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Research Article

Introduction, dispersal, establishment and societal impact of the long-tailed silverfish *Ctenolepisma longicaudata* (Escherich, 1905) in Norway

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Abstract

Urban insects are continuously introduced to new areas as stowaways or contaminants of trade goods and may, if established in the recipient country, affect society on several levels. The bristletail *Ctenolepisma longicaudata*, an indoor nuisance pest, was recently detected in Norway and has shown a swift and nationwide upsurge. This study describes its numerical increase and spatio-temporal dispersal into all 18 counties of Norway within a period of 5 years. *C. longicaudata* showed a distinct 2–3-fold increase per year in measures of submitted pest samples, reported professional pest control cases, insurance claims, news coverage and court cases concerning disputes in transfer of ownership in real estate sales. The insurance claims concerning *C. longicaudata* are strongly dominated by buildings constructed in the last 15 years and reflect *C. longicaudata*'s use of the urban habitat, while the 6788 pest control cases pinpoint the magnitude of the problem. The dispersal biology and societal impact of this nuisance pest is discussed in relation to other bristletail species and indoor pests in Norway. The study suggests that an increased import risk, aspects of modern construction and the environmental stability in new buildings may promote populations of *C. longicaudata*.

Key words: invasive, insurance, economic, lawsuits, pest, control

Introduction

Dispersal of insects between countries and continents may cause ecological problems and have cultural and societal effects. Concerns are often related to conservational topics or establishment of new pests (Kenis et al. 2009; Lantschner et al. 2019; Lester and Beggs 2019; McLaughlin and Dearden 2019; Paini et al. 2016), but urban ecosystems and indoor environments may also be affected (Robinson 2005; Rust and Su 2012). Globalization of trade and travel is a driving force behind such unwanted introductions (Banks et al. 2015; Dawson et al. 2017; Gippet et al. 2019), with commodities, contaminants or stowaways being typical pathways of introductions (Doggett et al. 2018; Hulme et al. 2008; Padayachee et al. 2017; Pergl et al. 2017). Urban pest problems are mostly of an economic character or connected to health issues (Bonnefoy et al. 2008; Mallis et al. 2011; Robinson

2005), and while disease-carrying vectors are monitored closely to predict, detect and mitigate human and animal health threats (Kading et al. 2018; Takken and Bart 2007), many of the more common tramp species are often ignored. Continuous urban invasions are best exemplified by the persistent worldwide presence of insects such as the German cockroach (Tang et al. 2019), Pharaoh ants (Wetterer 2010) and more recently the major comeback of the common bed bug (Doggett et al. 2018).

Monetary and social elements are obvious and important characteristics connected to control of urban insect pests. The global resurgence of the common bed bug has affected the revenue of pest control companies (Doggett et al. 2018) and severely hampered quality of life particularly in low-income parts of society (Trájer et al. 2019; Wang et al. 2016, 2018). Cockroaches have also shown socially skewed medical impact due to greater asthmatic effects being related to limited economic means (Gore and Schal 2007; Rabito et al. 2017; Sarpong et al. 1996), and Pharaoh ants may affect patient security in hospitals through dispersal of pathogens (Moreira et al. 2005; Robinson 2005). These aspects are somewhat quantifiable compared to the more hidden costs of an abundance of indirect effects on business strategies and society (Bradshaw et al. 2016). Expenses connected to brand damage and loss of revenue through bad publicity are difficult to measure, and the large-scale societal cost of pest control related to procurement competence, management organization, insurance issues, legal disputes, law suits or health economic aspects are commonly disregarded despite many stakeholders being involved and mutually sharing the costs.

Ctenolepisma longicaudata (Escherich, 1905), Zygentoma – Lepismatidae (commonly named as long-tailed silverfish, grey silverfish or giant silverfish), is a nuisance indoor pest in many parts of the world (Bennett et al. 2010; Mallis et al. 2011), and is interesting in terms of anthropologically reinforced dispersal biology. It is solely described from human influenced environments (Heeg 1969; Molero-Baltanas et al. 1997), while its natural biology and distribution are unknown. It was first observed in South Africa in 1905, and soon after in Australia, Palestine, the Seychelles and the New Hebrides (Lindsay 1940). It was also early defined as an indoor pest in the US (Mallis 1941) and was observed as a reoccurring indoor species in Spain and the Netherlands toward the end of the twentieth century (Molero-Baltanas et al. 1997; Nierop and Hakbijl 2002). These European descriptions were followed by an extensive sequence of observations in many other European countries (Bujis 2009; Goddard et al. 2016; Kulma et al. 2018; Lock 2007; Mattsson 2014; Meineke and Menge 2014; Pape and Wahlstedt 2002; Querner 2017; Schoelitsz and Brooks 2014; Thomsen et al. 2019), which indicate that *C. longicaudata* has spread throughout Europe during the last 20 years.

Ctenolepisma longicaudata is a species with habitat preferences suited to indoor environments, i.e. 24 °C and 55% relative humidity (RH) (Lindsay 1940). It is difficult to eradicate, compared to *Lepisma saccharina* (Linnaeus, 1758) and *Thermobia domestica* (Packard, 1873), which in cold and temperate regions may be controlled by simple moisture or temperature adjustments (Bennett et al. 2010; Mallis et al. 2011). *Ctenolepisma longicaudata* is more drought resilient (Lindsay 1940; Sahrhage 1954) and may consequently utilize larger parts of buildings (Bennett et al. 2010; Mallis et al. 2011). Silverfish and firebrats in general are pests on paper, some also on fabric and various materials of vegetable origin, and are only considered a serious threat in institutions like museums and libraries (Querner 2015). Apart from this problematic situation, silverfish control receives relatively little attention. Several species are known to inhabit human dwellings, but species-specific control measures have not been developed because they are usually only considered a nuisance. However, in private households, a high-density population appears much like a cockroach infestation, potentially causing food contamination, mental distress or social stigma (Aak et al. 2019).

In this study we describe the introduction, dispersal and nationwide establishment of *C. longicaudata* in relation to other silverfish species. We label and evaluate their impact as a pest in Norway through numerical measures of submitted pest samples, reported professional pest control cases, insurance claims, news coverage and court disputes concerning real estate sales.

Materials and methods

Insect samples and pest control

Since 1971 the Department of Pest Control at the Norwegian Institute of Public Health (NIPH) has registered and monitored the urban pest situation in Norway through insect pest samples submitted by the public, officials and pest control technicians (ENTBAS 2020). In 2007, NIPH also started a collaboration with Norwegian pest control companies to collect the number of pest control assignments of the most significant Norwegian indoor pests in order to monitor activity in all the largest and in the majority of small pest control companies in Norway (NIPHpest 2020). *Ctenolepisma longicaudata* was first included in the statistics in 2016, shortly after its official discovery in Norway (Mattsson 2014), and when suspected to be an emerging Norwegian nuisance pest.

Insurance

Norwegian house owners may have pest control included in their home insurance, and the insurance company Norsk Hussopp Forsikring (NHF) covers approximately 65% of the Norwegian market of insurance agreements concerning pests. Upon confirmation of a pest problem, management is contracted by the insurance company to ensure a correct and efficient approach, while practical issues are handled through a collaboration between the insurance holder and the designated pest control technician. The insurance company continuously register insurance holders and their claims in an in-house database which provides information on (1) pest status, (2) location, (3) building type and (4) building construction year.

Media coverage

The Norwegian media coverage of *C. longicaudata* was evaluated by counting occurrence of the phrase "skjeggkre" (Norwegian for *C. longicaudata*) in news cases in the Retriever data base (NTB 2020). Retriever is owned by the Norwegian News Agency and serves most of the editorial media (newspapers, web-based news, television and radio). News cases registered were restricted to media content with the search phrase either in the headline, ingress or body of the text. The numerical output from the database was summarized and organized according to year.

Court cases and rulings

Court cases in Norway are available to the general public and can be accessed on request to the National Court Administration and local court houses. Disputes in transfer of ownership related to *C. longicaudata* typically concern costs of control in combination with a potential reduced future sales value if control fails. If a seller of an apartment/house fails to disclose known problems or issues with the sales object, the buyer may claim a corresponding compensation. Rulings in transfer of ownership cases during 2014–2019 were collected from the Norwegian District Courts in the cities Bergen, Trondheim, Stavanger and Oslo (with its surrounding densely populated areas Asker and Bærum, Follo and Romerike). Disputes concerning *C. longicaudata* were extracted from the total pool to quantify relative numerical impact of such cases, and the number of rulings in favor of compensation were registered and scored according to size of compensation as a percentage of the sales value of the residence.

Extraction of data and analysis

The numbers regarding the pest samples and pest control were collected by NIPH, and the insurance information was extracted by NHF in January 2020. The information regarding news and court cases was summarized by NIPH in April and May 2020. Court cases can require 12 months to reach a verdict. Because all cases from 2019 were not complete by May 2020, we used relative numbers throughout the court case analyses, i.e. verdicts per number of cases available per year. All personal sensitive information was removed before analyses, and descriptive statistics were handled in Sigmaplot 14.0 (Systat Software Inc., San Jose, CA, USA). An anonymous descriptive analysis is considered outside the requirements for approval by the Regional Committees for Medical and Health Research Ethics in Norway (REK, Oslo, Norway).

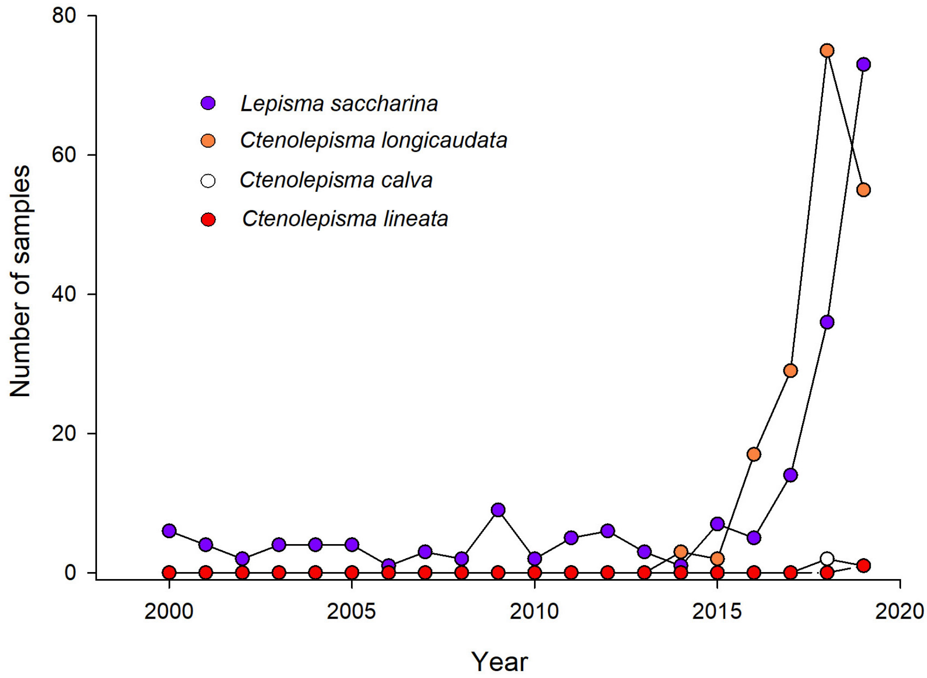

Figure 1. Submitted samples of *Lepisma saccharina*, *Ctenolepisma longicaudata*, *Ctenolepisma calva* and *Ctenolepisma lineata* to the Norwegian Institute of Public Health during 2000–2019.

Results

Ctenolepisma longicaudata was not submitted to NIPH through pest samples during 1971–2014. After the initial three and two submissions in 2014 and 2015, respectively, the number of samples approximately doubled each year up to 2019 when it declined by 27% (Figure 1). *Lepisma saccharina*, the only indoor bristletail species previously known to be permanently present in Norway, has been submitted regularly to NIPH since 1973. During the last 20 years it has shown 3.7 ± 0.6 (average ± standard error) submissions per year until 2015 when it increased strongly in parallel with *C. longicaudata* (Figure 1). *Ctenolepisma calva* (Ritter, 1910) appeared in two samples in the last month of 2018 and once in the spring of 2019, whereas *Ctenolepisma lineata* (Fabricius, 1775) was registered once in December 2019 (Figure 1).

The number of *C. longicaudata* infestations treated in Norway showed the same overall pattern as the submitted samples. Since the registrations started in 2016, the number of control instances increased by 195–297% per year to reach 6788 in 2019 (Figure 2). Single control cases, investigated in retrospect, also showed infestations of *C. longicaudata* in 2004, 2006, 2008 and 2009 (Aak et al. 2019), as well as nine cases described in detail in 2014 (Mattsson 2014).

The same overall situation was observed in the insurance claim database, where *C. longicaudata* was absent until 2014, after which numbers increased rapidly (Table 1). For 2014–2019, the database holds a total of 4072 addresses/buildings with claims of silverfish compensation. Of these, there were 452 for *L. saccharina* and 3617 for *C. longicaudata*; 79.7% of the 3617

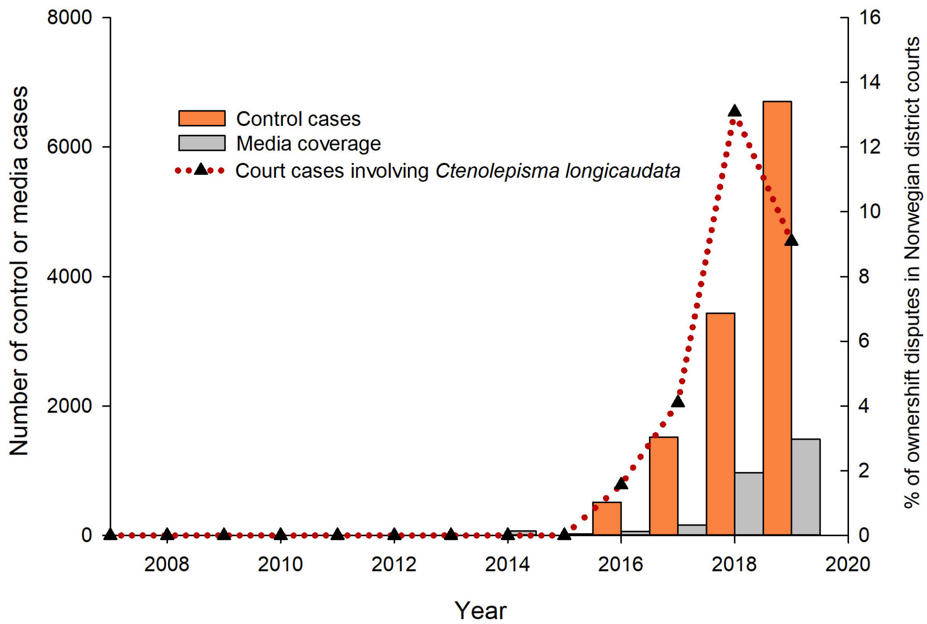

Figure 2. Visualization of the societal impact of *Ctenolepisma longicaudata*. Nationwide pest control efforts, news case coverage and court cases in Norway. Percentages of total court cases concerning disputes in transfer of ownership are given because court rulings were only collected in the district courts of the four major cities of Trondheim, Bergen, Stavanger and Oslo (with its surrounding regions).

Table 1. Insurance cases related to *Ctenolepisma longicaudata* in Norwegian counties. The counties are organized along the coast from north to south, with the two inland counties Hedmark and Oppland last. The grayscale shading represents annual change: light gray (decrease or 0–25% increase), gray (25–100% increase) or dark gray (more than 100% increase).

County of	Insurance holders	2014	2015	2016	2017	2018	2019	*Total*
Finnmark	6012	0	0	0	0	1	2	*3*
Troms	15668	0	0	0	3	22	21	*46*
Nordland	31110	0	0	1	3	16	29	*49*
Trøndelag	41947	0	4	1	16	39	97	*157*
Møre og Romsdal	34795	1	0	6	19	48	113	*187*
Sogn og Fjordane	15392	1	1	2	24	18	37	*83*
Hordaland	64564	0	13	20	61	211	424	*729*
Rogaland	45331	0	1	9	57	150	310	*527*
Vest-Agder	28160	0	1	3	9	38	120	*171*
Aust-Agder	25046	0	0	2	6	13	31	*52*
Telemark	30152	0	0	2	2	8	20	*32*
Vestfold	30776	0	0	2	5	42	71	*120*
Buskerud	38592	0	0	0	15	40	55	*110*
Oslo	28667	0	1	11	35	112	228	*387*
Akershus	70448	0	2	17	69	194	389	*671*
Østfold	42971	0	0	3	19	35	87	*144*
Hedmark	32397	0	0	3	1	19	50	*73*
Oppland	33343	0	0	2	7	24	43	*76*
Ctenolepisma longicaudata		2	23	79	351	1029	2631	*3617*
% of total insect claims in portfolio		0.3%	1.9%	5.1%	14.0%	31.2%	43.2%	

cases were from detached houses, 15.5% from housing cooperatives, 1.1% from leisure homes and 3.8% from contents insurance covering all three housing categories.

The claims from home insurance holders regarding *C. longicaudata* changed from being absent from the portfolio before 2014 to representing 43% of the insect claims received by NHF in 2019 (Table 1). The number of

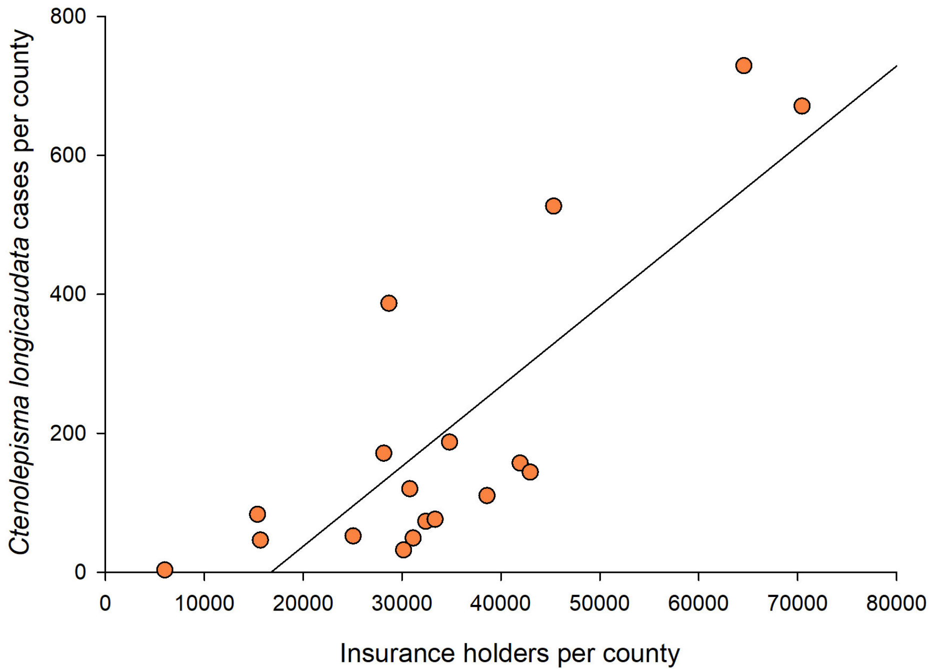

Figure 3. Relationship between number of home insurances in each county and total *Ctenolepisma longicaudata* insurance claims in the Norsk Hussopp Forsikring database.

C. longicaudata insurance cases reflect the home insurance situation, i.e. the number of houses in each county (linear regression of the cases of *C. longicaudata* vs number of insurance holders: $r^2 = 0.66$, $n = 18$, $F = 31.1$, $P < 0.001$, Figure 3).

The first complaints and insurance claims based on *C. longicaudata* among insurance holders appeared in two counties on the west coast of Norway in 2014 (Table 1 and Figure 4). Both adjacent counties received first reports the following year, in addition to the more densely populated counties of Trøndelag, Oslo and Akershus. By 2016 the distribution of *C. longicaudata* comprised 15 of 18 counties, and all 18 counties were affected in 2018. Except for three counties, an increase in insurance claims exceeding 100% was observed during 2017–2018. In 2019, there was an additional increase of more than 100% in 12 out of 18 counties.

Buildings constructed in the last 25 years showed a gradual increase in *C. longicaudata* cases until the construction year of 2014, before declining stepwise until 2019 (Figure 5). The claims regarding *C. longicaudata* were strongly dominated by buildings constructed during the last 15 years, whereas *L. saccharina* showed no such relationship to building age.

The media coverage shadows the development of the pest control situation. Norway experienced a smaller, but comparable numerical increase in news cases concerning *C. longicaudata.* The maximum relative media focus was in 2018 when the ratio of control cases to news cases was 1:5; overall this ratio ranged from 1:5 to 1:9 during 2014–2019 (Figure 2).

A total of 28 court cases founded on *C. longicaudata* infestations were found in the 7 district courts investigated. The first court case concerning a dispute in transfer of ownership was in 2016. The numbers increased in

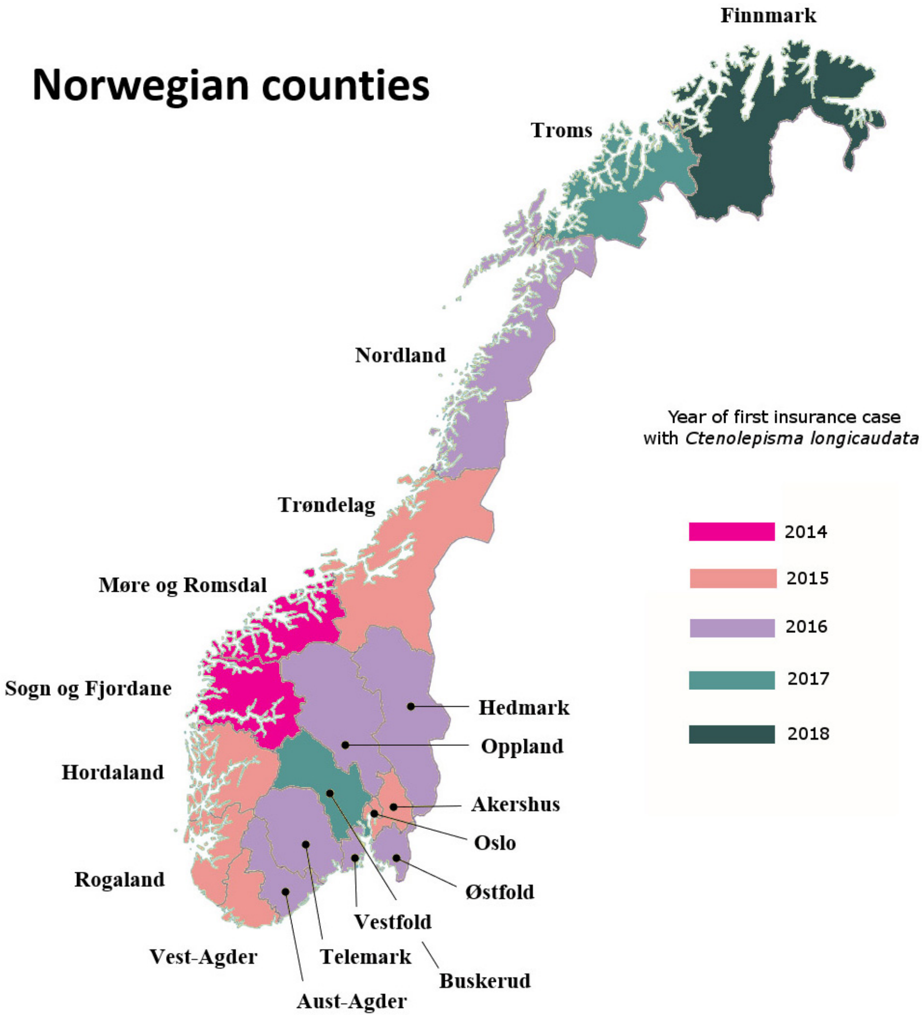

Figure 4. Map of Norway showing counties according to the division used until 2020 (source of map graphics: Kartverket – Creative Commons Attribution ShareAlike 3.0) and year of first registration of insurance cases with *Ctenolepisma longicaudata*.

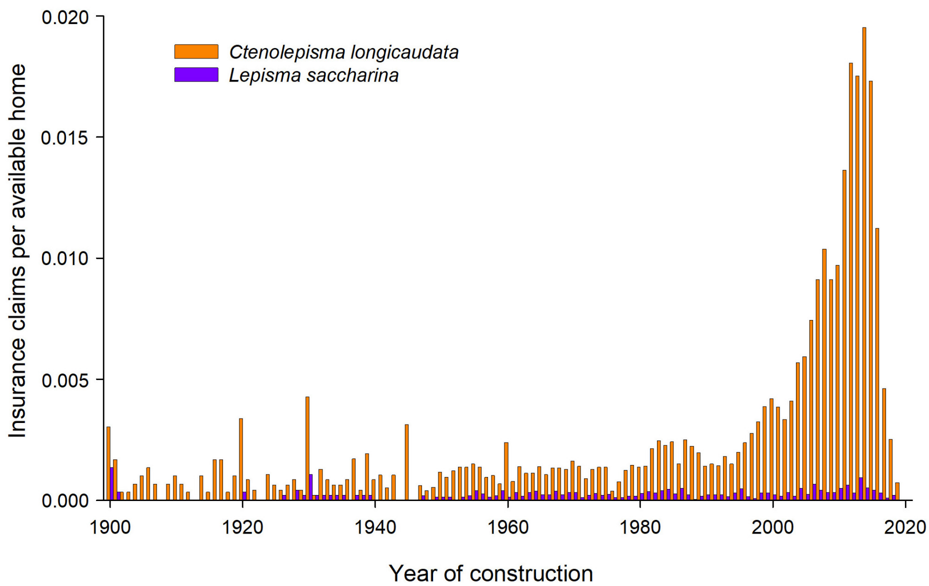

Figure 5. Home insurance cases involving *Ctenolepisma longicaudata* and *Lepisma saccharina* in Norwegian homes according to construction year. The insurance cases on the y-axis represent number of cases divided by available houses from the years of construction. The bars represent buildings/addresses of approximately 82% detached houses and 18% housing cooperatives.

parallel with the control cases and represented approximately 13% of the total disputes in transfer of ownership in 2018 but declined in 2019 (Figure 2). During the 4 years of court disputes, 63% of cases ruled against compensation based on *C. longicaudata* infestations, and the remaining 37% ordered compensation of 10.7 ± 1.2% (average ± standard error) of the purchase amount.

Discussion

The establishment, dispersal and societal impact of *C. longicaudata* were thoroughly described in this study. We describe the spatio-temporal dispersal of this nuisance pest into all 18 counties of Norway within a period of 5 years. The descriptions from insurance cases reflected *C. longicaudata*'s current use of the indoor habitat, while the number of pest control cases pinpointed the magnitude of the problem. Although a minor pest in regard to physical damage in private homes, *C. longicaudata* has managed to stir up Norwegian society through strong media coverage, indicating a remarkably large cultural impact shown by legal disputes not necessarily proportional to the actual problem caused by these insects. Such societal aspects of pest management are not commonly evaluated, but the close collaboration between governmental bodies, the insurance business and pest management companies in Norway allowed us to investigate and discuss the dispersal biology and the impact of nuisance pests in a scientific manner.

The basic route of introduction of indoor tramp species is believed to be travel or trade items (Doggett et al. 2018; Tang et al. 2019; Wetterer 2010). The swiftness of nationwide dispersal in Norway also clearly supports this assumption for *C. longicaudata*. The sudden appearance in thousands of buildings across most counties indicates an invasion cascade from well-connected hubs (Banks et al. 2015; Gippet et al. 2019). Possible introduction through trade goods is further emphasized when considering the infestation distribution according to construction year. New buildings experience elevated import-risk due to a high influx of boxed building materials and other objects during fixed furniture assembly or completion of technical tasks in the final construction phase. The introduction risk is further elevated through a synchronized housewarming with many large moving loads or acquisition of new furniture, household objects and other packaged items that may carry pest species to vacant habitats. From an insect habitat point of view, new buildings also have slightly elevated moisture levels during the initial years, which will support population survival among some moisture-demanding species (Baz and Monserrat 1999; Mallis et al. 2011). Wood and concrete dry-out times depend on complex interactions between the construction method, degree of insulation and climatic conditions (Blom and Holøs 2008; Fedorik et al. 2019; Gullbrekken et al. 2015; Pihelo et al. 2016). Construction legislation aims for humidity conditions below mold-formation critical values (Tek 2010, 2017), but an extended period of surplus water vapor in well-insulated or partially-closed spaces may yield more suitable habitats in cracks and crevices for *C. longicaudata*, which only requires moisture above 45–55% RH for survival and reproduction (Lindsay 1940). Such a minor factor may have created the observed new-building disparity compared with occurrence of *L. saccharina*, which demands 75–80% RH (Sahrhage 1954). Modern high-performance buildings also supply all zones with stable temperatures in the range of 20–26 °C (Berge and Mathisen 2016), encompassing the optimum temperature of 24 °C for *C. longicaudata* (Aak et al. 2019). It is likely that the dominance of infestations of modern buildings in Norway results from an initial period of greatly increased introduction rate into a slightly more suitable habitat. Modern construction techniques also use balanced ventilation, tubes for electricity, tube-in-tube for water systems and cable channels for television, doorbells, fiber communication or main electrical pathways. Such construction fundamentals, applied in full scale during the last 10 years (Tek 2010, 2017), create a multidirectional dispersal grid within the building and may consequently improve population survival by enhancing mobility, habitat choice and establishment of sub-populations. It is also possible that an increase in employment immigration, vacation trips and internet trade or extended construction with imported prefabricated modules may have combined with a lack of pesticide residues in new buildings to create and sustain the situation in Norway.

The *C. longicaudata* life-cycle is one and a half years under optimum conditions (Lindsay 1940), but 2–3 years under conditions found in buildings (Aak et al. 2019). It is likely that low initial numbers will require emergence of the third generation, after 4–6 years, before pest status is obtained. An approximation of 5 years for numbers to reach perceived infestation levels agrees well with the peak of infestations in buildings constructed after 2010 and the stepwise decline observed in buildings finalized in the last 5 years. The first nine official records from Norway were also mainly from buildings 2–8 years old at the time of observation (Mattsson 2014), and infestations in the Netherlands describe a similar trend toward modern buildings (Schoelitsz and Brooks 2014). Trade systems are probable keys to the invasion biology in the urban ecosystem (Banks et al. 2015; Gippet et al. 2019) and using an approximation of 5 years to reach high densities, and subsequent increased dispersal probabilities, also provides a possible explanation for the observed overall numerical increase in Norway. Early nuisance reports from Europe are about 20 years old (Molero-Baltanas et al. 1997; Nierop and Hakbijl 2002), and an initial introduction and establishment in a few international trade hubs may have been followed by minor but continuous dispersal to other storage facilities. This may provide a partial establishment with limited impact on private homes and fits the earliest Norwegian observations in 2006, 2007 and 2009 and also co-occurs with a few other initial observations in European countries (Bujis 2009; Lock 2007; Pape and Wahlstedt 2002). If establishment was gradually strengthened by persistent departure, transport and arrival within the trade and transport network (Banks et al. 2015; Gippet et al. 2019), this may explain the strong numerical increase in the end-habitat, Norwegian homes, after 2015. The Norwegian increase also occurred in parallel with many European first records and reports of increasing numbers of infestations (Goddard et al. 2016; Gutsmann 2019; Kulma et al. 2018; Meineke and Menge 2014; Querner 2017; Schoelitsz and Brooks 2014; Thomsen et al. 2019). Warehouses may house *C. longicaudata* (Kulma et al. 2018) and—because known cases are located in stores, warehouses, stock facilities or goods terminals (ENTBAS 2020)—it is likely that they act as infestation sources in Norway. Norwegian libraries, museums and office buildings also report problems with this new pest. The net direction and magnitude of dispersal between trade goods facilities, official buildings and private homes is unknown, but widespread presence in both public and private buildings is likely to sustain the problem.

Norway has experienced a remarkable pest situation with the invasion of *C. longicaudata*. The societal response has been surprising, with a high number of news cases indicating fear of infestations and highlighting the nuisance experienced. It is likely that the interaction between the public, traditional news agencies and social media in this case released a strong mediatization and agenda setting to generate a self-strengthening situation (McCombs 2004; Neuman et al. 2014). A situation with one news case per five control cases is remarkable because *C. longicaudata* is considered a harmless nuisance in other parts of the world. The dominance of recently constructed buildings with infestations may have increased this problematization because acceptance of pest problems is likely to be low in houses that are expected to be immaculate. The sudden spread of *C. longicaudata* also created a knowledge vacuum with uncertainty regarding efficiency and cost of control, which probably strengthened the focus further through unfavorable issue framing (Neuman et al. 2014) and the societal impact culminated in legal disputes with major compensation claims. The increase in legal disputes may be an additional societal burden because the legal system can become tied up in trivial arguments that could be settled outside of court. The observed decline of court cases, and submitted samples to NIPH, relative to the continued increase in control cases in 2019 may result from increased knowledge of the species, the legalization of baits against silverfish in February 2019 (Miljødirektoratet 2019) to promote safe and efficient control (Aak et al. 2020; Gutsmann 2019), or simply indicate an increased relative number of pre-court settlements. The number of infestations treated by pest control companies is also high compared to three other commonly imported tramp species.

The 2019 number of *C. longicaudata* infestations was more than twice the number for the common bed bug, four times those for German cockroach and 10 times those for Pharaoh ant (NIPHpest 2020). An increase from zero to more than 6000 control cases per year affects the revenue of pest control companies, but also their capacity to handle other and more harmful pests. This study is consequently interesting from social, economic and biological invasion perspectives. Excluding monetary side-effects, various business aspects and the cost of actual control, the main impact of *C. longicaudata* is related to health issues. Moving rapidly from zero cases to many heavy infestations appears to have increased the distress of house owners. Although of less magnitude, this is comparable to the mental health impacts of bed bug infestations (Doggett et al. 2018; Susser et al. 2012), and a high level of stress connected to insect infestations is of concern because it can result in excessive use of pesticides (Bennett et al. 2016; Wang et al. 2019) that will negatively affect indoor environments (Bonnefoy et al. 2008).

Lepisma saccharina has been an integral part of the Norwegian indoor fauna for decades, and its habitat overlaps with *C. longicaudata*. It requires higher moisture and is therefore restricted to rooms of high RH (Mallis et al. 2011). *Lepisma saccharina* population dynamics mostly keep infestation levels below detection or acceptance levels and only occasionally surpass the threshold for control. However, *L. saccharina* also showed a distinct increase in the pest samples submitted to NIPH. This increase results from a nationally raised awareness of silverfish evoked by the fear of *C. longicaudata* and does not reflect an actual increase in infestations. Almost all letters accompanying submitted samples requested clarification of whether the sample contained the main culprit *C. longicaudata*. This observation indicates that low-level infestations of *L. saccharina* are more common than heavy infestations and suggests a relatively wide and unnoticed presence of this species in Norway.

Very little is known regarding the biology of *C. calva*, but in the few Norwegian observations it co-occurs with *C. longicaudata* (Aak et al. 2019; Hage et al. 2020), and it is reasonable to assume that it will act in a similar manner to both *C. longicaudata* and *C. lineata* when encountered as a pest (Bennett et al. 2010; Mallis et al. 2011; Robinson 2005). As observed in Norway, there are also a few observations of *C. calva* and the more commonly encountered *C. lineata* in some European locations (Fink 2016; Hage et al. 2020; Molero-Baltanas et al. 2012; Querner 2017; Smith 2017; Zimmermann 2016), but the prevalence of these species is undescribed. Due to their nocturnal habit and cryptic way of living it is reasonable to assume that these species, both in Norway and the rest of Europe, may have been overlooked for some time, appeared in parallel during other silverfish infestations or mistakenly been identified as the more commonly observed and better studied *L. saccharina*, *C. longicaudata* or *T. domestica*.

Ctenolepisma longicaudata is only capable of causing serious damage by the slow destruction of irreplaceable objects in libraries, museums and historical collections (Querner 2015) and is mostly considered a nuisance in private homes. The mental stress factors related to high numbers of fairly large crawling insects with strong dispersal abilities should, however, not be underestimated, and in general, high densities of insects in indoor environments may exacerbate allergies (Bonnefoy et al. 2008). *Ctenolepisma longicaudata* therefore needs to be controlled efficiently to reduce its impact. Control with baits has been successful against cockroach infestations (Anikwe et al. 2014; Dingha et al. 2016; Snoddy and Appel 2014; Wang et al. 2019) and recent studies indicate that currently available baits offer a highly efficient and safe pest control alternative for this new European indoor invader (Aak et al. 2020; Gutsmann 2019). Additionally, all types of buildings, official buildings, storage facilities, shops and private homes, should focus on both surveillance and control to limit the local sources and reduce the general infestation risk through dispersal. Efficient control and deceleration of dispersal may not only remove the insects, it might also reduce the societal impact by reducing fear of infestations, stress during infestations, exaggerated media coverage, excess use of pesticides and partial obstruction of the legal system.

Conclusions

Ctenolepisma longicaudata has established itself in indoor environments in Norway through transport networks and dispersal of trade goods. The quick establishment and wide distribution in private homes has generated a strong societal response in addition to the rapidly increasing pest problems, leading to extensive indoor management efforts. The direct impact and the secondary problems involving *C. longicaudata* in Norway will be continuously monitored in the years to come, and a follow-up study would certainly be interesting to reveal the long-term perception and changes in societal impact of this mostly harmless nuisance pest.

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