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LARGE-SCALE SURVEILLANCE OF URBAN PESTS – A PIECE IN THE PUZZLE FOR KNOWLEDGE-BASED MANAGEMENT?

BJØRN ARNE RUKKE, ANDERS AAK, MORTEN HAGE, AND MARI STEINERT
[1]Department of Pest Control, Norwegian Institute of Public Health, Norway

Abstract Systematic approaches to map pest numbers are essential for detecting large-scale changes in urban pest activity. Pest distribution often depends on specific biological assets in interaction with characteristics of the urban environment and human activities. Infestations can be challenging to track due to the involvement of various non-transparent stakeholders managing an often stigmatizing and locally transient issue. The Norwegian Institute of Public Health has collaborated with the pest control industry to compile a 17-year time series describing changes in prevalence and seasonal fluctuations of selected important insect pests. The urban pest statistics of Norway includes eleven pests of which the common bed bug (*Cimex lectularius*), carpenter ants (*Camponotus* spp.), and the long-tailed silverfish (*Ctenolepisma longicaudatum*) are presented in greater detail in this paper. These species are compared and evaluated based on their societal costs, including control, damage, and health burden. The statistics identifies key focal areas for pest management and supports the allocation of resources by stakeholders capable of influencing pest control efforts. It can serve as a tool to improve pest awareness, evaluations, control strategies, advisory services, information initiatives, and research.

Key words Surveillance system, urban pests, societal cost, evaluations, control strategies

INTRODUCTION

Public health surveillance is the systematic collection and interpretation of health-related data that can warn about risks, evaluate the impacts of interventions, and guide priority-setting in public health policy and strategies (World Health Organization 2025). As a component of public health, the management of urban pests can similarly benefit from having a large-scale surveillance system that tracks the status of different pests to quantify both direct and indirect societal costs. This is particularly important for public health-related species, which in addition to the cost of control, impose a burden through mental stress, physical discomfort, and diseases (Bonnefoy et al. 2008, Goddard and DeShazo 2012, Susser et al. 2012, Doggett et al. 2018a, Wang et al. 2021). The scale of the societal impact from structural and item-damaging pests, such as some ants and beetles (Hansen and Klotz 2005, Querner 2015), should also be monitored to complement the understanding of urban pests.

A large-scale surveillance system can be utilized by a range of stakeholders, spanning from pest control companies to buyers of pest control services. Private homeowners, municipalities, media, and governmental bodies could rely on such a service through identification of pest species that are on the rise or decline, evaluation of the effectiveness of current control efforts, and provision of objective information distributed to large population groups. Proper knowledge of spatio-temporal dynamics of pests may consequently prevent suboptimal use of the limited resources for pest management.

An important prerequisite for enabling large-scale surveillance of pest species is a focus on knowledge-based management among multiple key stakeholders. The pest management system in Norway has several important characteristics that make nationwide monitoring possible. Firstly, there is an independent national governmental competence unit, which can develop and maintain the urban pest statistics. The Norwegian Institute of Public Health (NIPH) has maintained stable funding for the last 25 years, enabling collection and analysis of data. Secondly, Norway's small population of approximately 5.5 million inhabitants facilitates the ability to monitor and assess the pest situation efficiently and precisely. Thirdly, there are transparent and competent pest control companies (PCC) that contribute data to the surveillance system. Fourthly, Norwegian legislation standardizes the knowledge foundation and control approaches through the Pest Control Act. Finally, a strong collaborative environment exists among different stakeholders.

NIPH has been monitoring the pest situation in Norway since the 1970s through various information channels, such as 1) a phone service for pest related inquiries, 2) a pest identification service for submission of pest samples, 3) an e-mail service for pest-related questions, and 4) enquiries submitted to selected and relevant stakeholders. In 2006, NIPH recognized the need for a more comprehensive and systematic approach for monitoring of the urban pest situation nationwide and established the urban pest statistics of Norway. Initially, in 2007, seven species or species groups were included in the program, a number that was later increased to eleven. Inclusion criteria for the pest species have been based on whether they generate a significant number of pest control assignments, pose a particular threat to the Norwegian society, provide management challenges, or potentially generate health risks on their own or through extensive pesticide use. The species represent a range of insect taxonomic groups, with some being strictly indoor species, while others also thrive outdoors in Norway. These ecological differences influence the distribution patterns of the species and are reflected in the data collected. The statistical data therefore provide insights into the biology of the pest species by describing seasonal variations and changes in abundance through time. The information can also help to provide a nationwide economic understanding of the costs associated with treatment, extent of damage, and indirect effects of the pests. Additionally, it can support the evaluation of the countermeasures and aid in the refinement or tailoring of current and new control strategies.

The present paper describes the urban pest statistics of Norway, and we discuss how this data source is utilized to enhance pest management in Norway. To illustrate the use of the statistics, we provide detailed numbers and a full discussion of carpenter ants (*Camponotus* spp.), the common bed bug (*Cimex lectularius*), and the long-tailed silverfish (*Ctenolepisma longicaudatum*), while the other species are only briefly mentioned.

MATERIALS AND METHODS

Study area. Norway is a Scandinavian country in Northern Europe, home to 5.59 million people, with an average yearly income in households of 635 400 NOK (Statistics Norway 2024b, 2025). Approximately 83% of the population resides in urban settlements, while the remaining inhabitants live in rural areas (Statistics Norway 2024a). Most of Norway has a maritime climate, characterized by mild winters (average temperature: -5.5°C (DJF)) and cool summers (average temperature: 10.9°C (JJA)), although the eastern regions experience lower winter temperatures and warmer summers. Due to the influence of the North Atlantic Ocean, Norway's climate is much warmer than would be expected given its latitudinal position (World Bank Group 2025).

The pest control system in Norway. The management of urban pests in Norway is regulated by the enactment of the Pest Control Regulations (Ministry of Health and Care Services 2000). It specifies that pests must be managed using methods that cause the least harm to the environment and human health, while still achieving the desired control outcome. This principle has led to a focus on Integrated Pest Management (IPM) and efforts to minimize pesticide use when controlling urban pests.

According to the Pest Control Regulations, an approved pest control technician (PCT) must undergo formal education to be licensed to perform commercial pest control services. This includes a two-week theoretical authorization course with an exam administered by the Norwegian Directorate of Health and a two-month traineeship conducted under the supervision of an approved senior PCT.

The Department of Pest Control at NIPH is funded by the Ministry of Health and Care Services and entrusted with the responsibility to prepare and deliver the authorization course for PCTs. The department is also tasked with the role of supplying knowledge regarding the pest situation in Norway. In accordance with the Pest Control Regulations, PCTs are required to prepare a protocol following each pest control assignment. This protocol describes the pest species involved and the control measures applied. In addition to contributing to a more systematic approach to pest control, these protocols provide an overview and reference guide for infestation rates. This information serves as the foundation for the urban pest statistics.

Study species. Initially, in 2007, the urban pest statistics of Norway included the common bed bug, carpenter ants, the species group webbing clothes moth (*Tineola bisselliella*) and casemaking clothes moth (*Tinea pellionella*), the German cockroach (*Blattella germanica*), the pharaoh ant (*Monomorium pharaonis*), the vodka beetle (*Attagenus smirnovi*), and the species group yellowjackets and hornets (*Vespula* spp. and *Vespa* spp.). The common furniture beetle (*Anobium punctatum*) and the house longhorn beetle (*Hylotrupes bajulus*) were added in 2008, the garden ant (*Lasius niger*) in 2013, and the long-tailed silverfish in 2016.

The three focal insects in this paper, carpenter ants, the common bed bug, and the long-tailed silverfish, are responsible for a considerable number of assignments, have different damage potentials, and exhibit a substantial variation in their biology. Carpenter ants cause severe structural damage to wood and various insulation materials to establish nests (Hansen and Klotz 2005). Bed bugs are hematophagous insects that cause significant human discomfort due to their bites and the psychological stress associated with infestations (Ashcroft et al. 2015, Evison et al. 2018, Sheele et al. 2019). The long-tailed silverfish is mainly a nuisance pest with an element of psychological stress, but it may cause damage to valuable artifacts (Aak et al. 2019, Rukke et al. 2023). Carpenter ants live outdoors in all forested parts of Norway (Ødegaard et al. 2018), while the two other species only reside indoors in buildings.

Data collection procedure. NIPH collects data on the number of pest control assignments from various PCCs each month. Routinely, in the beginning of each month, an e-mail is sent to the participants requesting their results for the previous month, followed by a reminder the following week for those who have not submitted their data. Missing results from participating PCCs are then followed up by phone in January of the subsequent year.

All PCCs in Norway have been invited to participate in the urban pest statistics. In total, 57 PCCs have delivered data at least in one year, and eight have participated every year. The three largest companies, which account for more than two-thirds of the total reported pest control jobs, have always participated. Only one assignment per address is reported by the PCC for each pest control event. Therefore, in multi-housing buildings, several apartments may be treated, but only one registration is made per month for the entire building.

The annual cost of the pest control assignments for the three focal species is estimated based on information given by four of the largest pest control companies in Norway. The insurance company covering the most pest control policies in Norway, reported their cost to repair carpenter ant structural damages in buildings. All costs are given in Norwegian crowns (NOK), and 1000 NOK are approximately 100 Euros or US dollars (Average last five years, Norges Bank).

RESULTS

Number of assignments of all species. The top five pests of Norway, each with an annual average (± SE) of more than 1 000 assignments, were the long-tailed silverfish (4974 ± 974), the garden ant (3328 ± 178), the common bed bug (1811 ± 221), yellowjackets and hornets (1341 ± 125), and carpenter ants (1249 ± 47) (Table 1). The remaining six species ranged from 44 to 567 cases per year, with an annual average of 219 ± 89 reported control assignments.

Table 1. Number of pest control assignments in different years of the urban pest included in the urban pest statistics of Norway. No data in a particular year is denoted.

Year	Pharao ant	House longhorn beetle	Vodka beetle	Clothes moths	Common furniture beetle	German cockroach	Carpenter ant	Yellow-jackets and hornets	Bed bug	Garden ant	Long-tailed silverfish
2007	27	-	59	115	-	541	1440	816	447	-	-
2008	53	65	66	102	571	518	1559	1453	522	-	-
2009	32	71	50	109	637	495	990	835	623	-	-
2010	24	56	71	128	610	595	1227	1399	669	-	-
2011	44	47	64	100	381	691	1413	646	1087	-	-
2012	45	58	84	95	377	669	1237	2042	1224	-	-
2013	47	99	95	83	349	563	1313	836	1638	3641	-
2014	51	72	81	79	403	645	1171	2531	1945	2697	-
2015	43	56	110	148	419	606	1226	732	2330	3255	-
2016	59	58	103	130	459	736	1439	1618	3034	3871	511
2017	51	44	105	122	425	816	1306	1288	2857	4300	1516
2018	69	81	137	118	345	764	1531	1796	2810	4064	3433
2019	85	53	162	158	335	534	1265	1205	3058	2872	6788
2020	42	65	180	84	444	489	1228	926	2015	2636	7434
2021	36	50	97	85	324	323	978	1446	1772	2975	6364
2022	17	68	167	257	397	312	933	1417	2285	3540	7298
2023	30	26	123	191	183	346	978	1812	2463	2753	6447
Average	44	61	103	124	416	567	1249	1341	1811	3328	4974
± SE	± 4	± 4	± 10	± 11	± 29	± 36	± 47	± 125	± 221	± 178	± 974

Focal species between years. The number of carpenter ant assignments has remained stable since 2007, fluctuating only moderately around an average of 1250 (1249 ± 47) per year (Figure 1A).

Bed bug assignments showed an increase from the start of the registrations in 2007 until 2016. In the next four years, the numbers remained stable around an average of 3000 (2940 ± 62) (Figure 1B). Coinciding with the onset of the COVID-19 pandemic in 2020, the number of assignments dropped significantly, nearly halving, before increasing again in 2022 and 2023.

From the first year of registration in 2016 to 2019, the number of long-tailed silverfish assignments increased more than tenfold (Figure 1C). In the period from 2019 to 2023, the annual number of treated infestations stabilized around an average of 6900 (6866 ± 217).

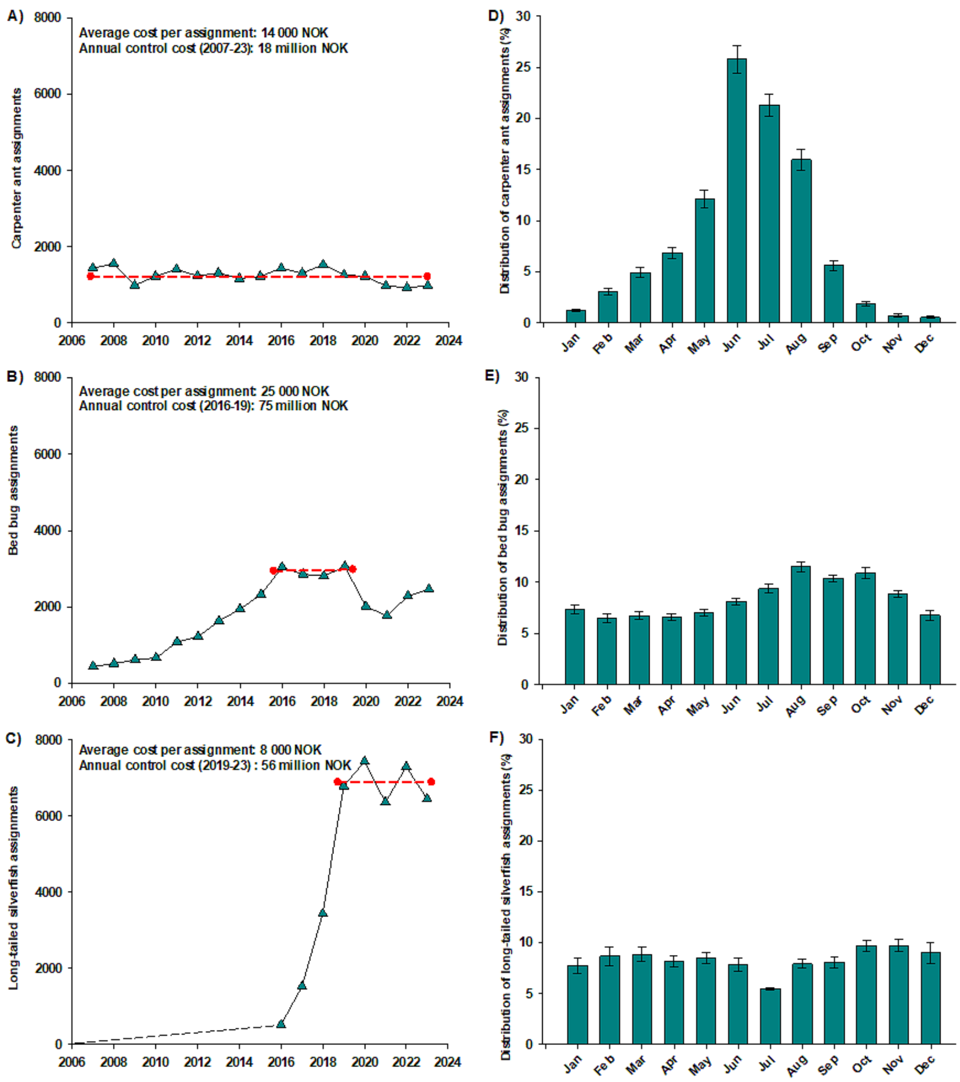

Figure 1. Annual number of pest control assignments and within year variation of assignments (± SE) of carpenter ants (*Camponotus* spp.), the common bed bug (*Cimex lectularius*), and the long-tailed silverfish (*Ctenolepisma longicaudatum*) in the urban pest statistics of Norway. The average cost per assignment (reported by pest control companies) and the estimated average annual cost of all treatments (average cost per assignment × average number of assignments) are also shown. The red dotted line shows the period when the annual cost of all treatments was estimated.

Focal species within years. The number of carpenter ant assignments was low during the cold months (November - February) and gradually increased with the onset of summer (Figure 1D). There was a distinct peak during the swarming period in June. In the following months, the numbers declined towards the winter.

Bed bugs exhibited a much more stable distribution of assignments throughout the year, but assignments increased following the summer vacation months of June, July and August, before decreasing again towards the end of the year (Figure 1E).

The only month in which the number of long-tailed silverfish assignments differed noticeably was during the joint summer vacation in July, with a lower number compared to the other months (Figure 1F).

Cost of control and repair. The average cost of treating a carpenter ant infestation was reported by the PCCs to be 14 000 ± 1700 NOK. An average of 1300 assignments gave an annual cost of 18 million NOK. The insurance company reported that in the period 2020 – 2024, the average cost to repair a single structural damage caused by carpenter ants in a building that they covered, was 33 000 ± 4000 NOK.

The reported average cost of treating a bed bug infestation was 25 000 ± 6000 NOK. Bed bugs represented the most substantial economic burden in terms of assignment cost. In the years from 2016 to 2019, Norway had approximately 3000 bed bug assignments annually, resulting an estimated 75 million NOK spent on control each year.

A long-tailed silverfish assignment costs on average 8000 ± 1000 NOK. The approximately 7000 long-tailed silverfish jobs from 2019 onwards therefore incurred an estimated annual cost of 56 million NOK.

DISCUSSION

The urban pest statistics of Norway has provided valuable information regarding temporal changes of pest assignments and enabled a rough quantification of the economic burden imposed by insect pests. Pest control companies openly share data to enable continuous quantification of both total pest control efforts and seasonal fluctuations in several important species. The three species receiving particular attention in this text currently exhibit high assignment numbers, but their roles as urban pests differ substantially. Carpenter ants show fairly stable numbers between years throughout the study period, but they have distinct seasonal fluctuations. In contrast, both the common bed bug and the long-tailed silverfish show minor seasonal changes related to human activity but have exhibited major changes across the years. They typically show characteristics of indoor imported species, and the long-tailed silverfish may even be considered invasive as it has appeared and expanded its range rapidly within the last 6-8 years. These latter two species have rather dramatically affected the overall pest control landscape of Norway within a relatively short time.

An urban pest will typically constitute a societal burden both through the cost of control, their damage, and indirect effects affecting the people who experience the infestation (Robinson 2005, Bonnefoy et al. 2008, Bennett et al. 2010, Mallis et al. 2011, Shah et al. 2018, Rust et al. 2024). The control cost is easy to grasp, whereas the impact from damage can be more difficult to quantify. Actual damage to structures or objects can be calculated and incorporated into the monetary damage potential of each species, whereas it is very difficult to precisely include the indirect effects from psychological trauma, skin lesions, allergies, asthmatic issues, and diseases. Such indirect pest-economic societal costs are often lacking in evaluation of pest impacts, and improved understanding of these aspects is surely a potential way forward for a true understanding of the need for control.

Carpenter ants provide a relevant example of integration of both control and damage cost as this group is an important structure infesting species in Norway due to the large proportion of timber and insulation used in buildings (Birkemoe 2002, Ottesen et al. 2009, Hill and Zimmer 2018). Their impact is generally considered large with relatively high number of cases and intermediate cost connected to control of their nests. A mature carpenter ant colony may contain several thousand individuals (Abenius et al. 2012, Ødegaard et al. 2018), and the structural damage may consequently become large (Hansen and Klotz 2005). Not all carpenter ant infestations require repairs, but if needed and incorporated into the cost, a strongly elevated impact becomes apparent. The average repair cost is often three times higher than the average control cost.

Total pest burden should also be evaluated in relation to bed bugs. In Norway they are the costliest of the three focal species in terms of control efforts, but these costs are only part of the societal burden. Economic costs from loss of reputation and clients in the travel industry are also evident (Doggett et al. 2018b), and bed bugs contribute significantly to physical discomfort due to bites and psychological distress which subsequently may lead to sleep disorders, absence from work, and isolation (Susser et al. 2012, Ashcroft et al. 2015, Perron et al. 2018). These indirect costs are hard to estimate but should also be included to properly estimate the impact from bed bugs. The use of tools comparable to health-economic modeling for disease burden could be highly beneficial for this pest (Doggett et al. 2012).

The long-tailed silverfish is primarily a nuisance pest imposing a societal cost mainly through pest management efforts (Aak et al. 2021). Although the cost per individual management assignment is relatively low, the large cumulative number of infestations results in a considerable total financial burden. This species incurs no structural or material damage of noteworthy costs except potentially in libraries, archives, and museums holding valuable or irreplaceable items (Rukke et al. 2023)

In addition to providing general large-scale estimates of the societal impact by various pest species, the statistics can also help to identify focal areas and aid in allocation of resources by those who have the ability to influence the situation. Proper knowledge can guide the prioritization of research-, information- and control efforts toward where it is most needed, help identification of the species that pose a risk, allow more detailed targeting of efforts, and enable different stakeholders meet emerging demands based on seasonal or between-year changes in pest prevalence.

A typical example of a proactive use of the statistics is the PCCs anticipation of an increase in carpenter ant assignments from May onwards, reallocating resources from other pest assignments toward this summer-issue. The long-term trends in the carpenter ant statistics also show that the problem is stable and persistently present, and that the PCCs are likely to be in balance with their efforts from year to year.

A striking example of relevant information obtained from the statistics is the anthropogenic nature of bed bug infestations and their connection to human travel. The statistics shows a yearly increase in assignments after the joint summer holidays (June-July in Norway) and a considerable temporary drop during the COVID-19 pandemic when international travel strongly declined in 2020 and 2021 (Helliesen et al. 2021, Statistics Norway 2023). The drop actually indicates that half of the yearly cases are associated with international travel, and as such, preventive measures during travel or staying at accommodations are appropriate. Bed bug distribution is heavily reliant on passive human-mediated dispersal, particularly via luggage (Fountain et al. 2015, Hentley et al. 2017, Evison et al. 2018). Information to the public should be enhanced through outreach efforts and information campaigns before peak travel periods, and the tourist industry should strengthen detection and prevention routines to minimize the risk of bed bug infestations (Cain 2018).

A consistent national monitoring is also useful in evaluating how efforts taken against pest are working out, and how to refine methods or strategies. This surely needs to be done in retrospect, but when numbers of controlled infestations are combined with information on the methods and strategies in use, the statistics becomes a powerful tool for improving pest control.

Carpenter ant control in Norway provides an example of such a retrospective evaluation. The pest control act deployed in 2000 pushed forward a shift in management practices from preventive sprayable and dust-based neurotoxic treatments to nest removal and the use of poisoned baits with low quantity of active ingredients for colony control. Concerns were initially raised by PCCs regarding the banning of preventive pesticide use against ants, but the urban pest statistics indicates no increase or change in prevalence after the altered practice. Instead, the distinct summer activity peak of the control efforts of carpenter ants indicates a control practice that focuses on actual removal of established nests. The current control efforts are connected to the ants' temperature dependent activity which increases the probability of detecting an ant problem in a structure during the warm months. The peak also coincides with the swarming activity in late May to early July (Abenius et al. 2012, Ødegaard et al. 2018) when hundreds of large, winged queens can be observed awaiting flight on the walls of an infested building.

A similar retrospective evaluation explains the bed bug numbers. The development in the infestation rate since 2007 is connected to changes in the Norwegian control practice and improved knowledge among PCCs. During the early part of the bed bug resurgence, traditional neurotoxic pesticides were used without proper effect due to widespread pesticide resistance in bed bug populations (Davies et al. 2012, Zhu et al. 2016, Dang et al. 2017). The strong increase was not quelled until proper IPM was deployed, and the traditional methods were replaced mostly with desiccant dust, heat treatments and freezing of furniture. The use of neurotoxic insecticides is now rare in Norway, and the bed bug problem has not increased since 2016 suggesting that these changes in management procedures have been successful and result in safer pest control practices.

The initial rapid increase in long-tailed silverfish cases during a period of non-knowledge-based management in Norway (Aak et al. 2021), presents a situation similar to that of the bed bug issue. The effect of an improved and new poisoned bait strategy (Aak et al. 2020, Rukke et al. 2021) is evident by the stabilization of infestations, which occurred in parallel with the deployment of the strategy in 2019. The dramatic initial increase that led to high temporary societal costs (Aak et al. 2021), was completely mitigated by this new method. The statistics also suggests that further actions should be implemented to reduce the number of pest control assignments. There is still a high number of infestations per year, and preventive measures, such as addressing infestations in warehouse environments before they can spread to private homes, are required to mitigate the issue further.

Interpretation of pest statistics to enhance pest management must integrate existing biological knowledge of the species involved. The division between outdoor and indoor living species is important for the understanding of the management approaches, as exemplified above. In Norway, with its relatively cold outdoor climate, the naturally occurring, outdoor living carpenter ants tend to show more stable numbers between years but have strong seasonal fluctuation, whereas the strictly indoor living bed bugs and long-tailed silverfish show smaller shifts within a year but appear to more strongly change with management practices over time.

Among the other species in the statistics, garden ants, common furniture beetles, and yellowjackets and hornets can also be found outdoors and thus tend to be stable with their activity following the outdoor season (unpublished results). Pharaoh ants, German cockroaches, house longhorn beetles, and vodka beetles are considered synanthropic, relying entirely on indoor environments and are therefore more strongly related to human activities and pest control practices.

In some situations, the pest statistics provides important knowledge-based contributions to the mass media at national level. The different media channels can play a valuable part in informing the public about emerging pest issues and can be a tool for education of the public on preventive measures. Sometimes however, media speculation stemming from insufficient knowledge and click-baiting can lead to unnecessary concerns and superfluous actions in pest situations of minor importance. In such situations, a thorough and precise statistics can effectively provide a more balanced and informed perspective on the situation. "Killer ladybugs", "watch out for wasp- and rodent-years", and "bed bug alert" are typical media hypes that effectively can be countered by correct and sober information, and thereby prevent a media discussion not grounded in evidence.

Although valuable in its current state, the Norwegian pest statistics could certainly be improved through various approaches. The present statistics bears the mark of manual data collection and rely on relations between governmental officials and PCCs. It would be desirable to get hold of information on all pest species in Norway and to have faster access and more precise information on the species already included. However, these improvements may increase the labor and strain on all involved parties, and inclusion of more species must therefore be assessed within a cost-benefit framework. Emerging technologies have the potential to alleviate the workload and could therefore facilitate more automated processes and open the door to more a complete statistics (Duggal 2011). An immediate opportunity for improvement lies in incorporating rodent data into the statistics. Rodent cases comprise a considerable fraction of the pest control assignments in Norway, but they have so far been left out due to a high proportion of them being service assignments without proper reporting on the presence or absence of rodents. Some PCCs have indicated that the current rodent activity registrations could make it possible to include precise rodent statistics. Moreover, potential advancements in technology may allow for real-time, online reporting of pest control assignments, as many PCCs have already adopted electronic registration methods. This could enhance the utility of the pest statistics as more detailed information, such as the location of infestations, the estimated size and severity of pest attacks, and photographic evidence for verification of species, could be incorporated. Such technological advancements would provide multiple stakeholders with immediate access to pest status, enabling prompt implementation of counter measures, and it could allow neighboring premises to take preventive actions when pest issues are detected in their proximity.

CONCLUTIONS

Although the large-scale surveillance of the urban pest statistics of Norway is relatively coarse, it has provided valuable insights into pest dynamics, societal impacts, and control strategies for multiple stakeholders in Norway. The statistics highlights trends in the prevalence of urban pests by quantifying presence and magnitude of both endemic and imported pest species. When combined with the burden they impose, biological insights, and evaluation of cost, the pest statistics has highlighted societal impact of different species, improved our understanding of pest issues, and contributed to more effective management strategies.

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