. Micheli, *J. uruguayensis* Camb.
Family	Onagraceae
English name	Largeflower primrose-willow, water primrose
German name	Ludwigie
French name	Jussie à grandes fleurs
Italian name	-

Description and identification

Life form	Aquatic perennial herb.
Description	Emergent aquatic herb, rooted up to 2 m below the water surface, stems up to 6 m long, erect or ascending up to 80 cm above the water surface. Leaves alternate, lanceolate, entire, 1.5-2.5 cm wide and 7-12 cm long, slightly hairy. Flowers solitary from the upper leaf axils, flower stalk short. Flowers are 2-5 cm in diameter, 5 petals, bright yellow. The capsules are elongate, elliptic, with 5 locules containing many small (1.5 mm) seeds. Flowering period: June-September.
Similar species	A very similar species is *L. peploides* (HBK) Raven, native in Florida. This species can be distinguished from *L. grandiflora* by its oblong to round, subentire and glabrous leaves and smaller flowers. There is some taxonomic confusion in the *Ludwigia* complex and many European records refer to *Ludwigia* sp. or *Ludwigia* spp.

Biology and ecology

Invaded habitats	The plant is found in marshes, along marshy shores, in ponds, lakes, ditches and irrigation and drainage canals, and in shallow, still or slowly flowing streams. The recent colonization of wet grasslands in southern France has increased concern about the potential negative impacts of water primrose in Europe.
Ecology and dispersal	The aerial stems are killed by frost, but the rhizomes will survive as indicated by the recent colonization of *L. grandiflora* in the continental climate of north-eastern France. Water primrose grows in dense mats and disperses mainly by stem fragments. Seed production seems to be very small in Europe. The growth is very fast, the biomass can double within 15 days in standing water.

Origin	South America
Introduction and mode of spread	*L. grandiflora* was introduced in the botanical garden at Montpellier, France, around 1823 and intentionally released in 1830 in the wild. The spread of water primrose has been very significant during the last 2 decades in France, and now in other European countries. Plant fragments are easily spread by shipping, waterfowl and other birds and human activity. The plant is also commercialized as an ornamental.

Current status and distribution

Distribution in CH	Water primrose has only been found recently in Genève. On the

	Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	In France, the species is already present in half of the country. Water primrose has started to colonize Spain, Italy, Belgium and the Netherlands.

Impacts

Environmental	The plant forms dense stands that eliminate the native vegetation. The functioning of the whole ecosystem can be altered. Large plant biomass results in a reduction in dissolved oxygen, an increase in the acidity of the water, the eutrophication of the water body, and an increase in sedimentation. Dense mats also reduce the habitat of surface water birds.
Economic	Large colonies can hinder small boat navigation and recreational use of shoreline areas, and hamper access to the water. It can affect irrigation as well as drainage and flood control in canals and ditches.

Management options

Mechanical methods can be used to remove water primrose. However, it is essential to prevent the spread of plant fragments by creating filters downstream before any mechanical treatment is carried out. All plants removed must be carefully disposed of to prevent dissemination of fragments. Draining of the water body and removal of the sediment can provide a good solution but is a very drastic disturbance and probably harms the habitat. None of the methods tested provide effective long-term control. Once the species is established, it is very difficult if not impossible to eradicate it or stop the long-term re-infestation and spread of water primrose. Biological control seems to be an attractive potential control method.

The commercialization of *L. grandiflora* (and *L. peploides*) should be prohibited.

Information gaps

Potential spread and distribution. Prevention.

References

Selected literature

Anonymous (2002) Pour contrôler la prolifération des jussies (*Ludwigia* spp.) dans les zones humides méditerranéennes. Guide technique. Agence Méditerrannéenne de l'Environnement. Région Languedoc-Roussillon, 68 pp.

McGregor, M.A., Bayne, D.R., Steeger, J.G., Webber, E.C. and E. Reutebuch (1996) The potential for biological control of water primrose (*Ludwigia grandiflora*) by the water primrose flea beetle (*Lysathia ludoviciana*) in the south-eastern United States. Journal of Aquatic Plant Management 34, 74-76.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

http://www.cps-skew.ch/
See info sheet on *Ludwigia grandiflora*

http://www.nwcb.wa.gov/weed_info/primrose.html

http://www.plantatlas.usf.edu/main.asp?plantID=135

http://www.cps-skew.ch/jussie.pdf *http://www.espace-riviere.org/ripisylv/jussie.htm*

Lupinus polyphyllus

Taxonomic status

Scientific name	*Lupinus polyphyllus* Lindley
Synonyms	-
Family	Fabaceae
English name	Large-leaved lupin, Russel lupin
German name	Vielblättrige lupine
French name	Lupin à folioles nombreuses
Italian name	Lupino foglioto

Description and identification

Life form	Perennial herb
Description	Herbaceous perennial up to 60-150 cm tall. Stems sparsely to moderately hairy, erect, branched from base. Leaflets 9-17, usually ± glabrous above, sparsely to moderately sericeous below, narrowly elliptic to oblanceolate, acute to acuminate, 4-15 cm long and 1-3 cm wide. Inflorescence 15-50 cm long, many-flowered; lower flowers alternate; upper flowers subverticillate; pedicels 5-14 mm long. Calyx densely hairy; upper lip shallowly 2-toothed; lower lip slightly longer, entire. Corolla blue, rarely purple, pink, or whitish. Pod densely villous, 3-6 cm long, containing 5-10 seeds. Seeds ellipsoid, smooth. Flowering period: May-September.
Similar species	There are no native *Lupinus* species. *L. albus* L. and *L. angustifolius* L. have been introduced from the Mediterranean region.

Biology and ecology

Invaded habitats	Mountain meadows, abandoned meadows and pastures, wet grasslands, riparian zones, forest clearings, road verges.
Ecology and dispersal	A mountain pioneer and ruderal species, which prefers moderately moist and shaded sites. Vegetative and sexual reproduction. Long-distance dispersal by seeds.

Origin	North America
Introduction and mode of spread	Sown in the early 20th century for the amelioration of forest sites and the promotion of spruce plantations (Germany). Also sold as an ornamental species.

Current status and distribution

Distribution in CH	Locally present in the Jura, Plateau and Graubünden. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Most of Central and northern Europe. A potential invasive species in Austria. Locally invasive in Germany where it has been established since 1890. It is also an invasive species in New Zealand.

Impacts

Environmental	It has a negative impact on the native vegetation. In the central South Island of New Zealand, the specific damage by *L. polyphyllus* has been the colonization of braided riverbeds and loss of the open shingle habitats required by a number of river birds. In Germany, the plant replaces species-rich dry grasslands with monocultures.

Economic	No specific information. The plant contains alkaloids; the seeds and seedpods can be poisonous to cattle.
Management options	Grazing by sheep can regulate lupin. However, long-distance dispersal can take place since sheep excrete undigested seeds. A survey of plant pathogens as prospective biological control agents has been carried out in New Zealand.
Information gaps	Potential spread. Invasiveness. Prevention.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Otte, A., Ober, S., Volz, H. and E. Weigand (2002) Effekte von Beweidung auf *Lupinus polyphyllus* Lindl. in Bergwiesen des Biosphärenreservates Rhön. In: Kowarik, I. and U. Starfinger (eds), Biologische Invasionen. Herausforderung zum Handeln? Neobiota 1, 101-133.

Webb, C.J., Sykes, W.R. and J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.hortnet.co.nz/publications/nzpps/proceedings/96/96_119.htm

Mahonia aquifolium

Taxonomic status

Scientific name	*Mahonia aquifolium* (Pursh) Nuttall
Synonyms	*Berberis aquifolium* Pursh
Family	Berberidaceae
English name	Oregon grape
German name	Mahonie
French name	Mahonie
Italian name	Maonia

Description and identification

Life form	Evergreen fleshy-fruited shrub.
Description	Shrub up to 2 m tall, many-stemmed and stoloniferous, without spines. Leaves up to 25 cm long, composed of 2-4 pairs of sessile (excluding the terminal) leaflets. Most leaflets 5 cm long, ovate or elliptic-ovate, glossy above, prominently reticulate; margins undulate and spinose-dentate; apex spiny. Scales at base of fascicled racemes 5-10 mm long, membranous, brown. Racemes 3-5 cm long; flowers light yellow. Berries c. 10 mm in diameter, globose, blue-black, pruinose.
Similar species	There are no similar species. *Berberis vulgaris* L. is the only native species in the family Berberidaceae.

Biology and ecology

Invaded habitats	Forests, ruderal sites.
Ecology and dispersal	The species grows best in mesic-moist and shaded habitats in areas with relatively mild winters. Clonal growth takes place through below-ground stolons and by stem layering. In contrast to many other clonal plants, repeated seedling recruitment takes place in *M. aquifolium*, contributing to the colonization of available space within populations and to the local invasion process. In situations with grass competition, the number of successful recruits is reduced, and clonal growth is the dominant mode of reproduction. Sexual reproduction is also important for dispersal to new sites.

Origin Western North America

Introduction and mode of spread Introduced to Europe as an ornamental plant in 1922. Spread within Europe by trade in ornamentals. In North America, the plant also has a long history of medical use. The plant is known for its antipsoriatic active constituents and the potential antimutagenic/anticarcinogenic alkaloids contained in the stem bark.

Current status and distribution

Distribution in CH	Present in the Jura, Plateau and south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Present in various parts of Europe, mostly in Central and western Europe. Among the most successful alien shrubs in central and eastern Germany.

Impacts

Environmental	Not documented, but dense stands of *M. aquifolium* will likely have

a negative impact on native vegetation. The fruits of *M. aquifolium* are colonized by the native fruit fly *Rhagoletis meigenii* Loew (Diptera: Tephritidae), a seed predator of the native shrub *Berberis vulgaris* L. The ongoing invasion by *M*. *aquifolium* will strongly increase the abundance of this insect. This could lead to indirect effects on its original host, its parasitoids, and other hosts of those parasitoids.

Economic — Unknown

Management options — Unknown

Information gaps — Potential spread. Control options.

References

Selected literature

Auge, H. (1997) Biologische Invasionen: Das Beispiel *Mahonia aquifolium*. In: Feldmann R., K. Henle, H. Auge, J. Flachowsky, S. Klotz and R. Krönert (eds), Regeneration und nachhaltige Landnutzung: Konzepte für belastete Regionen. Springer, Berlin, pp. 124-129.

Auge, H. and R. Brandl (1997) Seedling recruitment in the invasive clonal shrub, *Mahonia aquifolium*. Oecologia 110, 205-211.

Auge, H., Brandl, R. and M. Fussy (1997) Phenotypic variation, herbivory and fungal infection in the clonal shrub *Mahonia aquifolium* (Berberidaceae). Mitt. Dtsch. Ges. allg. angew. Ent. 11, 747-750.

Soldaat, L.L. and H. Auge (1998) Interactions between an invasive plant, *Mahonia aquifolium*, and a native phytophagous insect, *Rhagoletis meigenii*. In: Starfinger U., K. Edwards, I. Kowarik and M. Williamson (eds), Plant invasions: ecological mechanisms and human responses. Backhuys Publishers, Leiden, pp. 347-360.

Cernakova, M., Kostalova, D., Kettmann, V., Plodova, M., Toth, J. and J. Drimal (2002) Potential antimutagenic activity of berberine, a constituent of *Mahonia aquifolium*. BMC Complementary and Alternative Medicine 2, 2.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.newcrops.uq.edu.au/listing/mahoniaaquifolium.htm

Oenothera biennis aggr.

Taxonomic status

Scientific name	*Oenothera biennis* L. aggr.
Synonyms	*Onagra biennis* (L.) Scop. The complex includes two species: *Oe. glazioviana* Micheli and *Oe. biennis* s.str.
Family	Onagraceae
English name	Evening primose
German name	Zweijährige Nachtkerze
French name	Onagre bisannuelle
Italian name	Enagra commune

Description and identification

Life form	Biennial herb
Description	An erect, robust, sometimes branched, tap-rooted biennial herb, 0.5-1 m tall. Rosette leaves narrowly lanceolate, long petiolated, hairy. Stem leaves numerous, with winged petiole or apetiolate, lanceolate, up to 15 cm long, 3-6 times longer than wide, entire or with a finely toothed margin. Inflorescence like a slender spike of yellow flowers. Petals 4, corolla tube 1.5-4.5 cm. Sepals long, turned downward on the pedicel. Fruit cylindrical, 4-8 mm wide and 1.5-3 cm long. Flowering period: June-September.
Similar species	*O. parviflora* L. (also of North American Origin) has a reddish, hairy stem and heart-shaped petals, =1.5 cm long.

Biology and ecology

Invaded habitats	Waste sites, disturbed ground, stony areas and neglected fields.
Ecology and spread	Pioneer species. Prefers relatively dry soils. Reproduces and disperses by seed. Seeds are dispersed short distances by wind, and are also ingested by birds and subsequently released intact.

Origin	North America
Introduction and dispersal	The plant was introduced to Europe early in the 17th century as an ornamental. The young leaves were also eaten in salads. The plant has a long history of use as a medicinal plant.

Current status

Distribution in CH	Common throughout the country.
Distribution in Europe	Most of Europe. Invasive in France. On the Watch Lists of alien species in Spain and Scotland.

Impacts

Environmental	Dense populations can have a negative impact on the native vegetation.
Economic	Unknown

Management options	Mowing before plants have set seeds. Ploughing destroys the rosette stage and prevents seed formation. Cultivation does however bring seeds to the soil surface where conditions are favourable for germination.
Information gaps	Environmental and economic impacts.

References

Selected literature

Hall, I.V., Steiner, E., Threadgill, P. and R.W. Jones (1988) The biology of Canadian weeds. 84. *Oenothera biennis* L. Canadian Journal of Plant Science 68, 163-173.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Mihulka, S. and P. Pysek (2001) Invasion history of *Oenothera* congeners in Europe: a comparative study of spreading rates in the last 200 years. Journal of Biogeography 28, 597-609.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Paspalum dilatatum

Taxonomic status

Scientific name	*Paspalum dilatatum* Poiret
Synonyms	*Digitaria dilatatum* (Poiret) Coste.
Family	Poaceae
English name	Dallisgrass
German name	Brasilianische Hirse
French name	Panic du Brésil
Italian name	Panico brasilinao

Description and identification

Life form	Rhizomatous perennial
Description	A leafy, tufted perennial with clustered stems arising from short, creeping rhizomes. Culms up to 1 m. Leaf blades flat, about 3-10 mm wide, 6-25 cm long, with a few basal hairs. Loose inflorescence of 3-6 racemes, alternate along the flowering stalk; raceme nodding, 2-10 cm long; spikelets paired, 3-4 mm long, ovate, flat, green or purplish. Upper glume sparsely hairy on the surface, more densely villous near the margin. Rhizomes with short internodes that look like concentric rings on the surface.
Similar species	A larger version of *P. dilatatum*, Vasey grass (*P. urvillei* Steudel), grows in some drier sites in southern Europe. Another exotic species of concern, *P. paspalodes* (Michaux) Scrib., does not occur in Switzerland. No native species.

Biology and ecology

Invaded habitats	Riverbanks, drainage ditches, roadsides, railway tracks, damp shady sites and waste ground. Also in turfgrass, irrigated orchards and gardens.
Ecology and dispersal	It grows best in heavy, moist, fertile, alluvial and basaltic clay soils. It is sensitive to flooding when actively growing, but is less so during its dormant period. Once established, it is drought-resistant and frost-tolerant. Dallisgrass produces abundant amounts of seeds, which are its primary means of dispersal. It can also reproduce by root fragments particularly when it is damaged by cultivation.

Origin	Native to South America (Brazil, Argentina, Uruguay).
Introduction and mode of spread	Accidentally introduced in Europe (Spain) in the early 20th century by the wool industries. Introduced in Italy in the 1960s as a forage plant. Seeds are spread by sticking to animals, clothing, machinery and vehicles, and in water. The basal parts of the plant may be broken and spread by earth moving and cultivation. The plant is cultivated and commercialized as a forage plant in several areas worldwide although it is considered as an invasive species in almost 30 countries.

Current status and distribution

Distribution in CH	South of the Alps, rare.
Distribution in Europe	Mostly south-western Europe and Italy. It has the status of an invasive species in France, Spain and Portugal. Present in most temperate areas worldwide.

Impacts

Environmental	In southern France, dallisgrass invades wet grassland and marshes and has a negative impact on the native vegetation.
Economic	No economic impacts are reported in Europe. In the USA, *P. dilatatum* can be a problem in golf courses, sports fields or home landscapes. The weed forms unsightly clumps in lawns that are difficult to remove selectively.
Management options	Plants can be removed by hand although a mattock will normally be required to remove the entire crown and prevent regrowth where plants are well established. Affected areas need to be resown with desirable species after the removal of the plant. Grazing and mowing can be used to prevent seed production, but putting stock in after the plants have begun seeding will spread the weed. The plant is quite resistant to mowing, trampling and many herbicides. Cultivation is effective if it breaks up the *Paspalum* clumps and leaves the small fragments to desiccate on the soil surface.
Information gaps	Potential spread. Invasiveness.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Tutin, T.G. et al. (eds) (1980) Flora Europaea. Vol. 5. Cambridge University Press.

Other sources

http://www.dijon.inra.fr/malherbo/hyppa

http://www.fao.org/ag/AGP/AGPC/doc/GBASE/data/pf000288.htm

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7491.html

Phytolacca americana

Taxonomic status

Scientific name	*Phytolacca americana* L.
Synonyms	*P. decandra* L.
Family	Phytolaccaceae
English name	American pokeweed, pokeberry
German name	Amerikanische Kermesbeere
French name	Raisin d'Amérique
Italian name	Cremesina uva turca

Description and identification

Life form	Herbaceous perennial
Description	A tall, erect, branched, glabrous, semi-succulent herb, 1-3 m tall. Stems thick with soft wood, often reddish. Leaves ovate to ovate-oblong, 12-25 cm long, alternate, petiole short. Flowers stalked, greenish or pinkish, in dense, cylindrical spikes (racemes) to 10 cm, drooping when mature. Tepals 5, 2-4 mm long, ovate, persistent, white or greenish, becoming pink or rose. Stamens 10, almost as long as tepals. Fruit a globular cluster of 10 fleshy, berry-like carpels, at first reddish and then purplish-black, c. 10 mm in diameter. Flowering period: July-August.
Similar species	*P. esculenta* Van Houtte (native in eastern Asia) can be distinguished from *P. americana* by its erect racemes.

Biology and ecology

Invaded habitats	Waste ground, disturbed sites, open woods, pastures, prairies, roadsides and railways. In the USA, *P. americana* is reported to invade maize and soyabean fields that have been managed under continuous no-tillage crop production practices.
Ecology and dispersal	A ruderal species. Seeds widely dispersed by birds but the plant can also spread vegetatively from root buds.

Origin Eastern North America.

Introduction and mode of spread Introduced in the 1700s as an ornamental.

Current status and distribution

Distribution in CH	Mostly south of the Alps, but also recorded in northern Switzerland.
Distribution in Europe	Widely naturalized in southern Europe, and locally in Central and western Europe. Listed as a potentially invasive species in Portugal and on a Watch List in France.

Impacts

Environmental	Forms dense stands that can outcompete native vegetation and prevent regeneration of forest species. Berries, roots and mature parts of plant are toxic to livestock and humans.
Economic	Unknown

Management options Mechanical controls such as mouldboard ploughing and discing are effective in crops.

Information gaps Environmental and economic threats.

References

Selected literature

Hyatt, L.A. (1998) Spatial patterns and causes of overwinter seed mortality in *Phytolacca americana*. Canadian Journal of Botany 76, 197-203.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Polunin, O. (1997) Flowers of Europe. A field guide. Oxford University Press.

Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV, Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.ceh.ac.uk/epidemie/

http://www.cropsci.uiuc.edu/classic/2002/Article2/

Polygonum polystachyum

Taxonomic status

Scientific name	*Polygonum polystachyum* Meissner
Synonyms	*Persicaria polystachya* (Wall. Ex Meissn.), *Reynoutria polystachya* (Meisn.) Moldecke
Family	Polygonaceae
English name	Himalayan knotweed
German name	Vielähriger Knöterich, Himalaja Knöterich
French name	Renouée à épis nombreux, Renouée de l'Himalaya
Italian name	Poligono con spighe numerose

Description and identification

Life form	Rhizomatous perennial herb.
Description	A rather robust hairy perennial, 1-2 m tall, with white or pale pink bisexual flowers in lax, leafy, branched, spreading clusters. Similar to *Polygonum alpinum* Allioni, but taller with stout red stems, large oblong, lance-shaped leaves up to 30 cm long, with the base slightly sagitate or heart shaped, and brown, persistent sheaths at the base of the leaf stalk. Fruit pale glossy brown. Flowering period: August-September.
Similar species	Native species: *P. aviculare* L., *P. alpinum*, *P. bistorta* L., *P. persicaria* L., *P. amphibium* L., *P. lapathifolium* L., *P. hydropiper* L., *P. mite* Schrank, *P. minus* Hudson, *P. viviparum* L. Alien species: *P. orientale* L. *P. polystachum* can be distinguished from *R. japonica* Houttuyn (see Fact Sheet) by its slightly hairy stems and its long, pointed leaves.

Biology and ecology

Invaded habitats	Damp meadows, forest edges, waste ground and hedges.
Ecology and spread	A ruderal species, Himalayan knotweed will grow on most soil types, but requires moisture. It grows in full sun but prefers partial shade. The plant spreads vigorously, both by seed and through creeping underground rhizomes.

Origin	Himalayas
Introduction and dispersal	Introduced as a garden ornamental.

Current status

Distribution in CH	Present in the Jura, Plateau and south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Most of Central Europe.

Impacts

Environmental	Dense clones will displace native vegetation and reduce biodiversity.
Economic	No information.

Management options	Little information but likely to be the same as for *R. japonica*. The plant is difficult to eradicate once it is established. It is, therefore, important to prevent new infestations and eradicate small patches before they spread. Grubbing is effective for small populations. The

entire root system must be removed and destroyed, since resprouting can occur from long rhizomes. Mowing followed by herbicide treatments will provide some control.

Information gaps Potential spread. Environmental and economic impacts.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://pi.cdfa.ca.gov/weedinfo/POLYGONU2A.html

Prunus laurocerasus

Taxonomic status

Scientific name	*Prunus laurocerasus* L.
Synonyms	*Laurocerasus officinalis* (L.) Loiseleur
Family	Rosaceae
English name	Cherry laurel, common laurel
German name	Kirschlorbeer
French name	Laurier-cerise
Italian name	Lauroceraso

Description and identification

Life form	Evergreen tree or shrub.
Description	An evergreen glabrous shrub or small tree, up to 6 m tall, with thick leathery, broadly lanceolate entire dark green leaves, with bright shiny upper surface, 10-15 cm long. Flowers in 10-15 cm long, slender, erect spikes. Petals white, 3 mm. Fruit globulous or ovoid, shining black, 7-10 mm in diameter. Flowering period: April-May.
Similar species	Native species: *P. spinosa* L., *P. avium* L., *P. padus* L., *P. mahaleb* L. Alien species: *P. armeniaca* L., *P. persica* (L.), *P. dulcis* (Miller), *P. insititia* L., *P. domestica* L., *P. cerasus* L. and *P. serotina* Ehrhart (see Fact Sheet).

Biology and ecology

Invaded habitats	Forests
Ecology and spread	In its natural habitat, the plant grows in woodland areas and requires slightly acidic soil. Tolerates full sun and shade, but not considered drought resistant. It is a poisonous plant. The leaves contain cyanogenic glycosides. Seeds are spread by birds that eat the berries. Cherry laurel also reproduces by root suckering, layering and stump sprouting.

Origin	Southern Europe, Asia Minor.
Introduction and dispersal	The plant was introduced as an ornamental into Europe in about 1580. Often planted as hedges. Used as a medicinal plant as well. More than 40 cultivars known.

Current status

Distribution in CH	Present in the Jura, more common on the Plateau and south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Known from Great Britain, Ireland, France, Portugal, and the Balkans. On the list of potentially invasive species in France.

Impacts

Environmental	Dense stands outcompete native species and this will reduce the biodiversity of invaded sites.
Economic	Unknown

Management options	Cutting generally increases sprout productivity. Little information is available on specific control methods.
Information gaps	Environmental and economic impacts. Control methods.

References

Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Other sources	*http://www.cps-skew.ch/* Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html* *http://www.floridata.com/ref/p/prun_lau.cfm* *http://www.emea.eu.int/pdfs/vet/mrls/067599en.pdf*

Prunus serotina

Taxonomic status

Scientific name	*Prunus serotina* Ehrhart
Synonyms	*Padus serotina* Ehrhart
Family	Rosaceae
English name	Black cherry
German name	Spätblühende Traubenkirsche
French name	Cerisier tardif
Italian name	Pruno autunnale

Description and identification

Life form	Deciduous tree
Description	A deciduous tree growing up to 20 m tall, also sometimes a shrub. Leaves alternate, oval to oblong, lance-shaped, coriaceous, dark green and lustrous above, usually with a dense yellowish-brown pubescence along the mid-rib below; margins finely serrate. White flowers in racemes, first erect, later bending. Pedicels 3-6 mm long, shorter than those of *P. padus* L. that are about 10-15 mm. Fruits dark purple to black, stone smooth. Flowering period: May-June.
Similar species	Native species: *P. spinosa* L., *P. avium* L., *P. padus*, *P. mahaleb* L. Alien species: *P. armeniaca* L., *P. persica* (L.), *P. dulcis* (Miller), *P. insititia* L., *P. domestica* L., *P. cerasus* L. and *P. laurocerasus* L. (see Fact Sheet). *P. serotina* can be distinguished from the other *Prunus* species by the persistent calyx on the mature fruits.

Biology and ecology

Invaded habitats	Woodland, forest margins, especially on dry and poor sites.
Ecology and spread	The species grows in a wide range of eco-climatic conditions and is well adapted to acidic soils. Seed dispersal is by birds and mammals that eat the berries. Black cherry reproduces vigorously by root suckering and stump sprouting.

Origin	Eastern North America
Introduction and dispersal	Introduced as an ornamental plant in Paris during the 17th century by Jean Robin. Planted in parks and garden. In the late 19th century foresters started to plant black cherry in forests for its timber. However, the plant does not usually grow to merchantable timber size but instead builds up into dense shrub layers.

Current status

Distribution in CH	Present in the Jura, but more common south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	*P. serotina* is present in large parts of the continental European lowlands, reaching high frequency and abundance in northern Germany, the Netherlands, Denmark, Poland and parts of France and Austria. Considered as a potentially invasive species in Austria.

Impacts

Environmental	Because of the deep shadow in dominant stands of *P. serotina*, there is considerable reduction in the number of species in the herbaceous layer, which also prevents the regeneration of native tree species, such as oak (*Quercus* sp.), pine (*Pinus sylvestris* L.)

or birch (*Betula pendula* Roth) which are mostly shade intolerant.

Economic — Unknown

Management options — Cutting generally increases suckers and sprout productivity. Effective control is achieved by treating freshly cut stumps with glyphosate or a bioherbicide produced from the fungus *Chondrostereum purpureum* (Fr.) Pouz. The treatment has to be repeated for several years to exhaust the seed bank.

Information gaps — Environmental and economic impacts.

References

Selected literature

DeJong, M.D. (2000) The BioChon story: deployment of *Chondrostereum purpureum* to suppress stump sprouting in hardwoods. Mycologist, 14, 58-62.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Rode, M., Kowarik, I., Müller, T. and T. Wendebourg (2002) Ökosystemare Auswirkung von *Prunus serotina* auf norddeutsche Kiefernforsten. In: Kowarik, I. and U. Starfinger (eds), Biologische Invasionen. Herausforderung zum Handeln? Neobiota 1, 135-148.

Starfinger, U. (1991) Population biology of an invading tree species – *Prunus serotina*. In: Seitz, A. and V. Loeschke (eds) Species conservation: a population biology approach. A. Birkhäuser Verlag, Basel, pp. 171-184.

Starfinger, U. (1997) Introduction and naturalization of *Prunus serotina* in central Europe. In: Brock, J.H., M. Wade, P. Pysek, and D. Green (eds) Plant invasions: studies from North America and Europe. Backhuys, Leiden, pp. 161-171.

Other sources

http://www.cps-skew.ch/

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Pueraria lobata

Taxonomic status

Scientific name	*Pueraria lobata* (Willd.) Ohwi
Synonyms	*P. montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S.M. Almeida; *P. hirsuta* (Thunberg) Schneider. Numerous synonyms.
Family	Fabaceae
English name	Kudzu
German name	Kopoubohne
French name	Puéraire hérissée
Italian name	Pueraria irsuta

Description and identification

Life form	Deciduous climber.
Description	A climbing or trailing, herbaceous to semi-woody deciduous, perennial vine. Leaves long-stalked, alternate, with 3 broad leaflets, 5-20 cm long. Leaflets entire or deeply 2-3 lobed with hairy margins. Individual flowers 2-2.5 cm long, purple, highly fragrant, and borne in 10-20 cm long axillary racemes. Seeds are produced in 4-10 cm long flattened brown hairy pods.
Similar species	-

Biology and ecology

Invaded habitats	Forest margins, open woods, hedges, waste ground and abandoned fields. It can persist on the floor of a closed canopy forest; the vines climb trees towards light.
Ecology and spread	Kudzu grows under a wide range of environmental conditions. Best growth is achieved where winters are mild, summer temperatures rise above 25°C, and rainfall is abundant. It grows in nearly any type of soil. Kudzu reproduces mainly vegetatively. It spreads by sending down roots from nearly every node along stems that contact soil. New root crowns develop at these nodes. Ramets develop the following spring. Seed production is limited. Seedlings are less competitive than established ramets.

Origin	East Asia, including Japan.
Introduction and dispersal	Introduced into Europe as an ornamental plant.

Current status

Distribution in CH	Present south of the Alps. On the Watch List of the CPS-SKEW working group.
Distribution in Europe	Not recorded in Flora Europaea. Imported in 1876 from Japan to the USA where it was promoted as a forage crop and an ornamental plant. It was later used to reduce soil erosion. Since then, it has become one of the most problematic invasive plants in the USA.

Impacts

Environmental	Kudzu monocultures can stop successional development of native plant communities. By girdling tree trunks, climbing and enveloping, it can eventually kill mature trees.
Economic	Unknown

Management options	For successful long-term control, the extensive root system must be destroyed. Any remaining root crowns can lead to re-infestation of an area. Mechanical methods involve cutting vines above ground level and destroying all cut material. Close mowing every month for 2 growing seasons or repeated cultivation may be effective. Late season cutting should be followed up with immediate application of a systemic herbicide to cut stems. Repeated applications of soil-active herbicides have been used effectively on large infestations in forestry situations. Some efforts towards biological control have started in the USA.
Information gaps	Invasiveness. Prevention and control methods.

References

Selected literature

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Mitich, L.W. (2000) Intriguing world of weeds. Kudzu [*Pueraria lobata* (Willd.) *Ohwi*]. Weed Technology 14, 231-235.

Other sources

http://www.cps-skew.ch/

http://www.fs.fed.us/database/feis/plants/vine/puemonl/botanical_and_ecological_characteristics.html

http://www.conservation.state.mo.us/nathis/exotic/vegman/fifteen.htm

http://www.bugwood.org/crp/images/98214.pdf

http://www.nps.gov/plants/alien/fact/pulo1.htm

Reynoutria japonica

Taxonomic status

Scientific name	*Reynoutria japonica* Houttuyn
Synonyms	*Fallopia japonica* (Houtt.) Ronse Decraene, *Polygonum cuspidatum* Siebold & Zuccarini
Family	Polygonaceae
English name	Japanese knotweed
German name	Japanischer Staudenknöterich
French name	Renouée du Japon
Italian name	Poligono del Giappone

Description and identification

Life form	Rhizomatous perennial herb.
Description	Herbaceous perennial plant, up to 3 m tall. Stem hollow with distinct nodes like bamboo, stem diameter up to 4 cm. Dark red in early spring turning to green with red/purple coloured speckles in late spring, becoming orange-brown and semi-woody in late autumn. Leaves broadly oval, acuminate, flattened at the base, up to 7-14 cm long. Cream-white flowers in cluster 8-12 cm long. Dioecious. Male flowers erect with protruding stamens; female flowers drooping with distinct stigma. Seeds triangular, 3 mm, dark brown and shiny, in a thin, papery, 3-winged achene. Flowering period: July-September.
Similar species	*R.* × *bohemica* is a hybrid between *R. japonica* and *R*. *sachalensis* (F. Schmidt)(see Fact Sheet on *R. sachalensis*). This hybrid grows to 2.5-3 m in height and has leaves slightly larger than *R. japonica* with a slightly heart-shaped base. *Fallopia convolvulus* (L.) and *F. dumetorum* (L.) are native species; *F. aubertii* (Henry) is an alien species from Central Asia. See also Fact Sheet on *Polygonum polystachyum* Meissner.

Biology and ecology

Invaded habitats	The plant occurs in a variety of relatively productive, mostly human-made habitats such as soil heaps, along streams and riverbanks, road verges and railway embankments, and in various urban habitats (vacant lots, neglected gardens or churchyards).
Ecology and spread	In its native habitat, Japanese knotweed grows in sun-exposed sites in hills and high mountains and along road verges and ditches. Other habitats are river gravels, roadsides and managed pastures, especially those where high levels of nitrogen fertilizer are applied. There are male and female plants and the species is characterized by high seed production and low seedling survival. In its introduced range, the presence of fertile male plants of Japanese knotweed is rare, and in the UK all Japanese knotweed plants recorded to date have been female. Thus, much if not all of the seed source has been found to be of hybrid origin. The role of seeds in the dispersal of the plants is considered minimal but more information is needed on seedling survival of Japanese knotweed and its hybrids. Outside its native range, regeneration and dispersal are therefore almost exclusively by vegetative means, not only via the extensive and rapidly growing rhizome system but also from fresh stem material. The dense rhizome system may explain the high colonization rate compared with the less successful *R. sachalinensis*. The plant likes half-shaded habitats and wet areas but is able to colonize well-drained pioneer habitats. It tolerates a

wide range of soil types and soil acidity.

Origin

Japan, Taiwan and northern China.

Introduction and dispersal

Introduced into Europe in 1825 and sold as an ornamental and fodder plant. It was also recommended as a possible species for fixing loose sand. The plant is now found widely dispersed due mainly to human-mediated transport of soil containing rhizome fragments.

Current status

Distribution in CH

Invasive in most of the country. On the Black List of invasive species of the CPS-SKEW working group.

Distribution in Europe

Invasive in western and Central Europe, e.g. in Austria, France, Spain, Scotland. *R. japonica* is also one of the most invasive species in eastern North America.

Impacts

Environmental

Despite the occurrence of Japanese knotweed in a wide variety of habitats, most impacts are reported from expansions in riparian areas due to impacts on nature conservation. The foliage forms a dense canopy that restricts growth of ground flora and prevents the growth and establishment of other native species. Because Japanese knotweed prevents the regeneration of trees, in autumn and winter when the vegetative growth has died back, the bare exposed soil is easily washed away, increasing soil erosion, especially on steep riverbanks.

Economic

Ground and riverbank maintenance costs are greatly increased. Japanese knotweed shoots are able to push up through asphalt, damaging pavements. Rhizomes have been recorded penetrating foundations and other walls. Estimated costs for annual control in a county council in Wales, UK, in 1994 were UK£ 300,000.

Management options

Whatever control method is used, killing the extensive rhizome system is essential if lasting control of Japanese knotweed is to be achieved. All cut material must be removed and disposed of safely. Chemical treatment should be carried out when the plant is actively growing and less than 1 m tall to avoid practical difficulties of access. Pulling and digging can be carried out during winter in preparation for subsequent herbicide treatment. All root and soil material must be removed safely. The plant is very difficult to control and can necessitate a management programme lasting a number of years. Rapid removal of Japanese knotweed will lead to two of the main problems, namely soil erosion and re-infestation. It is therefore necessary to build a strategy for revegetation into the treatment programme. A biological control programme has been initiated in the UK and should be reinforced.

Information gaps

Environmental and economic costs.

References

Selected literature

Child, L. and M. Wade (2000) The Japanese knotweed manual. The management and control of an invasive alien weed. Packard Publishing Ltd, Chichester, 123 pp.

Godefroid, S. (1996) A propos de l’extension spectaculaire de *Fallopia japonica*, *F. sachalinensis*, *Buddleja davidii* et *Senecio inaequidens* en Région bruxelloise. Dumortia 63, 9-16.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.
Pysek, P. and K. Prach (1993) Plant invasions and the role of riparian habitats: a comparison of four species alien to central Europe. Journal of Biogeography 20, 413-420.
Schnitzler, A. and S. Muller (1998) Ecologie et biogéographie de plantes hautement invasives en Europe: les renouées géantes du Japon (*Fallopia Japonica* and *F. Sachalinensis*). Revue Ecologie (Terre et Vie) 53, 3-38.

Other sources

http://www.cps-skew.ch/
Info sheet on *Reynoutria japonica*
http://wwwcjb.unige.ch/
Info sheet on *Reynoutria japonica*
http://www.cabi.org/BIOSCIENCE/japanese_knotweed_alliance.htm
Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

Reynoutria sachalinensis

Taxonomic status

Scientific name	*Reynoutria sachalinensis* (F. Schmidt Petrop.) Ronse Decraene
Synonyms	*Polygonum sachalinense* F.Schmidt
Family	Polygonaceae
English name	Giant knotweed
German name	Sakhalin-Knöterich
French name	Renouée de Sachaline, Renouée géante du Japon
Italian name	Poligono di Sachalin

Description and identification

Life form	Rhizomatous perennial herb.
Description	Similar in many respects to *R. japonica* Houttuyn (see Fact Sheet) but it is a much larger plant, 4-5 m tall. Leaves are also much larger (20-40 cm long) and are slightly heart-shaped at the base. The plant has greenish flowers carried on shorter, denser panicles than those of *R. japonica*. Flowering period: July-September.
Similar species	See Fact Sheet on *R. japonica.*

Biology and ecology

Invaded habitats	Moist areas, riverbanks, forest margins, roadsides.
Ecology and spread	Ruderal, marsh plant. Prefers moist, rich soils and half-shaded habitats. The plant is usually sterile in Europe and the reproduction is vegetative via the extensive and rapidly growing rhizome system. New shoots develop from rhizome buds at the base of the previous year's stems. Dispersal occurs through root and stem fragments caused by erosion being transported by the water, but mainly through human activities (transport of contaminated soils, modification of streams).

Origin North Japan, island of Sakhalin.

Introduction and dispersal Introduced in 1869 as an ornamental and forage plant.

Current status

Distribution in CH	Jura, Plateau. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Widespread in western and Central Europe, but much less common than *F. japonica*. Invasive in France. Potentially invasive in Austria and Scotland.

Impacts

Environmental	Same as for *R. japonica*.
Economic	Unknown. Likely to be the same as for *R. japonica* if there are large population build-ups.

Management options Same as for *R. japonica.*

Information gaps Distribution and potential spread.

References

Selected literature

Child, L. and M. Wade (2000) The Japanese knotweed manual. The management and control of an invasive alien weed.

Packard Publishing Ltd, Chichester, 123 pp.
Godefroid, S. (1996) A propos de l’extension spectaculaire de *Fallopia japonica*, *F. sachalinensis*, *Buddleja davidii* et *Senecio inaequidens* en Région bruxelloise. Dumortia 63, 9-16.
Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d’Histoire Naturelle. Patrimoines naturels, 62, 176 pp.
Pysek, P. and K. Prach (1993) Plant invasions and the role of riparian habitats: a comparison of four alien species to central Europe. Journal of Biogeography 20, 413-420.
Sukopp, H., and U. Starfinger (1995) *Reynoutria sachalinensis* in Europe and in the Far East: a comparison of the species ecology in its native and adventive distribution range. In: P. Pysek et al. (eds) Plant invasions: general aspects and special problems. SPB Academic Publishing, Amsterdam, pp. 151-159.
Other sources *http://www.cps-skew.ch/*

Rhus typhina

Taxonomic status

Scientific name	*Rhus typhina* L.
Synonyms	*R. hirta* (L.) Sudworth
Family	Anacardiaceae
English name	Staghorn sumac
German name	Essigbaum
French name	Sumac
Italian name	Sommacco maggiore

Description and identification

Life form	Deciduous tree or shrub.
Description	A tall shrub or small tree growing up to 6 m tall. The trunk is usually short, dividing frequently to form ascending densely and softly hirsute branches. Leaves alternate, up to 50 cm long, pinnately compound. Each leaf is composed of 5-15 leaflets that are lanceolate, serrate, and sometimes hairy below. Dioecious. Flowers are 5 mm wide, with 5 greenish petals, born on upright panicles up to 20 cm long. Drupes rounded, 5 mm in diameter, densely covered with long spreading purple hairs, forming dense cone-shaped clusters. Flowering period: May-June.
Similar species	None. There is only one other species in the Anacardiaceae family: *Cotinus coggygria* Scopoli.

Biology and ecology

Invaded habitats	Forest edges, clearings, scrubland, waste ground, abandoned fields and gardens.
Ecology and spread	Pioneer plant. *R. typhina* occurs on relatively dry, poor soils. It is not tolerant of shade. In its native area in North America, it is found at elevations up to 1500 m. Staghorn sumac forms large, dense colonies via root sprouts. Root sprouting is apparently stimulated by top-damage. Seeds are dispersed by birds.

Origin	Eastern USA.
Introduction and dispersal	Sumac has been cultivated in Europe for centuries as an ornamental prized for its vivid red autumn foliage and distinctive fruit.

Current status

Distribution in CH	Present in the Jura, Plateau and south of the Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	France, Italy, Central and eastern Europe.

Impacts

Environmental	Dense clones can reduce light intensity by up to 90% and will have a negative impact on native ground-layer perennial species.
Economic	Contact with the plant sap causes dermatitis in humans. The skin reaction occurs following sensitization to various alkyl catechols, phenols, quinols and resorcinols. At high concentrations, these compounds are also primary irritants.

Management options	Cutting might increase sprout productivity. Seedlings or small plants should be hand-pulled.

Information gaps	Distribution. Invasiveness. Environmental and economic impacts.
References	
Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Other sources	*http://www.cps-skew.ch/* Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html* *http://www.fs.fed.us/database/feis/plants/tree/rhutyp/all.html* *http://www.floridata.com/ref/r/rhus_typ.cfm*

Robinia pseudoacacia

Taxonomic status

Scientific name	*Robinia pseudoacacia* L.
Synonyms	-
Family	Fabaceae
English name	False acacia, black locust
German name	Robinie
French name	Robinier faux acacia
Italian name	Robinia

Description and identification

Life form	Deciduous tree.
Description	A nitrogen-fixing tree and sometimes a shrub, growing up to 30 m tall. Older trees have a deeply furrowed, dark brown bark with flat-topped ridges. Seedlings and sprouts with long, large thorns. Leaves glabrous, alternate, pinnately compound with 7- 21 leaflets (3-10 pairs). Leaflets elliptic to ovate, 25-45 mm long and 12-25 mm wide, shortly mucronate. The very fragrant white flowers grow in dense, drooping racemes of 10-20 cm length. Corollas white, 15-20 mm long. The glabrous drooping pods are 4-10 cm long, 1-2 cm wide, and contain 3-10 seeds of 4-5 mm in length. Flowering period: May-June.
Similar species	-

Biology and ecology

Invaded habitats	Forests, degraded woods, riparian habitats, old fields, grasslands, roadsides, waste sites and rocky areas.
Ecology and spread	This shade intolerant pioneer tree grows in a wide range of soils and environmental conditions. Due to its nitrogen fixing ability, *R. pseudoacacia* is capable of colonizing very low-nutrient substrates where few other tree species could thrive. Optimum conditions include sandy/loamy, well-drained soils in humid climates and open, sunny locations. Black locust reproduces vigorously by root suckering and stump sprouting to form groves (or clones) of trees interconnected by a common fibrous root system. The plant reaches sexual maturity at approximately 6 years of age. Seed production continues until an age of about 60 years. Seeds are hard and require scarification for germination to take place. Seedlings grow quickly on sites free of competition. Sprouting is essential for colonizing areas that have herbaceous plant cover but no woody canopy. Root suckers are usually more important to reproduction than are seedlings.

Origin	South-eastern USA.
Introduction and dispersal	Introduced as an ornamental in 1601 in Paris, France, by Jean Robin, Royal Herbalist of France. Frequently planted in urban areas. Many cultivars have been developed. Has been used for its wood and to stabilize riverbanks, railway embankments, etc.

Current status

Distribution in CH	Most of the country, invasive in warm areas in particular south of the Alps, up to 600 m altitude. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Most of Europe, invasive in particular in the Mediterranean region.

Declared an invasive species in countries such as Austria, France and Spain. A potentially invasive species in Portugal.

Impacts

Environmental

R. pseudoacacia grows quickly and is therefore able to outcompete other pioneer species for light. Dense pure stands displace native vegetation and create shaded areas with little ground vegetation. Also, the tree is nitrogen-fixing and increases soil fertility levels, which may affect the floristic composition of invaded sites.

Economic

Inner bark, young leaves and seeds are poisonous. Can be fatal for animals if large quantities are eaten.

Management options

Cutting or burning generally increases sucker and sprout productivity. Burning also favours seed germination. Repeated cutting can eventually kill the tree. Seedlings and saplings can be pulled or dug out, while roots must be removed. Effective chemical control is achieved by treating freshly cut stumps with glyphosate.

Information gaps

Environmental and economic impacts.

References

Selected literature

Bertacchi, A., Lombardi, T., and A. Onnis (2001) *Robinia pseudoacacia* in the forested agricultural landscape of the Pisan hills (Italy). In: Brundu, G., Brock, J., Camarda, I., Child, L., and M. Wade (eds) Plant invasions. Species ecology and ecosystem management. Backhuys Publishers, Leiden, pp. 41-46.

Boring, L.R. and Swank, W.T. (1984) The role of black locust (*Robinia pseudoacacia*) in forest succession. Journal of Ecology 72, 749-766.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Other sources

http://www.cps-skew.ch/
Info sheet on *Robinia pseudoacacia*

http://wwwcjb.unige.ch
Info sheet on *Robinia pseudoacacia*

http://tncweeds.ucdavis.edu/esadocs/documnts/lespcun.pdf
The Nature Conservancy. Element Stewardship Abstract for *Robinia pseudoacacia* (1984).

http://www.hort.agri.umn.edu/h5015/00papers/sabo.htm

http://www.nps.gov/plants/alien/fact/rops1.htm
http://www.fs.fed.us/database/feis/plants/tree/robpse/

Rosa rugosa

Taxonomic status

Scientific name	*Rosa rugosa* Thunberg
Synonyms	-
Family	Rosaceae
English name	Japanese rose
German name	Kartoffelrose
French name	Rosier à feuilles rugueuses
Italian name	Rosa con foglie rugose

Description and identification

Life form	Deciduous shrub.
Description	Deciduous, erect shrub, up to 2.5 m tall. Stems stout and rigid, densely tomentose. Armature of large, straight, narrow and slightly flattened prickles. Leaves with 5-9 leaflets, ovate, rugose, shining and relatively dark green above, ± tomentose, with prominent veins and numerous very short glandular hairs beneath. Flowers 1-3, c. 4-8 cm in diameter, deep rose. Pedicels moderately hairy to tomentose; ± scattered, rigid glandular hairs. Sepals persistent, lanceolate or ovate-lanceolate, entire or with a few small teeth near apex. Fruits 20-25 mm across, spherical, glabrous, shining deep red.
Similar species	The genus *Rosa* is taxonomically difficult with numerous wild and cultivated species. *R. rugosa* can however be easily distinguished by its deep rose-coloured flowers, entire sepals, stiff glandular hairs on the inflorescence and tomentose leaves.

Biology and ecology

Invaded habitats	Waste ground, sandy shores or dunes.
Ecology and dispersal	Ruderal species forming extensive thickets due to root and stem suckering. Long-distance dispersal by seeds or stem/root pieces. Seeds dispersed by water or small animals. *R. rugosa* prefers light, well-drained soil and sun exposure, and a continental type of climate.

Origin East Asia (Korea, Japan, eastern China).

Introduction and mode of spread Introduced as an ornamental at the end of the 18th century. Used as an ornamental and for hedges.

Current status and distribution

Distribution in CH	Present in the Jura, north-eastern Switzerland and the central Alps.
Distribution in Europe	Mostly northern and Central Europe. Invasive in Scotland. Also invasive in north-eastern North America.

Impacts

Environmental	Likely to have an impact on native vegetation. *R. rugosa* is reported to alter habitats to the detriment of rare plant species and dune systems on the coast of the Baltic sea.
Economic	Unknown

Management options Small plants can be hand-pulled. All root or cut material as well as soil material must be removed safely. Resprouting may occur if the entire root system is not completely removed.

Information gaps	Potential spread and invasiveness.
References	

Selected literature	Fremstad, E. (1997) Alien plants in Norway. Japanese rose - *Rosa rugosa.* Fremmede planter i Norge. Rynkerose - *Rosa rugosa.* Blyttia 55, pp. 115-121. (Norwegian).
	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
	Webb, C.J., Sykes, W.R. & P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.
Other sources	*http://www.cps-skew.ch/*
	Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*
	http://webapps.lib.uconn.edu/ipane/browsing.cfm?descriptionid=92

Rubus armeniacus

Taxonomic status

Scientific name	*Rubus armeniacus* Focke
Synonyms	In North America, the plant has been most often called *R. discolor* or *R. procerus*. However, *R. procerus* P.J. Müller is a younger taxonomic synonym of *R. praecox* Bertoloni which is a European non-weedy species. *R. discolor* Weihe & Nees has to be treated as a synonym of another European species, *R. ulmifolius* Schott.
Family	Rosaceae
English name	Himalayan blackberry
German name	Armenische Brombeere
French name	Ronce d'Armenie
Italian name	Mora d'Armenia

Description and identification

Life form	Evergreen or semi-evergreen shrub.
Description	The Himalayan blackberry is a robust, clambering or sprawling, evergreen shrub that grows up to 3 m in height. Leaves are compound, with 3-5 broad leaflets. Mature leaves are green and glabrous above when mature, and tomentose beneath. Sterile first-year stems (primocanes) develop from buds at or below the ground surface and bear only leaves. Young primocanes are pilose-pubescent, becoming glabrous with age, strongly angled and furrowed, bearing well-spaced, broad-based, straight or somewhat curved prickles, 6-10 mm long. During the second year, lateral branches develop and produce both leaves and flowers. Flowers are borne in clusters of 3-20, usually white, but rose or reddish flowers also occur. Petioles with hooked prickles. Ripe berries are soft, shiny black and composed of an aggregate of large succulent drupelets.
Similar species	There are a large number of native species or species groups such as *R. idaeus* L., *R. saxatilis* L., *R. caesius* L., *R. sulcatus* Vest, [*R. fructicosus* L. aggr: *R. canescens* DC., *R. montanus* Lejeune, *R. bifrons* Vest, *R. ulmifolius* Schott, *R. vestitus* Weihe et Nees, *R. hirtus* Waldstein et Kitaibel, *R. tereticaulis* P.J. Müller]. *R. phoenicolasius* Maximowicz and *R. laciniatus* Willedenow are cultivated and rarely subspontaneous species.

Biology and ecology

Invaded habitats	Railway embankments, waste ground, forest plantations, riparian woodlands, river flats, fence lines, grasslands, old field communities.
Ecology and spread	Pioneer species. *R. armeniacus* grows well on a variety of barren, infertile soil types. It tolerates a wide range of soil pH and textures, but does require adequate soil moisture. The plant exhibits extensive and vigorous vegetative regeneration. Although not specifically documented for Himalayan blackberry, most *Rubus* species are capable of sprouting and spreading vigorously from root or stem suckers, or rooting stem tips. Seeds are dispersed by many species of birds and mammals. Seeds can remain viable for several years and need stratification for germination.

Origin	Armenia
Introduction and	Introduced into Germany in 1838 because of its large, sweet fruits.

dispersal	It became the most frequently cultivated blackberry in Europe.
Current status	
Distribution in CH	Invasive in the Jura, Plateau and northern Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	It is a common garden escapee in nearly all European countries. It is not recorded as invasive in any other European countries probably because of misidentification or the taxonomic complexity of the genus. Invasive in North America.
Impacts	
Environmental	Dense thickets of Himalayan blackberry have a negative impact on native plant species.
Economic	The production of dense thickets, especially in wet areas, may hinder access of humans to water sources or recreational areas.
Management options	Mechanical removal or burning may be the most effective ways of removing the mature plants. All cut material must be removed and disposed of safely to avoid regeneration from cuttings. Removal of canes alone is insufficient to control *R. armeniacus* adequately as the root crown will resprout and produce more canes. Himalayan blackberry re-establishment may be prevented by planting fast-growing shrubs or trees, since the species is usually intolerant of shade.
Information gaps	Geographical distribution. Environmental and economic impacts.
References	
Selected literature	Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Other sources	*http://www.cps-skew.ch/* Info sheet on *Rubus armeniacus* *http://tncweeds.ucdavis.edu/esadocs/documnts/rubudis.pdf* The Nature Conservancy. Element Stewardship Abstract for *Rubus discolor* (*Rubus procerus*) (1989). *http://www.ou.edu/cas/botany-micro/ben/ben230.html* *http://www.fs.fed.us/database/feis/plants/shrub/rubdis/*

Rudbeckia laciniata

Taxonomic status

Scientific name	*Rudbeckia laciniata* L.
Synonyms	-
Family	Asteraceae
English name	Tall cone flower, cutleaf coneflower
German name	Schlitzblättriger Sonnenhut
French name	Rudbeckie découpée
Italian name	Rudbeckia comune

Description and identification

Life form	Rhizomatous perennial herb.
Description	Erect, branched, rhizomatous perennial herb, up to 2 m tall. Stems and leaves usually glabrous or with sparse short hairs. Lower leaves petiolate, pinnatisect, upper leaves becoming shortly petiolate or apetiolate, 3-5 lobed; segments ± entire to coarsely, irregularly serrate. Capitula solitary, c. 7-12 cm in diameter, in loose cymes. Involucral bracts in 1 row, glabrous, or ciliate to moderately hairy. Ray florets 6-10, yellow, asexual; disc florets numerous, greenish-brown. Achenes brown, glabrous, 4-5 mm long, pappus reduced to 4 teeth. Flowering period: July-September.
Similar species	Alien species: *R. hirta* L. (native in North America). *R. laciniata* can be distinguished from most Asteraceae by its large yellow flowers AND deeply lobed leaves, the upper leaves divided into 3-5 lobes.

Biology and ecology

Invaded habitats	Riverbanks, damp areas, slopes, waste ground.
Ecology and dispersal	Grows in average, medium-wet soils in full sun to partial shade. Tolerates hot and humid summers, but not drought. Species from sub-Atlantic type of climate. Spread by rhizomes. Long-distance dispersal by root segments and seeds. A very melliferous species.

Origin	North America
Introduction and mode of spread	Introduced in Europe in the 17th century as an ornamental plant. Cultivated and sold as an ornamental plant.

Current status and distribution

Distribution in CH	Recorded in the Jura and north-eastern Switzerland.
Distribution in Europe	Present in most of Europe except the north. Invasive in Austria and in north-eastern France. Also present in New Zealand.

Impacts

Environmental	Likely to have an impact on native vegetation due to the large size and dense foliage.
Economic	Can be toxic and in some cases fatal to animals if eaten.

Management options	No specific management methods are described.
Information gaps	Distribution and potential spread. Environmental impact.

References

Selected literature

Francirkova, T. (2001) Contribution to the invasive ecology of *Rudbeckia laciniata*. In: Brundu, G., Brock, J., Camarda, I.,

Child, L. and M. Wade (eds) Plant invasions: Species ecology and ecosystem management. Backhuys Publishers, Leiden, pp. 89-98.
Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition. Paul Haupt (ed).
Webb, C.J., Sykes, W.R. and P.J. Garnock-Jones (1988) Flora of New Zealand. Volume IV Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, DSIR, Christchurch, New Zealand.
Other sources
http://www.cps-skew.ch/
Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*
http://www.nature-en-lorraine.net/invasives/

Senecio inaequidens

Taxonomic status

Scientific name	*Senecio inaequidens* DC
Synonyms	*S. reclinatus* auct., *S. harveianus* auct.
Family	Asteraceae
English name	Narrow-leaved ragwort
German name	Südafrikanisches Greiskraut
French name	Séneçon sud-africain
Italian name	Senecione sudafricano

Description and identification

Life form	Short-lived perennial herb.
Description	A bushy short-lived perennial herb, 40-110 cm tall, woody at the base. Leaves alternate, glabrous, narrowly lanceolate-linear, 4-10 cm long and 3-4 mm wide, margins crenulate. Flowering branches ascending, in irregular corymbs, flowers yellow, 15-25 mm in diameter, with 10-15 ligulate flowers. The fruit is a feathery achene, 5 mm long. Flowering period: May-December.
Similar species	Native species: *S. capitatus* (Wahlenberg), *S. gaudinii* Gremli, *S. helenitis* (L.), *S. integrifolius* (L.), *S. alpinus* (L.), *S. paludosus* L., *S. ovatus* (Gaertner), *S. hercynicus* Herborg, *S. vulgaris* L., *S. viscosus* L., *S. sylvaticus* L., *S. halleri* Dandy, *S. incanus* L., *S. jacobaea* L., *S. erucifolius* L., *S. aquaticus* Hill, *S. erraticus* Bertoloni, *S. abrotanifolius* L., *S. doronicum* L., *S. vernalis* Waldstein et Kitaibel. Alien species: *S. rupestris* Waldstein et Kitaibel.

Biology and ecology

Invaded habitats	Waste ground, roadsides, railway tracks, grasslands and vineyards.
Ecology and spread	Pioneer species. The plant grows in relatively dry or moist soils, usually in full sun. Large seed production. Seeds are wind-dispersed; long-distance seed dispersal mainly through human activities.

Origin	South Africa
Introduction and dispersal	Introduced into Europe in the late 19th century with wool imports from South Africa. The spread started from five areas in the vicinity of wool industries in France, Italy, Belgium and Germany.

Current status

Distribution in CH	Jura, Plateau, south of the Alps. Invasive mainly in the Ticino and Vaud. On the Black List of invasive species by the CPS-SKEW working group.
Distribution in Europe	Recent records in several European countries. Spreading quickly throughout Europe. Invasive in France and Spain. On a Watch List of alien plants in Austria.

Impacts

Environmental	Once established, *S. inaequidens* can cover up to 80% of the ground and displace native vegetation.
Economic	Toxic to cattle, the plant reduces the productivity of grasslands.

Management options Isolated plants should be hand-pulled. Cultivation and chemical treatment provide temporary control. Mowing before fructification limits seed production. Eradication is difficult because of the extensive seed bank in the soil. Overgrazing should be avoided. Sowing of good cover plants in grassland helps suppress *S. inaequidens*.

Information gaps Distribution and potential spread. Environmental and economic impacts.

References

Selected literature

Bornkamm, R. (2002) On the phytosociological affiliations of an invasive species *Senecio inaequidens* in Berlin. Preslia 74, 395-407.

Boehmer, H.J. (2002) Das Schmalblaettrige Greiskraut (*Senecio inaequidens* DC. 1837) in Deutschland - eine aktuelle Bestandsaufnahme. Floristische Rundbriefe 35, 47-54.

Godefroid, S. (1996) A propos de l'extension spectaculaire de *Fallopia japonica*, *F. sachalinensis*, *Buddleja davidii* et *Senecio inaequidens* en Région bruxelloise. Dumortia 63, 9-16

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition, Paul Haupt (ed).

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Schmitz, G. (2001) The importance of the alien plant *Senecio inaequidens* DC. (Asteraceae) for phytophagous insects. Zeitschrift für Oekologie und Naturschutz 9, 153-160.

Other sources

http://www.cps-skew.ch/

http://wwwcjb.unige.ch/
Info sheet *Senecio inaequidens*)

Flora Europaea, web version: *http://rbg-web2.rbge.org.uk/FE/fe.html*

http://www.ame-lr.org/publications/espaces/espaces01.html

Solidago canadensis

Taxonomic status

Scientific name	*Solidago canadensis* L.
Synonyms	This plant belongs to a highly variable species complex. Plants in Europe are referred to as var. *scabra* (syn: *S. altissima*).
Family	Asteraceae
English name	Canada goldenrod
German name	Kanadische Goldrute
French name	Solidage du Canada
Italian name	Verga d'oro del Canada

Description and identification

Life form	Perennial herb.
Description	A tall herb of 50-200 cm in height, with erect, sparsely to densely pubescent stems that are branched only in the inflorescence. Leaves lanceolate, slightly to sharply toothed, 5-20 cm long, pubescent beneath. Inflorescences are large panicles at the ends of stems with recurved second branches. Flowerheads are 3-5 mm in diameter, with short ray florets and numerous disk florets. Florets yellow. Fruits are achenes of 0.5-1.2 mm length with a white pappus of c. 3 mm length. Rhizomes arise from the base and are 5-12 cm long. Flowering period: July-September.
Similar species	Alien species: *S. gigantea* Aiton (see Fact Sheet) and *S. graminifolia* (L.) (both of North American origin). The origin of *S. virgaurea* L. is uncertain (Eurosiberia, North America).

Biology and ecology

Invaded habitats	Grassland, forest edges, riparian habitats, railway embankments, disturbed sites.
Ecology and spread	The species occurs over a wide range of soil fertility and texture conditions but it is a light-demanding species. Soils that support stands of *S. canadensis* are mostly nutrient-rich and moist, but the species can also be found on relatively nutrient-poor and drier soils. *S. canadensis* occupies drier habitats than *S. gigantea*. Individual clones spread rapidly by vegetative lateral growth. The annual stems die in autumn and new shoots are regenerated from the rhizomes. Once established, the plant may remain dominant for a long period of time. Seeds are abundantly produced and dispersed by wind.

Origin	North America
Introduction and dispersal	*Solidago canadensis* was introduced first into the UK around 1735 as an ornamental. It is also used as a bee plant.

Current status

Distribution in CH	Invasive in most of the country, less abundant in the central Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Invasive in most of temperate Europe (e.g. in France and Austria). Less common in northern Europe.

Impacts

Environmental	*S. canadensis* forms extensive colonies with a high shoot density

and covering large areas, eliminating almost all other plant species.

Economic: Unknown

Management options: Control measures include repeated mowing, or mulching and reseeding with native species. Single clumps may be grubbed, rhizomes must be removed. Effective herbicides are 2,4-D or picloram. A good target species for biological control.

Information gaps: Environmental and economic impacts.

References

Selected literature

Jobin, A., Schaffner, U. and W. Nentwig (1996) The structure of the phytophagous insect fauna on the introduced weed *Solidago altissima* in Switzerland. Entomologia Experimentalis et Applicata 79, 33-42.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition, Paul Haupt (ed).

Meyer, A. and B. Schmid (1999) Experimental demography of the old-field perennial *Solidago altissima*: the dynamics of the shoot population. Journal of Ecology 87, 17-27.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Stoll, P., Egli, P. and B. Schmid (1998) Plant foraging and rhizome growth patterns of *Solidago altissima* in response to mowing and fertilizer application. Journal of Ecology 86, 341-354.

Werner, P.A., Bradbury, I.K., and R.S. Gross (1980) The biology of Canadian weeds. 45. *Solidago canadensis* L. Canadian Journal of Plant Science 60, 1393-1409.

Weber, E. (1997) Morphological variation of the introduced perennial *Solidago canadensis* L. sensu lato in Europe. Botanical Journal of the Linnean Society 123, 197-210.

Weber, E. (1998) The dynamics of plant invasions: a case study of three exotic goldenrod species (*Solidago* L.) in Europe. Journal of Biogeography 25, 147-154.

Weber, E. (2000). Biological flora of Central Europe: *Solidago altissima* L. Flora 195, 123-134.

Other sources

http://www.cps-skew.ch/
Info sheet on *Solidago canadensis*

http://wwwcjb.unige.ch/
Info sheet on *Solidago canadensis*

Flora Europaea, web version :
http://rbg-web2.rbge.org.uk/FE/fe.html

Solidago gigantea

Taxonomic status

Scientific name	*Solidago gigantea* Aiton
Synonyms	*S. serotina* Aiton
Family	Asteraceae
English name	Giant goldenrod
German name	Spätblühende Goldrute
French name	Solidage géant, solidage glabre
Italian name	Verga d'oro maggiore

Description and identification

Life form	Perennial herb.
Description	An erect herb of 50-150 cm in height, with glabrous and often glaucous stems, branched only in the inflorescence. Leaves glabrous, variably toothed, 10-20 cm long and 1.5-4 cm wide. Inflorescences are large panicles with pubescent branches at the ends of stems. Flowerheads are 4-8 mm in diameter, with the ray florets being slightly longer than the disk florets. Florets yellow. Fruits are achenes of 1-1.3 mm length, with a yellowish-brown pappus of 3-4 mm length. Rhizomes are branched and may exceed 50 cm in length. Flowering period: August-October.
Similar species	Alien species: *S. graminifolia* (L.) and *S. canadensis* L. (see Fact Sheet), both of North American origin. The origin of *S. virgaurea* L. is uncertain (Eurosiberia, North America). *S. gigantea* is smaller than *S. canadensis*, the stem is glabrous and often reddish, leaves glabrous or hairs only on the veins beneath.

Biology and ecology

Invaded habitats	Grassland, forest edges, reafforestations, riparian habitats, freshwater wetlands, disturbed sites.
Ecology and spread	*S. gigantea* occupies moister habitats than *S. canadensis*. It also also longer rhizomes that fragment easily and can be transported by streams, which allows rapid colonization. Individual clones rapidly expand due to vegetative growth and merge into a complete cover. Shoot densities may exceed 300 m^{-2}. Seeds are dispersed by wind and streams.

Origin	Eastern North America.
Introduction and dispersal	*S. gigantea* was introduced first into the UK around 1758 as an ornamental. It is also used as a bee plant.

Current status

Distribution in CH	Invasive in most of the country, less abundant in the central Alps. On the Black List of invasive species of the CPS-SKEW working group.
Distribution in Europe	Invasive in Central and eastern Europe, e.g. in France and Austria. Less common in northern and southern Europe.

Impacts

Environmental	This perennial forms extensive and dense, pure populations where invasive, displacing native vegetation and preventing establishment of native species.
Economic	Unknown

Management options	Once established the plant is difficult to control. Scattered stems may be pulled or dug out, all rhizomes must be removed. Repeated mowing reduces the plant's vigour. Stands can be treated with 2,4-D or glyphosate applied during active growth. A good target species for biological control.
Information gaps	Environmental and economic impacts.

References

Selected literature

Jobin, A., Schaffner, U. and W. Nentwig (1996) The structure of the phytophagous insect fauna on the introduced weed *Solidago altissima* in Switzerland. Entomologia Experimentalis et Applicata 79, 33-42.

Lauber, K. and G. Wagner (2000) Flora Helvetica. French Edition, Paul Haupt (ed).

Meyer, A. and B. Schmid (1999) Experimental demography of the old-field perennial *Solidago altissima*: the dynamics of the shoot population. Journal of Ecology 87, 17-27.

Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels, 62, 176 pp.

Stoll, P., Egli, P. and B. Schmid (1998) Plant foraging and rhizome growth patterns of *Solidago altissima* in response to mowing and fertilizer application. Journal of Ecology 86, 341-354.

Werner, P.A., Bradbury, I.K., and R.S. Gross (1980) The biology of Canadian weeds. 45. *Solidago canadensis* L. Canadian Journal of Plant Science 60, 1393-1409.

Weber, E. (1997) Morphological variation of the introduced perennial *Solidago canadensis* L. sensu lato in Europe. Botanical Journal of the Linnean Society 123, 197-210.

Weber, E. (1998) The dynamics of plant invasions: a case study of three exotic goldenrod species (*Solidago* L.) in Europe. Journal of Biogeography 25, 147-154.

Weber, E. (2000). Biological flora of Central Europe: *Solidago altissima* L. Flora 195, 123-134.

Other sources

http://www.cps-skew.ch/
Info sheet on *Solidago gigantea*

http://wwwcjb.unige.ch/
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Flora Europaea, web version : *http://rbg-web2.rbge.org.uk/FE/fe.html*