



Olfaction research as a conduit between pest management professionals and academia: the role of conspecific scents in establishing new tools for the control of urban rats: A final report

Funded Project:

“Rats follow their nose: Using social structure and scent origins to produce new tools for urban pest management”

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Research Objectives:

Manuscript #1: To identify the factors holding back urban rat research and introduce mechanisms for academics and industry to work together to provide new tools for rat control (published).

Manuscript #2: To establish the valence of mixed-male scents on urban rats in an industrial environment (submitted, in review).

Manuscript #3: To quantify the impact of feral cat predation on an active rat colony in an industrial environment (published).

Manuscript #4. To establish the valence of mixed-female scents on urban rats, and to determine whether trapping rate in a “refuge-trap” is enhanced by predator cues.

Executive Summary:

Since the 1970s, researchers have recognized that urban rats (*Rattus spp.*) extensively utilize conspecific scents (e.g., pheromones) to navigate their environment (Valenta and Rigby 1968; Krames et al. 1969; Gawienowski et al. 1976; Gawienowski 1977; Mason et al. 1988). Yet the theories behind olfaction have not been extended to practice in an urban pest management context (Banks and Hughes 2012; Parsons et al. 2017). The current project seeks to bridge the gap between theoretical knowledge and industrial applications through the exploration of scents as tools for pest management professionals (PMPs). There are three primary types of responses to scents (attractants (Gawienowski 1977), repellents (Valenta and Rigby 1968; Parsons et al. 2018a) and appeasement/anxiolytic scents (Krames et al. 1969; Sreng et al. 2017) that can be beneficial to PMPs. An attractive scent such as mixed-gender pheromones (Parsons et al. 2015) may increase trapping yields. Potential repellents such as sebum from an alpha male (Krames et al. 1969; Gawienowski et al. 1976) or alarm scents (Valenta and Rigby 1968), could produce micro-scale avoidance when rats have an alternative place (burrow or harborage point) to access (Parsons et al. 2018a). Appeasement or anxiolytic scents (Johnston 2003) may change the disposition of animals and lead to decreased neophobia (Mason et al. 1988) and/or increased intake of bait. Thus, this overarching study comprises several studies below that are related but different enough to warrant their own chapter and will be dealt with separately. Because these chapters have been submitted for publication, and in compliance with copyright laws, we will distill the main points from each experimental chapter and refer the reader to the publication.

Chapter one: In conjunction with pest management professionals (PMPs) at Arrow Exterminating Company, Inc., we have identified the factors holding back experimental urban rat research. We demonstrate the environmental and social challenges unique to urban rat research and provide a framework to understand and overcome the challenges of working with city rats. Additionally, we have offered several mechanisms by which academics can work with PMPs to undertake experimental research in urban industrial and park settings. Our principal finding is that long-term rat research is essential for the development of new management approaches, and that this research can be done when academic priorities are aligned with that of pest management companies.

Chapter two: One of the most salient rules in pest research is to work at the level of the individual in order to generalize findings across populations. To do otherwise could jeopardize the research as findings could be influenced by a few of the most active or most apparent animals--- not a true random sample of the broader population. To overcome this challenge, we used a field bioassay with radio frequency identification (RFID) tags to identify individual animals so that we can determine the valence (direction of responses) of male-only scents on individuals across the population. In an urban waste-management facility, we found that male-only scents are less evocative than mixed-male and female scents. Whereas, mixed gender scents were previously shown to be highly attractive to males and females, male-only scents provided less visitation incidents per animal, for short periods of duration, and then possible deterrence or avoidance.

Chapter three: Many urban dwellers and some municipal authorities have been intentionally releasing feral cats as a control mechanism for city rats. However, there is no evidence that feral cats can control large <300 g city rats such as the typical Norway rat (*R. norvegicus*). In this manuscript, we have provided evidence of the direct and indirect influence of feral cat predation on city rats. Our main finding is that the predation rate was extremely low. Because animals tend to over-estimate risks, however, rats did change their behaviors around the feral cats. They were less likely to be captured on video on days during or after cats had been spotted. This helps answer the conundrum of why lay people believe cats can control rats. Rats were still alive, but more often under cover, when feral cats were around. Based on our findings, we argue that cats are more likely to predate smaller and less-defensive prey (neotropical migrants, small mammals, mice) which, at 15-20 g, weigh about 10% of what an adult Norway rat may weigh. We believe this is the first-time that research on direct predation between feral cats and urban rats has been performed.

Chapter four: We have previously established that mixed-gender scents are highly attractive to male and female rats. City rats visited pheromones up to 30 times per day, for up to one minute per visit, for over 80 days. In chapter two, we learned that male rat scents had a negative valence in an industrial waste-management facility (these scents produced initial visitation and future avoidance). If mixed scents produce an attractant, and male scents produce a repellent, then we expect female scents may be responsible for much of the attraction in mixed-gender scents. The final chapter examines the attractiveness of female-only scents. During this final experiment, we observed that some rats were more likely to be trapped in covered traps under periods of high risk (human and cat activity). Thus, our secondary objectives were to determine if covered “refuge” traps were more likely to capture rats than bare, wire traps under periods of normal risk (no additional predator scent) and deployment of an artificially enhanced novel risk (mountain lion urine). Our initial findings are that female-only scents are highly evocative to male and female rats, and the effect persists for over 60 days. We are still in the collection period and it is too early to tell whether the covered traps are preferred to the wire traps under either risk-status.

Manuscript breakdown:

Chapter #1

Investigators: (Parsons et al. 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

City rats are among the most important but least-studied wildlife in urban environments. Their presence, compounded by the rate of human urbanization and effects of climate change, frequently bring potentially infectious organisms into contact with people and other wildlife. Urban rat control, however, is ineffective, largely because so little is known about their ecology.

It is therefore, essential that we exploit new research avenues if we are to better understand and manage these risks. The hallmark of robust science includes replication at the level of the individual and urban landscape, allowing researchers to study behaviors and populations over time. However, unlike most wildlife, urban rats are confined to environments where there are numerous incentives to exterminate, but few reasons to study them. Thus, gaining access to rats presents an exceptional challenge for researchers. To address this problem, we first identified prevailing knowledge gaps in the literature and then used a five-step ‘wicked problem’ framework to define the issues, identify stakeholders, and systematically examine options for remediation. We discuss pest management professionals (PMPs) as an important conduit between private enterprise and the research community and suggest that businesses supporting research be rewarded through part-compensation, or allowances (credits) from the health department. This allows urban rats to be studied like all other ecological research subjects—in the field, while animals are alive. Appropriate incentives could enable scientists and PMPs to work together toward ‘smart’ ecologically-based rodent management (Singleton et al. 2007), hereby enhancing options for control while preparing for the challenges of continued urbanization.

This paper has been published and is available at the following [link](#).

Chapter #2

Investigators: (Parsons et al. 2018c)

Understanding the valence of conspecific scents: Are free-ranging, urban brown rats attracted to, or repelled by, male-produced pheromones?

Rats depend on chemical (scents) and tactile cues to make mobility-related decisions in the urban environment. However, despite the importance of rats (*Rattus* spp.) to society, there has been little research to determine the influence, or valence, of rat scents on wild conspecifics. We previously learned mixed-gender, pooled (mg-p) pheromones were highly evocative. It was thus essential that we disambiguate which pheromones were eliciting attraction (+ valence), inspection, a conditioned response whereby attraction is followed by avoidance (– valence), or no response (0 valence). We assessed male-only scents by quantifying the relative number of visits and elapsed dwell time (sec/visit) between treatments (used bedding) and control (familiar wood chips). We placed treatment/controls within the rat runway, and 5 m away in an exposed environment. Rats initially visited both treatments (near, far) more often than controls (0.2 visits/day vs 0.1/day; $P < 0.05$) but the dwell time was no different (1.2s/visit vs 0.9 s/visit; $P > 0.2$), indicating possible inspection instead of attraction. This is in contrast to earlier work with mg-p scents whereby rats had a magnitude higher visits (2.7 visits/day) and dwell times (3s/visit). While establishing a baseline for wild rats experimentally exposed to pheromones, we conclude the evocative nature of mg-p scents may relate to the presence of females. Future research may assess female pheromones with/without mixed-male scents (see chapter 4), and from discrete social classes of males (alpha—omega). This information is essential if we are to understand how pheromones influence behavioral states and mobility of wild, urban rats.

This paper is under peer review. For further information, please contact the authors [here](#).

Chapter #3

Investigators: (Parsons et al. 2018b)

Temporal and space-use changes by rats in response to predation by feral cats in an urban ecosystem

Feral cats (*Felis catus*) are predators that cause widespread loss of native wildlife in urban ecosystems. Despite these risks, cats are commonly released as control agents for city rats (*Rattus* spp.). Cats can influence their prey directly by killing or indirectly through changes to feeding or space-use. However, cats prefer defenseless prey, and there are no data suggesting that cats influence large (>300g) urban rats. We used a pre-existing radiofrequency identification assay (microchipped rats and field cameras) and ethograms to assess the impact of cats, including temporal and space use patterns, on an active rat colony. From Dec 27, 2017 through May 28, 2018 we captured 306 videos of pre-identified cats and/or rats that shared the same space. There were three instances of predation and 20 stalking events. Logistic regression showed the likelihood of a rat being seen on a particular day is associated with the number of cats seen on the same day (OR=0.1, $p<0.001$) or previous day (OR=0.15, $p<0.001$). Space-use was also impacted. For every additional cat sighting, a rat is 1.19 times more likely to move in the direction of shelter. Our findings of low levels of predation support why ecologists believe the risks to native wildlife outweighs any benefits of releasing cats. Even though rats were less likely to be seen, they simply shifted their movements and remained present in the system. Our findings that cat presence led to fewer rat sightings may explain the common perception of their value as rat-predators despite the associated risks.

This paper has been published and is available at the following [link](#).

Chapter #4

Investigators: (Parsons et al. 2018d)

An RFID field bioassay to establish the evocative response of female Norway rat (*Rattus norvegicus*) scents on adult male, female and juvenile conspecifics

Despite the risks and high costs associated with urban rats, methods for rat control remain limited, with no known tools to influence rat movements and behaviors at the local scale. Pest management professionals (PMPs) must either exterminate rats, or modify human behaviors such as eliminating rubbish or sources for harborage. Nevertheless, there is an unexplored avenue to exploit rat behaviors. All rodents are continuously exposed to an intense array of scents that they use to navigate their environment. They depend on some scents to help them locate favored resources (food, harborage and potential mates) and at the same time, rely on other scents to reduce risks from conspecifics or potential predators. Thus, the response to all perceived scents (a cost: benefit ratio of attractants and deterrents) influences fine-scale movements across

particular types of corridors, into new forage patches, or when to challenge a rival or defend new territories. A better understanding of the scents that help govern city rat movements, and the social structure that helps determine the value of these particular scents, are essential to developing the first tools to manipulate rat behaviors at the local scale. Here, we have investigated whether the evocative response to female rat scents is specific to all sex and age groups of individual rats in a waste-management facility. We further investigated whether trapping rate of individual male, female and juvenile rats was influenced by perceived risks (novel mountain lion (*Puma concolor*) urine)).

This paper was still in progress at the time of the final report. For further information please contact the authors [here](#).

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