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Rapid Communication

Ctenolepisma longicaudata (Escherich, 1905): a common, but previously unregistered, species of silverfish in the Faroe Islands

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Abstract

We hereby report the finding of *Ctenolepisma longicaudata* (Escherich, 1905) in the Faroe Islands (62°N; 7°W), an isolated group of islands in the Northern Atlantic, approximately midway between Scotland and Iceland and > 300 km from the nearest land mass (Shetland). *C. longicaudata* is a wingless insect belonging to the order Zygentoma. Other insects in this group include the common silverfish, *Lepisma saccharina*, which has previously been reported in the Faroe Islands, but it seems less common than *C. longicaudata*. *C. longicaudata* and *L. saccharina* are superficially similar, but there are several features that distinguish the two species, such as the much longer tail filaments in the former. Although previously unregistered in the Faroes, a citizen-science approach using social media showed that *C. longicaudata* is widespread and common. Both insects often live in households. Although generally harmless, they may cause damage on paper, tapestries, etc. While *L. saccharina* needs warm and humid conditions, *C. longicaudata* can stand drier conditions, and thus can be more of a problem in archives, museums and alike.

Key words: citizen science, invasive species, isolated islands, wingless insects, Zygentoma

Introduction

Insects are an extremely diverse group of animals, some are immensely useful to humans (Velthuis and van Doorn 2006; The White House 2014), and others are considered pests (Querner 2015). Insects probably originated 470–480 million years ago (Early Ordovician) as wingless organisms, and the first winged insects can be dated to around 405 million years ago (Misof et al. 2014). Some of the present-day wingless insects, like lice and fleas, have evolved from winged ancestors (Misof et al. 2014). Many insects have been found embedded in amber, nearly perfectly preserved. However, it should be noticed that amber is fossilized tree resin (mainly from gymnosperms), and as such was not present during the early insect evolution (Grimaldi 2009). Also the primitive wingless insects, like Archaeognatha (jumping bristletails) and Zygentoma (silverfish) are found in such records (Shear et al. 1984; Sturm and Mendes 1998; Mendes and

Poinar Jr. 2013; Nicholson et al. 2014) together with the insect-like Collembola (springtails) and Diplura (bristletails). The two latter groups are presently not considered as insects, partly due to morphological differences, in particular the mouthpart, and partly due to genetic evidence (Nardi et al. 2003). Thus, silverfish and jumping bristletails are the most primitive insects. Springtails, bristletails and jumping bristletails mainly live free in nature and generally do not attract much attention from most people, but in contrast, several species of silverfish have found a habitat inside houses, particularly in the temperate and colder zones. In fact, in the climate conditions of Northern Europe, including the Faroe Islands, the silverfish may have difficulties to survive outside the houses for longer periods (see references in the Results and discussion). It is known that the common silverfish, *Lepisma saccharina*, occurs in the Faroe Islands (Bloch 2007). In a student project intending to study the common silverfish, some of the animals caught could not be identified as common silverfish. They were identified as the giant silverfish, *Ctenolepisma longicaudata*, a novel species to the Faroe Islands. Here *C. longicaudata* is described and compared with *L. saccharina*. Furthermore, its distribution in the Faroe Islands and elsewhere is briefly described together with the part of biology that is of particular interest to humans.

Materials and methods

Trapping, photography and identification

Several methods were used to trap the animals alive. Care is needed for keeping the animals as intact as possible. Their long antennas and tails are quite fragile, and similarly, the scales covering large parts of the body easily fall off during hard handling. Some success was achieved by the following method to trap live animals:

An inverted glass was placed over the animal. A sheet of smooth paper or plastic was carefully slid under the glass, and when the animal moved onto the sheet, the glass was moved so the sheet closed the opening. A thin, but stiff, item (e.g., a CD) was then slid under the sheet, and when the opening of the glass was covered, the whole assembly could be lifted and rotated so the animal fell into the glass.

For short-term tranquilizing of animals, they could be put in a freezer (−20 °C) for up to 2 minutes. The animals can easily be immobilized and anesthetized by applying a drop of 70% ethanol onto the animal. However, during storage in 70% ethanol colors slightly change, and the antennas and tails may entangle upon removal from ethanol, making it more difficult to study the specimen.

Most photos were taken of live animals, using a Nikon D810 DSLR (digital single-lens reflex) camera with a Tamron 90 mm macro lens, controlled from Camera Control Pro 2 software (Nikon). Using a smooth

glass surface, the animals' feet were sliding, giving poor locomotion, thus making the photo sessions much easier. The legs of both insects end in opposing claws (not shown), probably acting as pliers, and without any obvious foot pads at the present magnifications. This contrasts with flies and many other insects (Gorb 2005; Labonte and Federle 2013). Although these pliers give a good grip on rough or soft surfaces, they are less functional on very hard and smooth surfaces, like glass.

The images were cropped and digitally handled in Adobe Photoshop Elements 13 to adjust color balance, digital sharpening and to remove dust from the insect surroundings.

Lepisma saccharina and *C. longicaudata* were identified according to the key found in Wygodzinsky (1972).

Geographical distribution in the Faroes

A citizen-science approach was launched to investigate the geographical distribution of silverfish in the Faroes. A Facebook survey (https://www.facebook.com/sunnvork/posts/10156739662548294) was run from 31st October to 29th November 2017. People were asked to report sightings of silverfish along with the information about which town/village it was found and in what kind of room it was found. Either a photo or the insect specimen was required for the identification. The silverfish were categorized as *L. saccharina, C. longicaudata* or unidentified silverfish. The last category consisted of insects that could not be identified as *L. saccharina* or *C. longicaudata* based on the photo. In general, for this category, *L. saccharina* could be excluded because of the long tail filaments, but two other silverfish, *Ctenolepisma lineata* and *Thermobia domestica,* that potentially might be present in the Faroes, could not be excluded.

Results and discussion

Description of Ctenolepisma longicaudata *and comparison with* Lepisma saccharina

While searching for common silverfish (*L. saccharina*) during a bachelor project in biology, some of the individuals caught did not conform to the available images and descriptions for this species, which supposedly should be the only Zygentoma species in the Faroe Islands. The deviant individuals seemed to be larger, more hairy, and have more disordered scales. Please note that the use of the word "hair" does not imply that these structures are hair in the mammalian sense of the word. The hairy animals had much longer tail filaments and antennae than the common silverfish (Figure 1). According to the key in Wygodzinsky (1972), these individuals were identified as *C. longicaudata*. The identification was confirmed by Dr. Preben S. Ottesen, Dept. of Pest Control, Norwegian Institute of Public Health, Oslo, Norway, based on photos similar to those shown here. After

Figure 1. (A) *Ctenolepisma longicaudata* (body length approx. 1.35 cm). The tail filaments are long in *C. longicaudata* (≈ body length), and their full size is shown at lower magnification in (B). (C) *Lepisma saccharina* (body length approx. 1.15 cm) seen from the dorsal side. The tail filaments are much shorter in *L. saccharina* (1/3 of body length, or less). Also the antennae are relatively longer in *C. longicaudata* (≈ body length) *vs*. *L. saccharina* (< body length). The difference in lengths of the last body segments is indicated by the double-headed arrows. The photos show live animals on a glass surface. Photographs by SOM, SK and ET.

the initial identification of *C. longicaudata* the Faroese Museum of Natural History was contacted, and they informed that this species had not been registered in the Faroe Islands before.

There are a number of characteristics that distinguish the two species:

- *C. longicaudata* has much longer tail filaments (≈ body length) than *L. saccharina* (≈ 1/3 body length). Note that some individuals may have broken (shorter) tail filaments. The antennae are also generally longer in *C. longicaudata* (≈ body length).

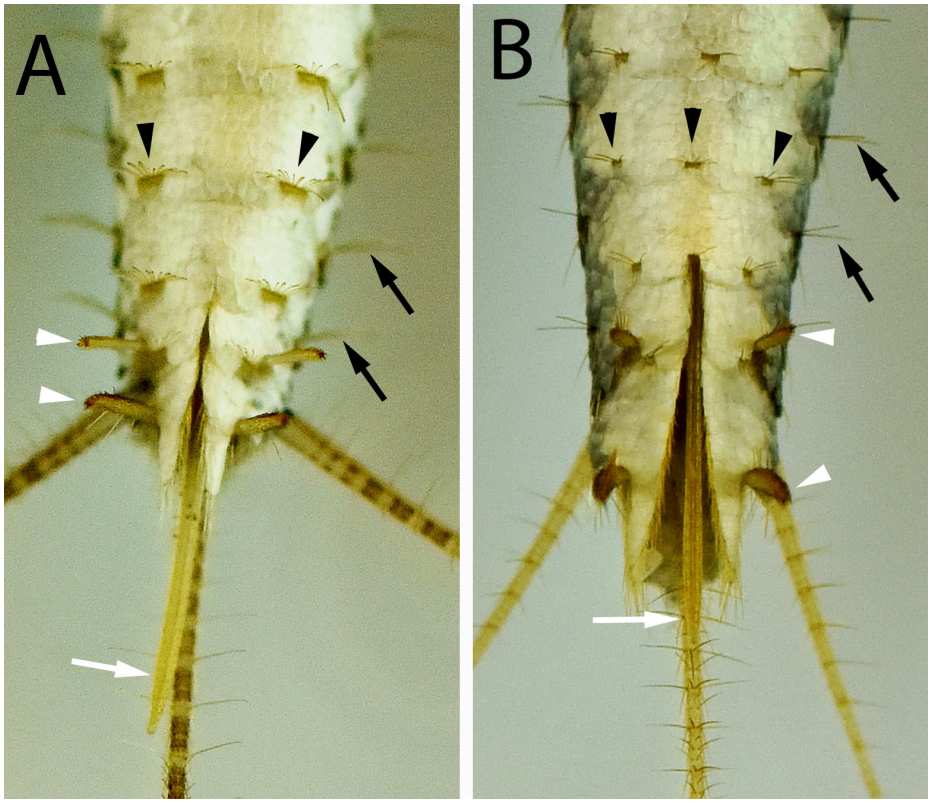

Figure 2. The posterior part of the abdomen of (A) *C. longicaudata* and (B) *L. saccharina*. The photos are from live animals, the same as shown in Figure 1. Both are females, shown by the long slit and the egg depositing tube (white arrows), long in *C. longicaudata* and short in *L. saccharina*. *L. saccharina* has a medial chetal comb, while *C. longicaudata* lack these (black arrowheads). Note the two pairs of styli in both species (white arrowheads). In addition to use those as extra pairs of "legs" keeping the abdomen lifted from the ground, the styli probably also act as sensory organs (Hädicke et al. 2016). Black arrows: Lateral chetae from dorsal side (unfocused in *C. longicaudata*). Photographs by SOM, SK and ET.

- The body of *L. saccharina* is more tapered towards the posterior, while *C. longicaudata* is more rectangular (Figure 1).
- The most posterior body segment is relatively long in *L. saccharina*, and clearly protrudes behind the point where the lateral tail filaments (cerci) emerge from the body (Figures 1 and 2). *C. longicaudata* has a much shorter posterior segment (Figures 1 and 2).
- Although the amount of hair can vary between individuals, *C. longicaudata* has in general more and longer hair than *L. saccharina* (most evident in Figures 3 and 4). The lack of hair makes it easier to see the straight and wide front of the head plate in *L. saccharina* (Figure 1 and 3). The front of the head plate is narrower in *C. longicaudata* (Figures 1 and 4). Additionally, the front of the head plate is clearly bent down in *L. saccharina*, and it is quite wide and straight (Figure 4B, D) compared with *C. longicaudata* (Figure 4A).
- *C. longicaudata* has three rows of hair combs (chetae) on the dorsal side of the abdomen, one central and two lateral. The lateral combs can easily be seen when viewing the insect from above. These can partly be seen in Figure 3. *L. saccharina* has much less hair on dorsal side.

Figure 3. More or less lateral views of (A) *C. longicaudata* (approx. 1.3 cm body length) and (B) *L. saccharina* (approx 1.0 cm body length). In general, *C. longicaudata* has more and longer hair than L. *saccharina*. The photos show live animals. These are different animals from those shown in Figures 1, 2 and 4. While *C. longicaudata* was reasonably docile, *L. saccharina* was much more active, and we were not able to make a clean lateral photo of it. Photographs by SOM, SK and ET.

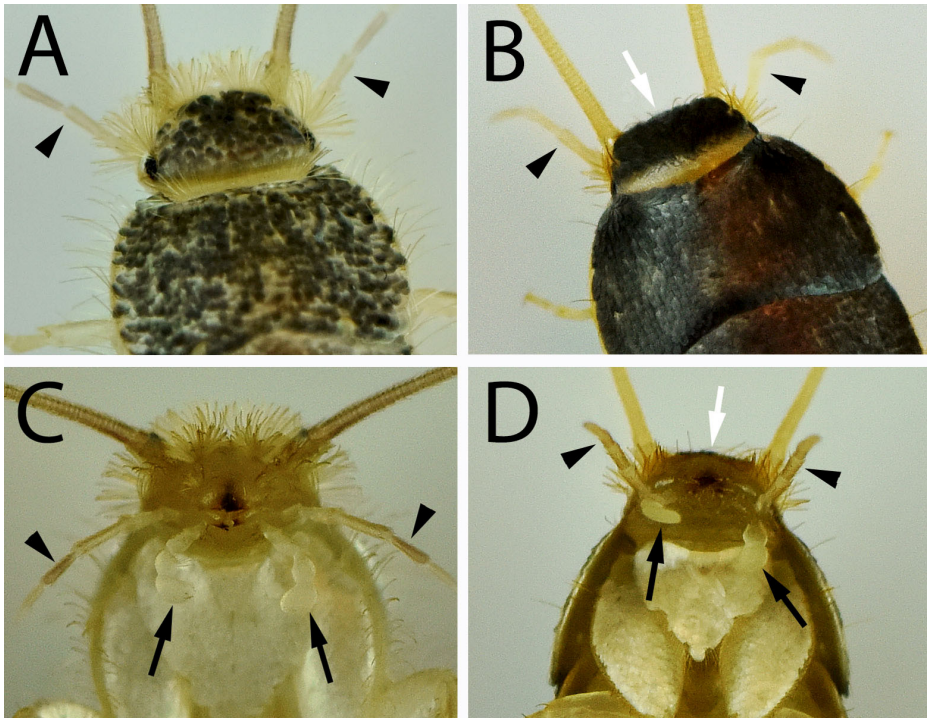

Figure 4. Heads of (A, C) *C. longicaudata* and (B, D) *L. saccharina* seen from the (A, B) dorsal and (C, D) ventral side. A and B are enlargements from Figure 1. Note the very hairy appearance of *C. longicaudata*, and that the front of the head plate is curved, while it in *L. saccharina* is quite straight (white arrow). Black arrowheads: Maxillary palps. Black arrows: Labial palps. Photographs by SOM, SK and ET.

- On the ventral side of the abdomen, *L. saccharina* has a central and two lateral rows of hair combs on each segment, while *C. longicaudata* only has the lateral rows (Figure 2).

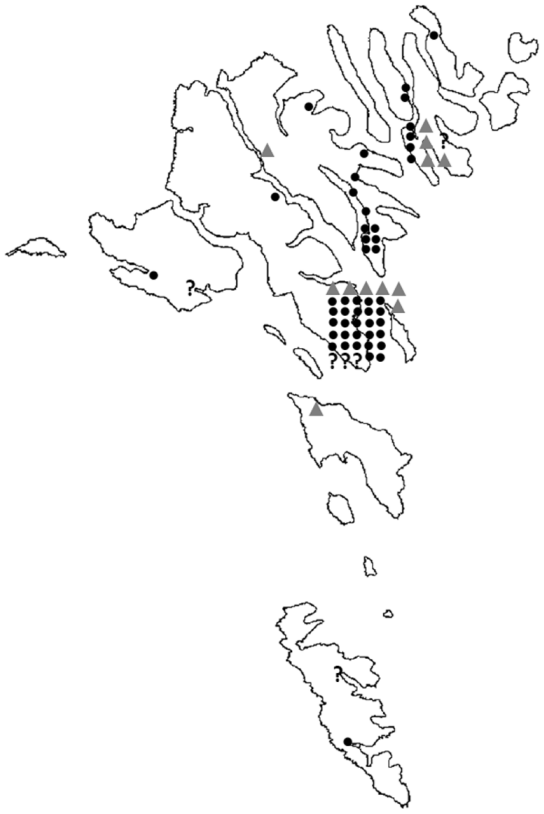

Figure 5. Distribution of *C. longicaudata* and *L. saccharina* in the Faroe Islands as reported in a Facebook survey that took place in November 2017. Black circles: *C. longicaudata*. Grey triangles: *L. saccharina*. ?: Reports where the photo details were insufficient. For these reports, we could generally exclude *L. saccharina*, but we could not exclude two other long-tailed species that potentially could be present in the Faroe Islands (see text). Each dot represents one report, although some reports included several individuals, but they were always of the same species. If a person did several reports, they were counted individually. Most of the animals were found in Tórshavn (62°00′N; 6°46′W), the largest city on the islands. For details see Supplementary material Table S1.

Distribution of Ctenolepisma longicaudata *in the Faroe Islands*

The Faroese National History Museum had no previous registrations of *C. longicaudata*, but already during our initial collection of *L. saccharina*, the impression was that the presence of *C. longicaudata* was not a rare exception. To get a rough impression of its distribution, a Facebook survey was launched. Around 65 reports with a total of 72 photos and 13 physical insect specimens were received. *Ctenolepisma longicaudata* was reported much more often than *L. saccharina* (Figure 5). As could be expected, most reports came from the most densely populated areas (Tórshavn/Hoyvík, Klaksvík, around Skálafjørður). In addition, we received reports from the islands Vágar, Sandoy, Suðuroy, Kunoy and Viðoy. Although most reports came from private houses, *C. longicaudata* was also reported in public institutions, like schools and kindergartens.

In six of the images received during the Facebook survey, *L. saccharina* could be excluded with certainty, mainly because of the presence of long tail filaments and the shape of the caudal segment, but the details in the images were too obscure to identify *C. longicaudata*. In fact, in two images,

the outline of the insect could suggest firebrat (*Thermobia domestica*). Unfortunately, the images did not have sufficient details to conclude its presence and no physical individuals belonging to this species were received. Anecdotal evidence (Heini Magnussen from Skaðadjóratænastan, *personal communication*) could suggest the rare presence of this species.

The prevalence and distribution of *C. longicaudata* in the Faroe Islands suggest that this species must have been here for quite some time, at least for several years. From the received reports, it may appear that *C. longicaudata* is more prevalent than *L. saccharina* in the Faroe Islands. However, there could also be other reasons for a reporting bias, for example that *L. saccharina* could be more agile and runs faster into shelter when disturbed. In handling the insects, the impression was *C. longicaudata* being more docile. *C. longicaudata* is generally somewhat larger than *L. saccharina*, and could therefore be easier to see. There were few households that reported the presence of both species, one of them is connected to one of the authors. Whether this pattern is caused by a real difference in distribution, randomness, the higher agility in *L. saccharina* (thereby more difficult to see and trap), or competition between the two species, is unknown.

Even though *C. longicaudata* was recorded in southern Europe more than 100 years ago (Molero-Baltanas et al. 2000), it was only closer to the turn of the century that the animal was found in the northern part of Europe. The first Dutch official registration was published in 2002 (Beijne Nierop and Hakbijl 2002), but it was already widely distributed in the country, and according to the paper it had first found in 1989. According to Lock (2007), the first individual in the neighboring Belgium was collected in 1998. It was officially reported in Sweden in 2002, but may have been imported around 10 years earlier (Pape and Wahlstedt 2002). A few scattered findings in Germany are from 2007 and 2014 (Meineke and Menge 2014). It was only registered in Norway in 2013, but was soon found to be wide-spread (Folkehelseinstituttet 2015). The first official British registration was published in 2016 (Goddard et al. 2016). The first Danish observation with identification appears to be in 2017 (Thomas 2017), but according to the observer, the species has probably been in Denmark for some time. The species was also only recently detected in the Czech Republic (Kulma et al. 2018), but the population seemed well-established, and could be the source of further local spreading (Kulma et al. 2018). The relatively high prevalence and wide distribution at the time of formal recognition of *C. longicaudata* seems to be the normal pattern in the Northern European countries. In nearly all countries mentioned above, *C. longicaudata* and *L. saccharina* are commonly found in households, but also in libraries (Beijne Nierop and Hakbijl 2002) and warehouses (Kulma et al. 2018). Wygodzinsky (1972) writes that *C. longicaudata* (together with two other species) are common in households, but are believed not to be native to the area of the USA and the Caribbean.

Short note on the biology of Ctenolepisma longicaudata *and its potential as a pest*

Lepisma saccharina and *C. longicaudata* are wingless insects that live indoors. In contrast to most insects, their life cycle does not include larvae, pupae and imago (adult) stages. The nymph is similar to the adult individuals, just in smaller scale, and they grow by molting their exoskeleton, having the adult morphology already from the early stages. They can live for several years (Lindsay 1940). In households, both insects feed on paper, cotton, starch, etc. (Lindsay 1940; Querner 2015; Hädicke et al. 2016). Before the cohabitation with humans, their natural source of food was probably organic detritus.

The silverfish are mainly active during the night, running rapidly into shelter when the light is turned on. The nightly lifestyle makes the animals more dependent on other types of senses than vision, and they probably have sensors in both the antennae, tail filaments and styli (Hädicke et al. 2016). In fact, some types of sensors (olfactory receptors) are found in silverfish, but not in Archaeognatha (Missbach et al. 2014).

While *L. saccharina* needs warm and relatively humid environment, and are often found in bathrooms and kitchens, *C. longicaudata* is able to stand drier surroundings (Heeg 1967). The present Facebook survey indicated that the insects were often found in typically dry rooms, like bedroom or sitting room. One of the authors twice found *C. longicaudata* climbing in the curtains in such rooms. In fact, it has been said: "They thrive in dry buildings where everything is new and proper… If you have the giant silverfish, you also have a dry, warm, modern apartment… where it is good to live. It is almost a quality mark." (Quotation from Kolbjørn Mohn Jensen, Mycoteam, given to Norwegian Broadcasting (NRK 2016)). This is just what makes *C. longicaudata* a potentially bigger problem than *L. saccharina*, as the former has good chances of surviving in archives, libraries and museums, where there additionally is plenty of suitable food for the insects in old books, cloths, etc. *C. longicaudata* is also attracted to cereals (Goddard et al. 2016), and could hypothetically be a vector for food contamination (Kulma et al. 2018), although we are not aware on any international reports on the subject.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Geo-referenced records of *C. longicaudata* and *L. saccharina* in the Faroe Islands in November 2017. Please note that for privacy reasons the locations only indicate the towns or villages, and not the exact buildings, where the individual insects were found.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2019/Supplements/BIR_2019_Thomsen_etal_Table_S1.xlsx