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DISTRIBUTION OF *CTENOLEPISMA LONGICAUDATUM* (ZYGENTOMA: LEPISMATIDAE) IN THE NETHERLANDS

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Abstract In The Netherlands, until 2002 it was thought that next to *Lepisma saccharina, Thermobia domestica* was present in residences as well. It appeared *T. domestica* had been identified incorrectly and was *Ctenolepisma longicaudatum*. It is hypothesized that the latter species is better adapted to the indoor environment than the other two species. *Thermobia domestica* has not been found in the last years. *Lepisma saccharina* is present far less than *C. longicaudatum*, whereas the latter is spread throughout The Netherlands and found within modern residences. Significantly more individuals of *C. longicaudatum* than *L. saccharina* are sent in by the public as have been found visually during house searches.
Key words Gray silverfish, common silverfish, firebrat.

INTRODUCTION

From the order of Zygentoma, over 400 species are known worldwide (Mendes, 2002). Only a few species are considered to be pests. *Lepisma saccharina* (the common silverfish) and *Thermobia domestica* (the firebrat) are relatively well studied indoor pest species and are (probably) cosmopolitan. Their pest status is based on their presence indoors and damaging of materials, such as old book binding, clothing and wallpaper glue (Robinson, 2005). *L. saccharina* occurs in warm and damp locations. *Thermobia domestica* is thermophilic with an optimum temperature of 37 to 39°C (Ebeling, 1975). Both *L. saccharina* and *T. domestica* have been described to be present in The Netherlands early in the 20th century (Oudemans, 1900). Oudemans (1900) described *T. domestica* to be found at or near bakery ovens, although Sweetman (1938) described this species to be a common household pest. Until 2002, it was thought to be common in The Netherlands, until Beine Nierop and Hakbijl (2002) discovered *T. domestica* had been incorrectly identified and were actually *Ctenolepisma longicaudatum* (gray silverfish).
Ctenolepisma longicaudatum differs from *L. saccharina* and *T. domestica* in that they are not as limited to temperature and moisture conditions (Ebeling, 1975).

Modern residences are built with increasing insulation values. In combination with the increased use of central heating, this provides a stable dry and warm environment. It is therefore hypothesized that *C. longicaudatum* is the dominant species within the modern household environment in The Netherlands.

In this study both the distribution of *C. longicaudatum* and the abundance of this species as a pest in the indoor environment as compared to the other species of Lepismatidae in The Netherlands are presented.

MATERIALS AND METHODS

Data for this study are acquired from three sources: archival data from identifications performed in 2007 until 2012, a survey in which people were requested to send in silverfish, and from visual inspections and manual capture within residences.

Archival Data

Data from samples that have been sent for identifications and advise on pest management that were sent to the Dutch Expertise Centre for Urban Pests (Kenniscentrum Dierplagen) in the period of 2007-2012 have been used to determine both the distribution as abundance of Zygentoma species within the household environment. Houses (terraced, semidetached, detached), apartments, flats, care shelters and attached sheds and garages, were considered as the household environment.

Coordinates of the addresses where the samples were found, were used for the map. In case the address was not known, the coordinates of the centre of the city, town or village were used. The coordinates were transformed to fit a grid with squares of 5x5 kilometres. Multiple samples within a 5x5 kilometre square are shown as a single square. The map was created using ArcGIS version 9.3.1 (Esri Nederland B.V., Rotterdam). Samples of Zygentoma species were identified using Beine Nierop and Hakbijl (2002), Gorham (1991), Weidner (1993) and Weidner and Sellenschlo (2010).

Survey

In October and November 2013 a survey was conducted in which people were contacted and encouraged to send in as many indoor Zygentoma as possible. The request was placed on the website (www.kad.nl), was sent by online newsletter and picked up by several media (including www.natuurbericht.nl and www.vroegevogels.nl). Respondents were asked to answer a few questions regarding the date of construction and type of building, and nuisance and control measures taken.

Residential Inspections

A total of 17 single-family houses within the municipality of Houten, The Netherlands were visited in May 2013 and visually inspected for the presence of Zygentoma species. From the nineteen seventies, the population of Houten increased from approximately 4,000 to approximately 45,000 in 2006. Within this period several residential districts were built in different decades. The inspected residences were selected on period of construction, which ranged from 1964 until 2007 with the exception of one house dating from early 19th century, and were located throughout town. Residents were contacted in person and were asked for permission to inspect their premises. Standard inspection locations were the crawling space, broom closet, meter cupboard, attic, storage rooms, sanitary areas, laundry, and central heating boiler. Based on the information provided by the residents, other areas were included as well. Residences were inspected by two persons. Zygentoma species. were hand collected and stored in plastic vials for further identification according to Weidner and Sellenschlo (2010). The surface temperature and relative humidity of locations where Zygentoma species. were found, and similar locations if they were not found, were measured using an infrared thermometer (Optris MS, Optris GmbH, Berlin, Germany) and a thermo-hygrometer (Testo 625, Testo BV, Almere, The Netherlands), respectively.

Data Analysis

Differences between number of individuals from different species are tested using the Mann Whitney U test. Numbers of individuals found with the residential inspects in houses built in different periods of construction were tested using the Mann Whitney U test. The observed number of *C. longicaudatum* from two different periods of construction were tested against the expected number of *C. longicaudatum*, based on the housing stock from these periods of construction, by a one way chi square test.

Data was analysed using IBM SPSS Statistics 20 (IBM Corporation, Armonk, United States).

RESULTS AND DISCUSSION

There was a significant difference (p= 0.004, Mann Whitney U) between the number of *C. longicaudatum* and *L. saccharina* that were sent in for identification from the household environment. *Ctenolepisma longicaudatum* makes up, on average (± s.e.), 11.5 ± 1.0 percent of all samples that were sent in from the household environment for identifications, whereas this is only 0.7 ± 0.2 percent for *L. saccharina*. *Thermobia domestica* was not among the samples received. In the survey that was conducted in 2013, a total number of 35 samples was sent in, in which only one contained a single *L. saccharina*, whereas in total 416 *C. longicaudatum* (>99%) were sent in, with an average (± s.e.) of 13.4 ± 2.9 individuals per residence. The maximum number of *C. longicaudatum* received was 62, whereas some respondents sent in a single one. From the pest species of Zygentoma that occur within buildings, *C. longicaudatum* is by far the most abundant.

Furthermore, *C. longicaudatum* can be found spread over the entire country, from east to west and from north to south (figure 1). It is even found on Ameland, one of the islands in the Wadden Sea.

The results of the survey of 2013 show a high percentage of samples of *C. longicaudatum* from residents of relatively recent periods of construction (67% in the period of 1991-2010), whereas the percentage of samples from earlier periods of construction was lower (33% in the period before 1991). The housing stock, however, shows an opposite distribution based on the period of construction. Residences built within the period of 1991 until 2010 make up only 22% of the housing stock, however (den Otter, 2012). The observed numbers of *C. longicaudatum* are significantly different from what was expected based on the housing stock (p< 0.001, one way chi square). This means that relatively more of these insects were sent in by people living in residence of recent construction. Altered construction requirements, methods and materials account for an indoor climate change, making the household environment warmer and drier. It is therefore expected that the ratio in abundance between a species that prefers warm, but can colonize drier environments, such as *C. longicaudatum*, and a species that is bound to a more humid environment, such as *L. saccharina,* increases through the decades. When comparing the number of insect samples received in the period of 1972 until 1977, the percentage of *L. saccharina* (2.3% ± 0.3 on average ± s.e.) is indeed significantly higher (p= 0.004, Mann Whitney U) than of *T. domestica* (0.1% ± 0.0 on average ± s.e., data from Anonymous (1978)), another thermophilic species capable of colonizing drier environments, although it is to be expected these were *C. longicaudatum* as well.

There was a significant difference between the number of *C. longicaudatum* found within the nine residences (seven terraced, one semi-detached and one apartment) built after 1990 (9.1 ± 2.2 on average ± s.e.) and the number found within the eight residences (six terraced, one detached and a single maisonette) built before 1991 (1.2 ± 0.5 on average ± s.e., p= 0.002, Mann Whitney

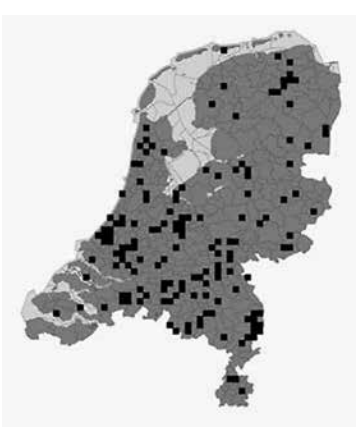

Figure 1. Distribution of Ctenolepisma longicaudatum in The Netherlands, based on data from 2007 – 2012 and the survey of 2013. Squares represent areas of 5 x 5 kilometres.

U). Although slightly higher, no difference was found in overall temperatures and relative humidity between locations where *C. longicaudatum* was found and locations without these insects, but these differences were not significant, perhaps due to the low number of houses visited.

There is a low level of tolerance for these insects, as ninety percent of the respondents considered them a nuisance, because of hygienic reasons (33%), damage (30%) or just their presence (36%), and nearly half of the respondents had taken control measures before: vacuuming, capturing by glue boards or by hand, using insecticide sprays, ventilating, reducing temperatures and cleaning up; see Figure 2.

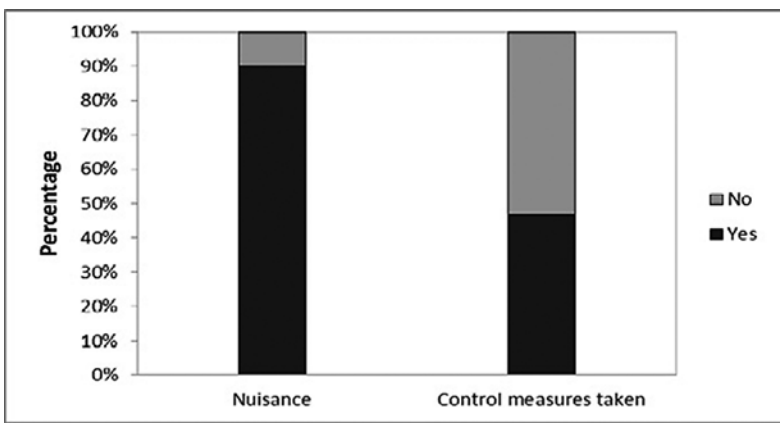

Figure 2. Percentage of respondents (N= 35) that consider Ctenolepisma longicaudatum as a nuisance and have taken control measures.

CONCLUSIONS

The majority of Zygentoma that are found within the household environment in The Netherlands are *C. longicaudatum*. *Lepisma saccharina* is found much less and *Thermobia domestica* not at all. *Ctenolepisma longicaudatum* is spread throughout the entire country and is mainly found within modern residences.

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