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LURES AND BAIT CONSUMPTION MOTIVATORS FOR RATS

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Abstract Pest control strategies would become more effective if semiochemicals (volatile organic signalling compounds) instead of foods were used as lures and bait additives. This is because (1) they can be encapsulated into non-perishable lure products that emit a sustained odour for extended time periods thus negating the need for constant replenishment and, (2) increase the amount of bait consumed by target animals thus increasing the likelihood of an animal ingesting a lethal toxic dose. We trialled six different semiochemical blends as lures and bait consumption motivators that we had previously identified as having potential as semiochemical products for rats. Two semiochemical blends accounted for 60% of all trap box entries and statistically outperformed the control. Bait consumption was increased in the presence of all six semiochemical blends with one leading to 2.6 times more bait being consumed. Our semiochemical blends, when developed and commercially available, will improve the effectiveness of rat monitoring and control. Ultimately, our products will help achieve major operational cost savings, especially by large reductions in labour, and enable a substantial expansion in the scale and frequency of pest control, especially in inaccessible locations.

Key words Rattus, semiochemical, control, monitoring, trap

INTRODUCTION

All vertebrate pest control and detection devices require baits and lures to be effective (Apfelbach et al., 2005; Kok et al., 2013). Emerging advanced smart multi-kill and monitoring devices, like those in the Rentokil Pest Connect system, in particular require longer-life baits and lures because they operate remotely for extended periods without maintenance. Unfortunately, the development of vertebrate pest lures and baits (including those containing toxins) has not kept pace with the innovation seen for invertebrate baits and lures (Kimball et al 2000, Schlexer 2008, Jackson et al. 2017). Today, vertebrate pest control still depends on the use of crude, perishable food-based products like peanut butter and cereals, and commercially available pastes and gels, to attract animals to monitoring and control devices (Eason et al., 2016; Jackson, Linklater, et al., 2018). But these are perishable rendering them ineffective in a matter of days. This means the likelihood of detecting, kill-trapping or delivering a lethal toxic dose to an animal rapidly diminishes soon after their deployment. In turn, this decreases control operation efficacy and increases labour costs, as lures or baits need to be frequently replenished at considerable cost (Linklater et al., 2013; Murphy et al., 2013; Parshad, 2002). In practice, therefore, devices commonly operate sub-optimally for substantial periods of time, especially in less accessible locations where traps cannot be more frequently visited. The logistic and financial constraints perishable lures impose, substantially impact management outcomes and pest control programme success.

More effective pest control strategies would become possible if semiochemicals (volatile organic signalling compounds), like those used as lure and bait additives for invertebrate monitoring and control for decades (Witzgall et al., 2010), could be developed for vertebrate pests. This is because (1) the semiochemicals attractive to animals can be encapsulated into non-perishable products that emit a sustained odour for extended time periods. They would ensure control and monitoring devices are always optimally attractive and facilitate the advance to automated smart technologies. (2) Semiochemical bait additives can increase the amount of bait consumed by target animals (Marsh, 1988; Mauchline et al., 2018). This is important, as sub-optimal take-up of toxic baits can lead to sub-lethal doses, bait shyness and ultimately failed control operations (Morgan et al., 2001).

In this paper we describe our ongoing development of semiochemical lures and bait consumption motivators for rats (*Rattus* spp.) and their transformation into sustained release, long-life products. We provide summarised results and discuss the implications of our product development to global vertebrate pest control.

METHODS

We trialled six different semiochemical blends as lures and bait consumption motivators (hereafter 'semiochemical blends') that we had previously identified as having potential as semiochemical products for rats (Jackson, et al., 2018a and 2018b). The six different semiochemical blends (coded S, T, V, W, X and Z) were presented to naïve wild-caught brown rats (*Rattus norvegicus*) inside bait boxes. Each trial consisted of four bait boxes placed in an indoor pen (Figure 1). Each of the four bait boxes contained 20 grams of non-toxic food-derived product (the current bait/lure product used in control operations). Three bait boxes were assigned one of the six semiochemical blends while the remaining was used as a control (coded NT). We used a stratified random sampling design to ensure all six semiochemical blends and the control were presented to rats in each of the four box locations, and to equal numbers of male and female rats. In total, we ran 16 trials (8 male and 8 female rats), using one naive rat per trial. Rats were acclimatised to the pen for 48 hours before trials commenced and provided food and water *ad libitum*. Each trial lasted 12 hours and pens were cleaned between trials to remove any scent marking from the previous rat.

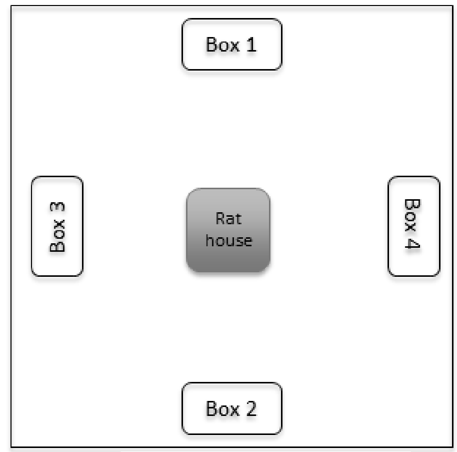

Figure 1. Pen design

Data Analysis. We used EthoVision XT (Noldus) to track animal movements and to obtain quantitative behavioural data about semiochemical blend attractiveness. We compared the performance of each semiochemical blend and the control to the best performer using binomial tests and used Welch's t-tests to compare bait consumption.

RESULTS

Bait consumption

Bait consumption was increased in the presence of all six semiochemical blends (Figure 2).
Semiochemical blend T was the best performer, leading to 2.6 times more bait being consumed, and statistically outperformed the non-toxic bait control ($P = 0.02$).

Attraction

Semiochemical products X and T accounted for 60% of all first entries to bait boxes (defined as the whole body of the rat entering the bait box) and statistically outperformed the non-toxic bait control ($X = P < 0.001$ and $T = P < 0.04$) that had no first entries recorded across the 16 trials. The average time to first entry for all semiochemical products was just 49 minutes. Rats made more visits in and around trap boxes containing semiochemical products (top performer Z with more than 50% more visits in and X with 63% around, respectively; Figure 3) compared to the non-toxic bait alone. Rats also spent more time inside bait boxes that contained a semiochemical product (semiochemical product V was the best performing with more than 50% more time spent inside the bait box).

DISCUSSION

Our semiochemical products led to increases in bait consumption (by up to 2.6 times more) and the activity of rats in and around bait boxes, commonly by more than 50%. In particular, two semiochemical products (X and T) statistically outperformed the control for attraction and bait consumption, respectively. This is interesting as previous field-based studies conducted by us in New Zealand also identified semiochemical product X (the best performing product for first entries in our pen studies) as an effective lure for kill-trapping wild, free-ranging ship and Norway rats. Also, our modelling had indicated that semiochemical blend T may drive biting and mastication in rats.

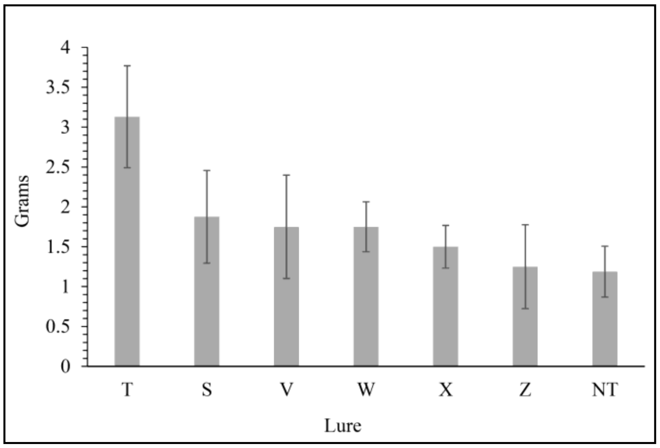

Figure 2. The amount of bait consumed in the presence of each semiochemical lure product and including the non-toxic bait control (NT).

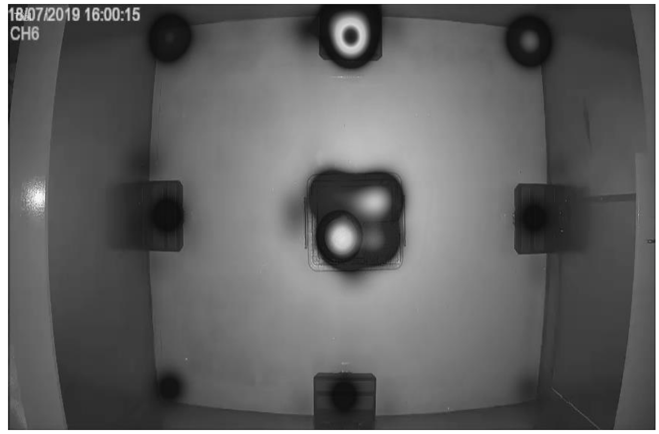

Figure 3. EthoVision XT heat map showing the intensity of activity in the pen. Yellow and red indicates areas of high activity.

Our semiochemical products, when developed and commercially available, will likely improve the effectiveness of rat monitoring and control, by overcoming the current limitations of food-based lures (Turkowski et al., 1979; Shivik et al., 2014). They will increase the probability of rats entering trap boxes by helping overcome the neophobic responses of animals to them. Control and eradication operations often fail due to trap shyness associated with neophobic individuals (Seymour et al., 2005). They may increase the consumption of baits by ensuring a lethal toxic dose is ingested, thus decreasing learned avoidance and adaptive tolerance, and increasing the efficacy of control operations. Ultimately, our products will help achieve major operational cost savings, especially by large reductions in labour, and enable a substantial expansion in the scale and frequency of pest control, especially in inaccessible locations. These economic, operational savings, and expansion in efficacy, are amplified because semiochemical product enable automated pest detection and control devices to reach their maximum operational potential.

We are currently working to transform our prototype semiochemical products into sustained release, long-life lure and bait consumption motivator products for national and international markets. We are trialling several technologies as different environments and context (in-doors, out-of-doors, urban, and rural) will necessitate different application technologies. Our early prototypes (including semiochemical product X) were effective at kill-trapping wild, free-ranging ship and Norway rats without replenishment for 6 months. We have since engineered other products with different life-spans (1, 2 and 3 months) and comprising different semiochemical blends to suit different applications (e.g., X for kill-trapping and monitoring and T for bait consumption).

Our semiochemical-based lures and bait consumption motivator products will be applicable to all current and emerging biosensor, monitoring, trapping and baiting technologies and will help emerging remotely operated, smart multi-kill, automated monitoring and recognition, and toxin delivery devices realise their potential. Lastly, our animal response-guided discovery method (Jackson et al., 2016; Jackson et al., 2018a and b) is an advance that could be adapted more widely for semiochemical lure discovery in other pest species.

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