



# Editorial: Trends in Urban Rodent Monitoring and Mitigation: Improving Our Understanding of Population and Disease Ecology, Surveillance and Control

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## Editorial on the Research Topic

### Editorial: Trends in Urban Rodent Monitoring and Mitigation: Improving Our Understanding of Population and Disease Ecology, Surveillance and Control

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The urban environment is unique among earth's ecosystem in that it is almost entirely created, maintained, and modified by humans. As such, it is not often a focus of ecological research (Dyson et al., 2019). However, a number of wild animals thrive in urban centers, particularly rodents. Indeed, certain species of rodents are so well-adapted to close cohabitation with people that they are rarely found in habitats devoid of their human counterparts (Aplin et al., 2003). These so-called commensal rodents can be found in almost every corner of every city on earth (Lund, 1994) and humans are more likely to interact with them than any other wildlife species.

Unfortunately, these interactions can lead to a diverse array of negative consequences. For example, urban rodents carry a number of zoonotic pathogens associated with significant human morbidity and mortality (Himsworth et al., 2013). Exposure to rodents may also impact mental health, particularly among marginalized populations (Lam et al., 2018). Finally, urban rodents consume and contaminate food stuffs, damage property and infrastructure, start fires and result in significant expenditures on pest control (Feng and Himsworth, 2014). Over half of the world's population currently live in urban centers (United Nations, 2018), and given increasing rates of urbanization, these issues are likely to increase in the future. Unfortunately, there are a number of significant gaps in our understanding of urban rodents which impede our capacity to adequately prepare for current and future threats (Parsons et al., 2015).

There are several reasons for the prevailing knowledge gaps (Traweger et al., 2006; Banks et al., 2014). Many urban rodents are inherently difficult to study as they are nocturnal, secretive, and reside in habitats not readily accessible to researchers (e.g., deep within infrastructure) (Parsons et al., 2015). They disproportionately populate impoverished neighborhoods (Himsworth et al., 2013; Feng and Himsworth, 2014) where residents are disempowered to deal with rodent-related issues compared to those living in more affluent areas (Lam et al., 2018). Many societies have negative

associations with rodents (German and Latkin, 2016) and property owners may keep infestations secret because of shame, fines or possible business closures (Pimentel et al., 2005; Parsons et al., 2017).

Counter intuitively, the fact that humans have so much exposure to urban rodents may be responsible for the fact we know so little about them. Specifically, it is commonly assumed that because urban rodents are omni-present, scientists and authorities already understand all there is to know about them (Parsons et al., 2016). This attitude is compounded by a plethora of scientific literature based on laboratory rodents—animals that are so dramatically different from their wild counterparts that extrapolation is virtually impossible (Stryjek and Pisula, 2008; Puckett et al., 2018). Additionally, decision makers may be apathetic regarding urban rodents owing to a perception that infestations and related harms are inevitable, and attempts to address them fruitless. Finally, a lack of substantive gains regarding urban rodent-related issues may be related to the fact that the responsibility for these issues is not easily assigned to any one sector or discipline. This has resulted in a siloed approach in which gains are made in specific areas (such as pest-control techniques), without moving the field of urban rodent research forward as a whole (Parsons et al., 2016).

We consider our special topics issue as a global “call to action” for researchers to help address these gaps and barriers through fresh, innovative, and multidisciplinary approaches. Therefore, in preparing this issue, we have brought together authors and reviewers from a wide array of field and laboratory-based disciplines (genetics, ecology, pest management, social sciences, public health) and from countries around the world (Australia, Brazil, Canada, Finland, France, Germany, Hungary, Japan, Netherlands, New Zealand, Poland, and the United States) to share as many ideas and perspectives as possible. From the resulting set of manuscripts, a number of critical themes emerged.

The research presented here paints a compelling picture of the complex interactions between rats and the urban environment. For example, Minter et al. show that within a specific neighborhood, the features of the urban built environment (i.e., variations in land use and building disrepair) did not significantly impact *Leptospira* spp. carriage in rats (*Rattus* spp.). However, variation in infection dynamics among cities suggested that broader features of the urban ecosystem impact pathogen ecology. Minter et al. found that although lethal rat control can produce a temporary decrease in the risk of *Leptospira* spp. infection in humans, only permanent and significant environmental modification was capable of producing a significant and sustained impact. The impact of the environment extends beyond *Leptospira* spp., with Cummings et al. showing that the distribution of newly identified influenza A virus in rats was significantly influenced by the urban microenvironment (e.g., parks vs. residential areas) and season.

Byers et al. present a review of rat movements in urban ecosystems, including how these movements are determined in equal measure by innate rat biology/behavior and by features

of the specific environment in which rats reside, such as resource availability and anthropogenic barriers (e.g., roadways). Given that movement of rats can impact everything from the efficacy of rat control to the transmission of zoonotic disease among rats, this information may provide a lens through which to better understand the relationships between rodents and their city habitat. Going forward, it is clear that the study of disease ecology in urban rodents must include a detailed and thoughtful accounting of the role of the urban environment.

This issue also demonstrates the importance of understanding the potential impact of human intervention on rat ecology when seeking to monitor or mitigate rat-associated issues. Minter et al. showed that carriage of *Leptospira* spp. among rats is strongly influenced by specific social interactions (e.g., aggressive encounters) regardless of geographic location. This supports a growing body of evidence that interventions that upset established social structures and pathogen transmission pathways (e.g., indiscriminate lethal pest control) could have unpredictable consequences on public health risks. Richardson et al. showed that lethal control programs cause rapid and severe changes in rat population genetics—a human-driven evolution for which the fallout has never before been contemplated. Byers et al. showed that even the act of trapping rats is fraught with ecological complexities, as the probability of a rat entering a trap depends on the duration of the trapping campaign, as well as the demographics of the rats in the target population.

With regard to alternative strategies in rat control, the use of predator scents to repel rodents has been known for producing markedly different results in the laboratory as compared to the field. Using a comprehensive review, Bedoya-Pérez et al. show that key variables, such as habitat familiarity and resource availability dramatically impact the amount of risk that a rodent perceives, thus the efficacy of predator scents in rodent control will depend on the context in which they are presented.

Another emergent theme is the continuously changing face of rodent population and the pathogens they carry. This includes the first detection of influenza A virus in rats by Cummings et al. It also includes a description by Childs et al. of how the “transmission web” of established rodent associated zoonoses, such as Seoul Hantavirus and Lymphocytic Choriomeningitis Virus, has evolved over time and is likely to continue evolving. Kosoy and Bai expand on this theme by highlighting the fact that the health burden associated with rodent-associated pathogens, such as *Bartonella* spp., is likely to increase as a result of the intersection of urbanization and ongoing, related changes in urban rat, vector, and pathogen ecology.

Using a population genetics approach, Russell et al. found that there have been multiple introductions of *R. norvegicus* and *R. rattus* in New Zealand, as well as a continued spread of both rat species within some parts of the country. This work has important implications for our understanding of how rats and their pathogens could move across the landscape, and complements the work presented by Kosoy and Bai which shows how rat ecology, including rat movement,

has influenced the distribution and prevalence of different *Bartonella* spp. at scales ranging from a city block to the entire globe.

Innovation was also a feature of much of the research presented here. For example, Minter et al. present a novel mathematical model for identifying the optimum combination of control methods to prevent leptospirosis. Stryjek et al. have produced an innovative hanging trap that allows several parameters, such as rodent-type and distance from target to be preset. Because the trap is inconspicuous, it overcomes the tendency of rodents to avoid novel structures, such as conventional, ground-based traps (e.g., neophobia).

As often occurs during field-based research, serendipity, or discovering the unexpected, was key to Parsons et al. findings. Intending to study rat scents as possible deterrents, their study site was over-run by feral cats. Using a combination of microchipped rats and cameras deployed throughout a large study area, Parsons et al. were able to document, for the first time, the degree to which feral cats prey on rats, showing that cats are not likely to be an effective means of urban rat control. Murray et al. were able to use a novel partnership between researchers and private practitioners to investigate the degree to which rat complaints correlated with trapping data and can be used as a metric to monitor rat populations in the future.

In addition to presenting novel products and methodologies, several authors presented a number of compelling ideas and perspectives that can potentially be used to revolutionize urban rodent research in the future. For instance, Stephen astutely recognized a number of entrenched research paradigms that have hampered the progress of the field. Specifically, a largely reactionary viewpoint focused on documenting current or past hazards and adverse events, as well as the existence of a patchwork of disconnected approaches to urban

rodent research and policy. This led to programs that are fragmented, inefficient, or even counterproductive. He suggests a paradigm shift toward the production of actionable intelligence, particularly regarding factors associated with vulnerability and resilience.

In order to understand the true complexity of the urban ecosystem, it is clear that a multidisciplinary and collaborative approach is needed: no one discipline or sector has the knowledge or capacity to manage on its own. A diversity of perspectives can be combined to provide a more comprehensive picture of the problem at hand. By reaching out across disciplinary lines into field and laboratory-based studies, it is possible to identify approaches that can be adapted and developed to foster true innovation. It is important to note, however, that this diversity of voices should not only include researchers, but also members of the public and decision makers, who ultimately determine the true impact of research findings (Stephen). The onus is therefore on urban rodent researchers, now and in the future, to venture beyond laboratories and trapping sites, and engage with those who will ultimately determine the relevance and value of what we do. This is perhaps the most important first step toward creating significant and meaningful changes in the trends regarding urban rodent monitoring and mitigation.

## AUTHOR CONTRIBUTIONS

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## REFERENCES

- Aplin, K. P., Chesser, T., and ten Have, J. (2003). "Evolutionary biology of the genus *Rattus*: profile of an archetypal rodent pest," in *Rats, Mice and People: Rodent Biology and Management*, eds G. R. Singleton, L. A. Hinds, C. J. Krebs, and D. M. Spratt (Canberra, ACT: Australian Centre for International Agricultural Research Monograph), 487–98.
- Banks, P. B., Bytheway, J. P., Carthey, A. J., Hughes, N. K., and Price, C. J. (2014). "Olfaction and predator-prey interactions amongst mammals in Australia," in *Carnivores of Australia: Past, Present and Future*, eds A. S. Glen and C. R. Dickman (Collingwood, VIC: CSIRO Publishing), 389.
- Dyson, K., Ziter, C., Fuentes, T. L., and Patterson, M. S. (2019). Conducting urban ecology research on private property: advice for new urban ecologists. *J. Urban Ecol.* 5:juz001. doi: 10.1093/jue/juz001
- Feng, A. Y., and Himsforth, C. G. (2014). The secret life of the city rat: a review of the ecology of urban Norway and black rats (*Rattus norvegicus* and *Rattus rattus*). *Urban Ecosyst.* 17, 149–162. doi: 10.1007/s11252-013-0305-4
- German, D., and Latkin, C. A. (2016). Exposure to urban rats as a community stressor among low-income urban residents. *J. Community Psychol.* 44, 249–262. doi: 10.1002/jcop.21762
- Himsforth, C. G., Feng, A. Y., Parsons, K., Kerr, T., and Patrick, D. M. (2013). Using experiential knowledge to understand urban rat ecology: a survey of Canadian pest control professionals. *Urban Ecosyst.* 16, 341–350. doi: 10.1007/s11252-012-0261-4
- Lam, R., Byers, K. A., and Himsforth, C. G. (2018). Beyond zoonosis: the mental health impacts of rat exposure on impoverished urban neighborhoods. *J. Environ. Health* 81, 8–11.
- Lund, M. (1994). "Commensal rodents," in *Rodent Pests and Their Control*, eds A. P. Buckle and R. H. Smith (Oxfordshire: CAB International), 23–43.
- Parsons, M. H., Banks, P. B., Deutsch, M. A., Corrigan, R. F., and Munshi-South, J. (2017). Trends in urban rat ecology: a framework to define the prevailing knowledge gaps and incentives for academia, pest management professionals (PMPs) and public health agencies to participate. *J. Urban Ecol.* 3:jux005. doi: 10.1093/jue/jux005
- Parsons, M. H., Sarno, R., and Deutsch, M. (2015). Jump-starting urban rat research: conspecific pheromones recruit wild rats into a behavioral and pathogen-monitoring assay. *Front. Ecol. Evol.* 3:146. doi: 10.3389/fevo.2015.00146

- Parsons, M. H., Sarno, R. J., and Deutsch, M. A. (2016). A detailed protocol to enable safe-handling, preemptive detection, and systematic surveillance of rat-vectored pathogens in the urban environment. *Front. Public Health* 4:132. doi: 10.3389/fpubh.2016.00132
- Pimentel, D., Zuniga, R., and Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecol. Econ.* 52, 273–288. doi: 10.1016/j.ecolecon.2004.10.002
- Puckett, E. E., Micci-Smith, O., and Munshi-South, J. (2018). Genomic analyses identify multiple Asian origins and deeply diverged mitochondrial clades in inbred brown rats (*Rattus norvegicus*). *Evol. Appl.* 11, 718–726. doi: 10.1111/eva.12572
- Stryjek, R., and Pisula, W. (2008). Warsaw Wild Captive Pisula Stryjek rats (WWCPS)-establishing a breeding colony of Norway Rat in captivity. *Polish Psychol. Bull.* 39, 67–70. doi: 10.2478/v10059-008-0011-x
- Traweger, D., Travnitzky, R., Moser, C., Walzer, C., and Bernatzky, G. (2006). Habitat preferences and distribution of the brown rat (*Rattus norvegicus*Berk.) in the city of Salzburg (Austria): implications for an urban rat management. *J. Pest Sci.* 79, 113–125. doi: 10.1007/s10340-006-0123-z
- United Nations (2018). *68% of the World Population Projected to Live in Urban Areas by 2050, Says UN*. United Nations Department of Economic and Social Affairs. Available online at: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html> (accessed August 2, 2019).

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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