

ATELURA FORMICARIA, A NEW SILVERFISH FOR THE NETHERLANDS

(ZYGENTOMA: NICOLETIIDAE)

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Until recently, six species of silverfish have been reported from the Netherlands. Four of these are associated with humans and spend their lives predominantly indoors. Some silverfish species are obligatory myrmecophilous, meaning they live inside ant nests. In this paper we present a new silverfish species for the Netherlands, and the first myrmecophilous one. Considering its small size and cryptic lifestyle, it has probably been overlooked until now, as is proven by a dedicated search in the south of the country.

INTRODUCTION

Silverfish are so-called 'primitive insects'. Despite this qualification they are a successful insect order, having spread across the world, excepting the Antarctic. All silverfish species live on debris, organic waste. In the Netherlands, three species have been introduced in the past and have now established populations: *Ctenolepisma longicau-*

datum Escherich, 1905, *Lepisma saccharinum* Linnaeus, 1758 and *Thermobia domestica* Packard, 1873. The latter was thought to be common, but most silverfish considered to be this species turned out to be *C. longicaudatum* (Beijne-Nierop & Hakbijl 2002). All three are anthropogenic and are believed to live exclusively indoors. *Thermobia domestica* is now possibly rare in the Netherlands



Figure 1. *Atelura formicaria*, 19.XI.2022, Horn (province of Limburg). Note the lack of eyes, short antennae and short abdominal cerci, which distinguish Nicoletiidae from Lepismatidae. A few styli under the abdominal segments can just be seen. The at least five visible segments and short styli rule out species belonging to the related genus *Proateturina*. Photo Rick Buesink.

Figuur 1. *Atelura formicaria*, 19.XI.2022, Horn (provincie Limburg). Let op de ontbrekende ogen, korte antennen en korte achterlijfsaanhangselen, wat Nicoletiidae onderscheidt van Lepismatidae. Aan de onderzijde van de achterlijfssegmenten zijn nog net enkele styli te zien. De meer dan vijf zichtbare achterlijfssegmenten en de korte styli sluiten soorten uit het verwante genus *Proateturina* uit. Foto Rick Buesink.

or has disappeared entirely. The other two species are probably spread throughout the country and at least *C. longicaudatum* is common. For instance, in 2013 a call for silverfish from the general public yielded 524 silverfish specimens collected in Dutch houses. Only one concerned *L. saccharinum*, while all the other ones were *C. longicaudatum* (Merkus 2014). Apart from these four species, two other species of silverfish, *Acrotelsa collaris* (Fabricius, 1793), and possibly *Gastrotheus sumatranus* Silvestri, 1916, have been reported (Wygodzinsky, 1954). They were probably accidentally imported, but details are lacking.

None of the silverfish species known to occur in the Netherlands until now appeared to be associated with ants. However, Peter Boer has found *L. saccharinum* in ant nests around his house in Bergen (province of Noord-Holland). They occur for instance in compacted balls of plant material containing a small nest of *Lasius fuliginosus* (Latreille, 1798), as well as in nests of *Lasius niger* (Linnaeus, 1758) and *Tetramorium caespitum* (Linnaeus, 1758) built in the soil against the house. *Lepisma saccharinum* can frequently be seen here at night around the ants' nest entrances. In Belgium, *L. saccharinum* was found in nests of *Formica rufa* Linnaeus, 1761 and *F. polyctena* Förster, 1850 along a forest edge (Claus et al. 2022). *Lepisma saccharinum* is regarded as being xenomyrmecophilous, meaning it can be encountered in a range of habitats, but rarely inside ant nests (Molero-Baltanás et al. 2017).

An obligate myrmecophilous silverfish, *Atelura formicaria* Heyden, 1855, has been found once in the insectarium of Artis Zoo in Amsterdam (province of Noord-Holland) in the past, apparently without settling (Beijne Nierop & Hakbijl 2002). Unfortunately, specifics such as year or host species could not be retrieved. In both 2021 and 2022, *A. formicaria* (fig. 1) was found outdoors at three different locations (fig. 2) and seems to have established permanent populations. It concerns the fifth silverfish species in the Netherlands.



Figure 2. Localities of *Atelura formicaria* in the Netherlands.

Figuur 2. Vindplaatsen van *Atelura formicaria* in Nederland.

LOCATION AND MATERIAL

Faltering sewerage at Brederodestraat in Bakkum (province of Noord-Holland) (Amersfoort coordinates 105.596-507.879), where the first author lives, was the main reason to clear the garden of vegetation in spring and summer of 2021. On a number of occasions attention was drawn to 6 mm long golden-coloured silverfishes. They appeared to be associated with the black garden ant *Lasius niger*, which is abundant in the garden, as well as in the near surroundings. The silverfish were mostly found somewhat deeper below the surface in the sunniest part of the garden, and always quickly slid away when soil was removed. During the evening of 11 July 2021 about fifteen individuals were seen, two of which were caught. One was accidentally bruised and quickly died. They were photographed (fig. 3) and preserved in alcohol 70 %. They were identified by Rafael Molero-Baltanás as *A. formicaria*. In the more shaded part of the garden less *L. niger* and few to no silverfish were seen. *Lasius fuliginosus* was



Figure 3. Two *Atelura formicaria*, caught by hand in a nest of *Lasius niger* under flagstone, 11.VII.2021, Bakkum (province of Noord-Holland). Photo Guido Keijl.
 Figuur 3. Twee mierengoudvisjes *Atelura formicaria*, 11.VII.2021, Bakkum (provincie Noord-Holland), gevangen in een nest van gewone wegmier *Lasius niger*. Foto Guido Keijl.

more common in this part, but there appeared to be no silverfish associated with them. At other places near the house other ant species (*Lasius flavus* (Fabricius, 1782), *Lasius umbratus* (Nylander, 1846)) have been found before, but not in the part of the garden where the clearing took place. The sewerage works were finished in late 2021 and the garden was gradually filled with plants again. On 29 July 2022 a flagstone was lifted to check whether the silverfish were still there. *Lasius niger* was present under the stone with a large number of pupae, and two silverfish were seen,



Figure 4. Nest of *Lasius niger* with *Atelura formicaria*, under a sidewalk tile in a garden next to an outdoor sink in Horn (province of Limburg), 18.XI.2022. Photo Maartje Vijgenboom.
 Figuur 4. Nest van gewone wegmier *Lasius niger* met *Atelura formicaria* onder stoeptegels naast een vloerrooster van een buitenwasbak in Horn (provincie Limburg), 18.XI.2022. Foto Maartje Vijgenboom.

so both ants and silverfish survived the clearing of the garden.

In the night of 18 November 2022 fourteen members of the Dutch Youth Nature Federation (JNM - Jeugdbond voor Natuur- en Milieustudie) were searching for myrmecophilous insects in and around Horn, Limburg, in the village as well as in the surrounding nature reserves. Six specimens of *A. formicaria* were found in a nest of *L. niger* (AC 193.650-358.015) (fig. 4). The nest was situated below pavement tiles alongside a lawn, in humid soil next to an outdoor sink, in an urban area. Only few ants were visible underneath the tile, but quite a lot of springtails *Cyphoderus albinus* Nicolet, 1842 and woodlice *Platyarthrus hoffmannseggii* Brandt, 1833, which are both associated with ants. In contrast to the rapid moving *A. formicaria*, the ants were very inactive due to the low temperature, which was close to freezing. The next day, approximately ten other tiles and stones were lifted in urban areas and close to natural areas a few kilometres south of the population in Horn, but although several nests of both *L. niger* and *L. flavus* were found, no new locations of *A. formicaria* were encountered.

On 7 May 2023 a single *A. formicaria* was found in a nest of *L. niger* at Reuver, Limburg (AC 203.217-366.632). Reuver lies about twelve kilometres north-east of Horn (Waarneming.nl).

Two specimens of *A. formicaria* collected in Bakkum are now incorporated in the collection of Naturalis Biodiversity Center in Leiden, under collection number RMNH.INS.1123938. Single specimens are in the collections of the second and fourth author, respectively. A DNA analysis ('barcode') from specimens collected at Horn will be prepared under the programme ARISE and will be available in due time in the Barcode of Life (BOLD) programme.

IDENTIFICATION

Atelura formicaria belongs to the family Nicoletiidae (subfamily Atelurinae). This family differs from Lepismatidae, to which the remaining species in the Netherlands belong, by the lack of eyes, short antennae and very short cerci at the tip of the abdomen (fig. 1). The genus *Atelura* differs from other Palearctic genera in the subfamily Atelurinae by the eight pairs of styli on the underside of the abdomen. Most of the other genera in the subfamily are not associated with ants and their habitus is more elongate. Obviously, the distinguishing character of the styli cannot be seen in photographs, which usually only provide a dorsal perspective.

The genus *Atelura* comprises four species, which can only be distinguished after microscopic investigation. *Atelura valenciana* Molero-Baltanás et al., 1998 occurs in a small area in eastern Spain, *A. montana* (Stach, 1939) is found in the Balkans, while *A. abkhazica* Kaplin, 2016 was described from the Caucasian region. All four are covered with shiny golden hairs and scales and have the oval-fusiform body shape typical for *Atelura*. See Molero-Baltanás et al. (1998) and Kaplin (2016) for identifying characters of the species. A species with which *A. formicaria* could be easily confused is *Proatelurina pseudolepisma* (Grassi, 1887). This species also belongs to the subfamily Atelurinae and is widespread in Mediterranean countries. It can be distinguished by the three pairs of abdominal styli.

Other myrmecophilous silverfish with which *A. formicaria* could be confused are species belonging to the genera *Neoasterolepisma* Mendes, 1988 and *Tricholepisma* Paclt, 1967. Although they may superficially appear similar due to the broad front, strongly tapering rear, and golden colour, they belong to Lepismatidae, so they have, for instance, small black compound eyes that can be seen in lateral view.

DISTRIBUTION AND HABITAT

Atelura formicaria has a fairly wide distribution in Europe. It is known from Finland, Poland, Germany, Czech Republic, Slovakia, Switzerland, Austria, mainland Italy, Hungary, (former) Yugoslavia, Albania, mainland Greece and Ukraine (Mendes 2013). Apart from these countries, it also occurs in France. Some records from France, such as those mentioned by Wygodzinsky (1941), and previously considered doubtful records by other authors, have been checked by Rafael Molero-Baltanás. Parmentier et al. (2013) reported *A. formicaria* as a new species for the Belgian fauna, based on a single specimen caught in a nest of *Lasius flavus* on 22 September 2012 near Dinant, in the east of the country. After the latter publication, the species has also been found at other sites in Belgium, and some of these individuals have been photographed (Waarneming.net). One of these is a site less than 20 km west of Geleen (province of Limburg).

There are also observations, several of which accompanied with photographs, of *A. formicaria* from Portugal, Bulgaria and Russia on INaturalist.org (and some duplicate observations on Observation.org). *Atelura formicaria* was hitherto unknown from these countries. However, identifications based on photographs should be regarded as uncertain.

DISCUSSION

It is unknown how long *A. formicaria* has been present in the garden in Bakkum and how it has arrived. As the insects are wingless, it can be assumed that they have been brought in with plants. Since 2000, apart from a single prune tree *Prunus domestica*, and a few blackthorn *Prunus spinosa* and Guelder rose *Viburnum opulus*, which were all planted prior to 2004, no plants have been introduced. The trees were bought at two different plant nurseries in Noord-Holland. The silverfish may have been introduced with any of these, although neither ants nor other invertebrates were noted during the planting process. In 2000 the well-maintained garden was already filled with a variety of (mostly cultivated) plants, while elsewhere in the street active gardening takes place. It is well known that plants with accompanying insects or other animals are being continuously introduced (Boer & Vierbergen 2008, Heijerman & Hellingman 2009, Noordijk 2022).

An alternative hypothesis is that *A. formicaria* has reached Bakkum by itself. Myrmecophiles have a range of options to spread, for instance by walking to a new ant nest, or even by phoresy (Hölldobler & Kwapich 2022), but we could not find information about the natural way of dispersal of *A. formicaria*. Nests of *L. niger* may approach each other as close as the width of a few sand grains. Skirmishes between ants of different nests regularly occur, and vacant space is soon taken by new ants of either species. It seems likely that myrmecophiles are able to find these vacant spaces and readily occupy them. If a queen of a monogynous nest (such as *L. niger*) dies, the entire nest space becomes vacant within a few weeks, and is usually soon taken over by ants of the same or another species. This also enables the symbionts to occupy new ground (Parmentier 2019, Parmentier et al. 2021). Considering the wide distribution in Europe and its cryptic lifestyle, it is well possible that *A. formicaria* is more common in the Netherlands than considered until now. The discovery of this species in

November 2022 in Horn proves this: *A. formicaria* was found here only after a targeted search. This location is only 23 km away from the nearest site in Belgium. The geographical distribution of these species is probably expanding due to global warming (pers. obs. Rafael Molero-Baltanás) and they have spread in a natural way from other regions of Central-Europe. On the other hand, there are several researchers actively working on ant biology and distribution in the Netherlands, and their members are well aware of myrmecophiles (e.g. Boer et al. 2018, Felix & Bouvy 2014, Nlmieren.nl), so if *A. formicaria* would have been widespread and common, its presence would have been noted earlier. Until proven otherwise, it seems appropriate to place this species in category 1b according to the Dutch Species Register ('indigenous, but less than ten years of independent survival'). As *A. formicaria* was still present in the garden in Bakkum in 2022, it is likely that it will stay, unless future residents of the house would exterminate the ants with poison. As *L. niger* is very common in the area, *A. formicaria* may have already spread to neighbouring nests.

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SAMENVATTING

Atelura formicaria, een nieuw zilvervisje voor Nederland (Zygentoma: Nicoletiidae)

In de zomer van 2021 is op verschillende dagen in Bakkum (NH) het zilvervisje *Atelura formicaria* gezien. In 2022 was de soort op dezelfde locatie aanwezig. De diertjes leefden ondergronds en waren geassocieerd met de gewone wegmier *Lasius niger*. Ze vielen op door hun geringe formaat, karakteristieke, sterk taps toelopende lichaam en vooral de opvallende goudkleur. Het betreft een nieuwe soort voor Nederland, hoewel in het verleden een exemplaar is gevonden in dierentuin Artis in Amsterdam. Dezelfde soort is op 18 november 2022 tijdens een jeugdbondskamp in Horn (LI) gevonden, tijdens een gerichte zoekactie naar mierengasten, eveneens in een nest van gewone wegmieren. Recent is de soort ook gemeld in Reuver (LI), wederom in een nest van gewone wegmieren. In Nederland waren tot nog toe drie soorten zilvervisjes bekend: het papiervisje *Ctenolepisma longicaudatum*, het zilvervisje *Lepisma saccharinum* en het ovenvisje *Thermobia domestica*. Alle zijn ooit geïntroduceerd en hebben zich hier gevestigd. Ze hebben in het Nederlands soortenregister de status 2a (exoot, voortplanting gedurende meer dan honderd jaar in Nederland). Het recent gevestigde vierstreepzilvervisje *Ctenolepisma lineata*, dat zich sinds 2017 in Nederland heeft gevestigd, heeft in het Nederlands soortenregister de status 1b (incidenteel/periodiek), hoewel gezien zijn voorkomen (overwegend) binnenshuis verwacht kan worden dat ook deze soort een blijvertje is. Een of twee andere soorten zilvervisjes zijn eenmalig in Nederland waargenomen. *Atelura formicaria* is dus de vijfde zilvervisjessoort die in Nederland is vastgesteld. Het is het eerste zilvervisje in ons land dat uitsluitend buitenshuis leeft, de eerste van de familie Nicoletiidae, en de eerste obligaat myrmecofiele soort. De andere vier zilvervisjes behoren tot de familie Lepismatidae en leven voornamelijk binnenshuis. Alleen *L. saccharinum* wordt soms ook buitenshuis gevonden. Hij komt voor in bewoonde omgeving en is incidenteel geassocieerd met mieren. *Atelura formicaria* is eerder dwergmierengast genoemd (Bellmann 2021, Waarneming.nl), maar dit is geen handige naam omdat er talloze 'dwergmierengasten' zijn en niet alleen zilvervisjes. Vanwege de opvallende kleur stellen wij voor de soorten behorend tot familie Nicoletiidae in het Nederlands goudvisjes te noemen en *A. formicaria* mierengoudvisje.

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