NOBANIS –Invasive Alien Species Fact Sheet

Arthurdendyus triangulatus

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Species description

Scientific names: *Arthurdendyus triangulatus* (Dendy, 1894), Platyhelminthes, Geoplanidae
Synonyms: *Artioposthia triangulata* (Dendy, 1894)
Common names: New Zealand flatworm (GB), ploštěnka novozélandská (CZ), Newzealandsk fladorm (DK), Neuseelandplattwurm (DE), Uus-Meremaa lameuss (EE), Du ver plat de Nouvelle-Zélande (F), Ný Selendski flatmaðkurin (FO), Nýsjálenski flatormurinn (IS), New zealandsk flatorm (NO), Nyazeeländska plattmasken (SE).

Fig 1. *Arthurdendyus triangulatus,* photo by Ole and Janice Mather-Christensen
More pictures on the web.

Species identification

Arthurdendyus triangulatus has a flattened, strap-like body, without the segmentation of earthworms and leeches. The flatworm is typically seen on a bed of mucus in a flattened spiral but on becoming active can extend and elongate its body considerably. The colour of the dorsal surface is liver-brown to purple, with a pale yellow-beige marginal fringe dotted with grey specks. The underside of the flatworm continues the colouration of the marginal fringe being pale yellow-beige with grey-brown specks. The entire body is covered by sticky mucus. The size of the worm may vary from 5 to 20 cm dependent on the level of body

extension. General descriptions of *A. triangulatus* are given by in several scientific papers (Willis & Edwards, 1977; Boag *et al.*, 1994; Christensen & Mather, 1999; Jones, 2005)

Native range
The land planarian *A. triangulatus* originates from New Zealand, where it occurs naturally in southern beech (*Nothofagus*) forest soils, apparently without causing problems for the native earthworm fauna (Blackshaw & Stewart, 1992). In New Zealand the species is also found in cultivated soils such as gardens and plant nurseries (Johns *et al.*, 1998; Mather & Christensen, 1998; Christensen & Mather, 1999; Dynes *et al.*, 2001).

Alien distribution

History of introduction and geographical spread
The New Zealand flatworm was first recorded outside of New Zealand in Northern Ireland in 1963 where it was probably introduced inadvertently with a shipment of ornamental plants (Willis & Edwards, 1977; Blackshaw & Stewart, 1992). *Arthurdendyus triangulatus* has now reached all parts of Northern Ireland (Moore *et al.*, 1998), has spread widely in the Republic of Ireland as well as in Scotland and England (Cannon *et al*. 1999). The species has also been found on the isolated Faroe Islands since 1982 (Bloch, 1992; Mather & Christensen, 1992). It is suspected that the New Zealand flatworm was imported with plants from Britain.

Ecoclimatic modelling suggests that *A. triangulatus* may survive in other parts of Europe, such as western Norway, southern Sweden, Denmark, Germany, The Netherlands, Belgium and northern parts of Poland, at least in places where cool and damp conditions are found (Boag *et al.*, 1995a; Boag *et al.*, 1995b). Despite this, there are no records from continental Europe. This represents a puzzle since *A. triangulatus* has been present in the UK and Ireland, including off-shore isolated islands, since the early 1960s. It may be that the flatworm requires quite specific environmental conditions.

Pathways of introduction
Arthurdendyus triangulatus was first recorded in the 1960s in gardens in Belfast and Edinburgh. It is believed that the flatworm was unintentionally introduced with ornamental plants from Christchurch in New Zealand (Christensen & Mather, 1999). The risk of non-intentional transfer is greatest from the commercial trade with hardy ornamental plants, but domestic garden trade also poses a prominent risk (Alford, 1998).

Alien status in region
The New Zealand flatworm is presently found on the Faroe Islands (Bloch, 1992; Mather & Christensen, 1992; Christensen & Mather, 1998). See Table 1.

Country	Not found	Not established	Rare	local	Common	Very common	Not known
Austria	X						
Belarus							
Belgium							
Czech Republic	X						
Denmark	X						
Estonia	X						
European part of Russia	X						

Finland	X
Faroe Islands	X
Germany	X
Greenland	X
Iceland	X
Latvia	X
Lithuania	X
Norway	X
Poland	X
Slovakia	
Sweden	X

Table 1. The frequency and establishment of *A. triangulatus*. Please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available.

Ecology

Habitat description

New Zealand flatworms are usually found under stones, old wood and debris on the soil surface. They can also be recovered directly from the soil such as when sampling for earthworms (Murchie *et al.*, 2003). Optimal temperatures for the animals are 12-15 °C (Christensen & Mather, 1999), while temperatures consistently above 20 °C are lethal (Blackshaw & Stewart, 1992). The New Zealand flatworms feed on native earthworms thereby reducing the number of these markedly (Murchie & Gordon, 2013). Presently, it is not clear whether the presence of the species is determined by availability of earthworms or if the flatworms are also regulated by other factors such as micro-climate or predators.

Reproduction and life cycle

Arthurdendyus triangulatus is hermaphroditic and although mating has not been observed it is likely that adult individuals reproduce after mutual fertilisation (Baird *et al.*, 2005b). *Arthurdendyus triangulatus* produce shiny-black spherical egg capsules that contain on average six juveniles, although the range is 1-14 juveniles (Blackshaw & Stewart, 1992; Christensen & Mather, 1997). A flatworm may produce up to one egg capsule every two weeks (Christensen & Mather, 2001; Baird *et al.*, 2005a).

Dispersal and spread

Egg capsules and adult flatworms are spread passively by commercial and non-commercial transport of plant and soil material (Cannon *et al.*, 1999). Locally, the New Zealand flatworms move around through naturally occurring crevices in the soil or by utilising passages that earthworms have made. They do not form burrows themselves. Surface movements of up to 17 metres per hour have been demonstrated (Mather & Christensen, 1995). An important feature is the ability of the flatworm to survive extended periods of time without food. Survival without food for more than one year has been reported (Christensen & Mather, 1995). The flatworm is capable of resorbing its own tissues and degenerating its reproductive organs (Baird *et al.*, 2005b). As individuals can survive in the absence of food

for prolonged periods, they can maintain a residual population in the soil making earthworm re-colonisation from adjacent non-infected areas difficult.

Impact

Affected habitats and indigenous organisms
Field experiments in Ireland have demonstrated that *A. triangulatus* reduces the diversity and number of native earthworm species (Blackshaw, 1990; Murchie & Gordon, 2013). These results were confirmed under agricultural and horticultural conditions in the Faroe Islands (Mather & Christensen, 1992; Christensen & Mather, 1995). Anecic earthworm species, in particular *Lumbricus terrestris*, are most at risk from flatworm predation (Fraser & Boag, 1998; Murchie & Gordon, 2013). This is probably due to the fact that they produce vertical semi-permanent burrows that allow the flatworm easy access. In addition, *L. terrestris* is comparatively long-lived and slow to reproduce compared to smaller earthworm species.

Earthworms are important components of the soil in both natural and semi-natural ecosystems, since they decompose dead plant material, aerate and drain the soil, and maintain intricate relationships with both fungi and bacteria. There have been only a few studies on the indirect impact that *A. triangulatus* may have on soil quality via depletion of earthworm biodiversity. These demonstrate the potential for reduced water infiltration, leading to water-logging and increased surface run-off (Haria, 1995; Haria *et al.*, 1998). Furthermore earthworms are important as a food source for native bird and animal species (Alford, 1998; Boag, 2000). Potentially therefore, *A. triangulatus* could severely threaten native biodiversity as well as the fertility of Europe's farmland.

Genetic effects
No genetic effects have been reported.

Human health effects
The mucus that surrounds the New Zealand flatworm may irritate the skin (EPPO, 2001a).

Economic and societal effects (positive/negative)
Due to the dispersal pathway of the New Zealand flatworm, the most affected habitat is domestic gardens. However, systematic surveys of fields in Northern Ireland have demonstrated that *A. triangulatus* is spreading into agricultural grasslands (Murchie *et al.*, 2003).

Management approaches

Prevention methods
The national border control measures in use in the 1960s were not effective enough to prevent the original introduction of the New Zealand flatworm and other alien flatworm species to the British Isles (Murchie, 2008). Indeed, when first found *A. triangulatus* was considered as a zoological curiosity and not as a potential invasive species or pest (Blackshaw, 1990; Blackshaw & Stewart, 1992). When scientific evidence started to demonstrate the impact of *A. triangulatus* on earthworms, various Scandinavian countries added *A. triangulatus* to their plant quarantine pest lists. In 1997, Sweden proposed that *A. triangulatus* be added to the European and Mediterranean Plant Protection Organisation (EPPO) A2 list of pest species recommended for quarantine measures. However, following

vigorous debate, an agreement could not be reached and therefore a compromise was proposed whereby EPPO issued a statement and two EPPO standards as guidelines on *A. triangulatus* (Murchie, 2010). These are: "Import requirements concerning *Arthurdendyus triangulatus*" (PM 1/3 (1) and "Nursery inspection, exclusion and treatment for *Arthurdendyus triangulatus*" (PM 1/4 (1) (EPPO, 2001b; EPPO, 2001c).

Since then, European Council Directive 2000/29/EC of May 2000 (on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community) has been implemented in the EU countries. Through the national implementation of this directive, member states have discretionary powers to deny the import of plants or plant products infested with non-indigenous species considered harmful or at risk of spreading. More recently, the risks posed by invasive alien species to the wider environment as well as agricultural are being addressed through European legislation. In 2013, the European Commission published a proposal for a Regulation on the prevention and management of the introduction and spread of invasive alien species.

Although there are now international phytosanitary measures and regulations, enforcement is still a daunting task – especially with increased commercial and private trade in plants, including via the internet. Considering the level of plant trade between countries, there is still a risk that *A. triangulatus* will eventually become introduced to new areas. Apart from adequate national border control measures, awareness of the risks associated with moving plant material is essential to limit introductions. In the UK, the Department for Environment, Food and Rural Affairs produced a code of practice to 'Prevent the Spread of Non-Indigenous Flatworms'. This Code is a practical guide to help producers and traders of nursery stock to detect and thereby to limit the spread of non-indigenous flatworms, notably *A. triangulatus*, but also the 'Australian' flatworm, *Australoplana sanguinea*. Adherence to this code of practice is central to prevent the dispersal of the New Zealand flatworm.

In the Faroes there is public awareness concerning the New Zealand flatworm, but no official measures have been taken to prevent dispersal. There is no national border control of plant material (Janus Hansen, *pers. comm.*).

Eradication, control and monitoring efforts

At present no eradication methods (trapping or spraying with pesticides) have proven successful against the New Zealand flatworm (Blackshaw, 1996).

Information and awareness

Scientists in England, Northern Ireland, Scotland and Denmark have initiated various information campaigns through popular articles in the media. Perhaps the best documented of these is the MEGALAB survey, which was organised in conjunction with the BBC and national newspapers in the UK (Jones & Boag, 1996). This survey encouraged members of the public to submit flatworm sightings. A similar approach was taken in Northern Ireland, where a request for flatworm sightings was made on the local news and media (Moore *et al.*, 1998). The result is an increased knowledge and awareness of the potential threat the New Zealand flatworm poses. Should the species arrive in a the country, it is anticipated that early publicity, internet and social media communication will ensure a rapid and adequate response from biologists and the horticultural community. However, a degree of caution should be exerted as some media articles on the impact of the New Zealand flatworm were sensational and could have the counter effect of being dismissed as alarmist

On the Faroe Islands the New Zealand flatworm is a well known species. However, there is a lack of public knowledge about the dispersal pathways and therefore public awareness may not help to prevent dispersal of the species.

Knowledge and Research
Research is ongoing regarding specific aspects of the biology of *A. triangulatus* as well as related to the establishment and development of populations in new areas and to the risks to local earthworm fauna following introduction. The following institutes are involved in the work:

England: The Food and Environment Research Agency, York
Scotland: The James Hutton Institute, Dundee
Northern Ireland: Agri-food & Biosciences Institute, Belfast
Denmark, The Faroes & Scotland: Aarhus University

Recommendations or comments from experts and local communities
The Faroe Islands consist of distinct islands linked by bridges, tunnels and ferries. There are regulations regarding the movement of e.g. sheep between islands. Such regulations for soil and plants would probably act to reduce the rate of spread. Turf roofs are common and movement of turf is a likely dispersal pathway. Precise knowledge of where the New Zealand flatworm occurs and dissemination of this knowledge would probably reduce the transfer of soil, plants and turf.

References and other resources

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Links

Biological and ecological studies of the New Zealand Flatworm – a joint research project in the UK

University of Aarhus, Denmark – Information folder on *A. triangulatus* – in Danish

DEFRA's code of practice to prevent the spread of non-indigenous flatworms

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