Proceedings of the Ninth International Conference on Urban Pests
Matthew P. Davies, Carolin Pfeiffer, and William H Robinson (editors) 2017
Printed by Pureprint Group, Crowson House, Uckfield, East Sussex TN22 1PH UK

RODENT CONTROL: BACK TO BASICS TO UNDERSTAND THE FUTURE

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Abstract The current urban rodent control servicing model which relies very heavily on baiting with rodenticides is being increasingly challenged, and two studies are reported here that attempt to 'go back to the basics' of rodent behavior in order to investigate new avenues for innovation. The ability of several candidate food-based attractants was assessed in a pen containing a colony of mice maintained in 'semi-natural' conditions. None of the materials tested had any effect on increasing bait take in any of the bait boxes treated – in fact the control bait boxes sprayed with water had the highest mean daily bait take. The same colony was used on another occasion to test various candidate mouse-proofing products, through which the mice had to pass to access a central enclosure. Some professional products, as well as industry-recommended materials such as steel wool, did not last the 90 days of the test period. However professional products Mouse Stop and Rodent Barrier, as well as one DIY product (Polyfilla) lasted the length of the trial and would appear suitable for use as part of a rodent control IPM program.

Key words Prevention, rats, mice, bait, neophobia, traps, exclusion, proofing, monitoring.

INTRODUCTION

The current urban rodent control servicing model (lay bait, return every 6 weeks to check bait) is under increasing threat as restrictions on product choice and product usage begin to emerge from the European and US regulatory processes. It also exposes some of the deficiencies in that model which have been traditionally overlooked – the main one being an overreliance on bait take from bait boxes for detecting and estimating the size of a rodent population.

Rats will show neophobic behaviour (Barnett, 1963) and avoid going into newly-placed bait boxes, often for weeks at a time. Evidence from the field (Charlton, 2012) backed up by research in our own laboratory has shown that a proportion of mice in a population also avoid going into bait boxes – many approaches to bait boxes result in mice passing through without feeding, climbing on top, or walking around in some cases. This limitation means that treatments may take longer to achieve control, but perhaps more importantly it means low-level infestations (especially of mice) could go completely undetected, despite the presence of a pest control service contract. Is there any way bait boxes could become more attractive to rodents in order to overcome this issue?

The first part of this paper looks at a selection of studies of different potential 'attractant' compounds, in order to ascertain if they have the potential to attract mice into bait boxes to consume a greater amount of bait. These materials have been suggested based on field observations, or the materials are known to be used in some commercial products where attractant potential is claimed.

As part of a fully Integrated Pest Management (IPM) programme, non-lethal measures should also be considered that restrict the ability of rodents to gain entry or move around a building – although these are often neglected in order to concentrate on checking bait boxes. An example of an IPM technique is proofing, and examples of these techniques are given by Baker et al. (1994, and more

recently abridged by Vantassel et al., 2009). While extremely good guides, they do contain an important error – they confuse the statement that mice can squeeze under a ¼ inch (approximately 6 mm) gap with a later figure that shows a round hole of ¼ inch diameter, clearly too small for even a newly-weaned mouse to get through. Howeve,r facts such as this can become accepted wisdom in the pest control industry, especially in the absence of recent basic behavioural research on proofing techniques.

As part of a programme of proofing, the second part of this paper therefore looks at the relative effectiveness of different hole-proofing materials, in order to assess how more traditional techniques perform compared to some of the modern proofing pastes and other products.

MATERIALS AND METHODS

Both sets of trials used the same colony of House Mice*, Mus musculus domesticus*, although at different times. These mice were maintained in a pen 1.8 metres by 3.6 metres in semi natural conditions, with plenty of harbourage locations and pelleted RM1 lab diet and water available ad libitum. These mice originated from wild-caught mice from a farm in Berkshire, UK that have been maintained as a colony in a variety of semi-natural conditions for approximately 20 years. The number of animals in the colony fluctuates between 60 and 100 animals approximately, and includes all life stages.

Attractants

Standard Rentokil Tamper-Resistant Bait Boxes for mice were used in this trial (dimensions 12.5 cm long x 7 cm deep x 4 cm high). These were baited with a proprietary non-toxic Rentokil paste bait and were treated with various attractants as detailed below, or used as controls. Bait boxes were placed along the wall-floor junction of one wall of the pen that was clear of any harbourages or other obstructions. Bait take was measured daily, and sufficient bait was placed in each bait box to ensure it was not emptied overnight. Boxes were placed 30 cm apart along the wall, and each replicate ran for 3 days, after which there was a lag period of 4 days until the next trial. The trial was repeated twice more, each time with the order of placement of bait boxes changed in order to control for possible position preferences.

Trial 1 tested a vanilla extract powder ex Berkem. This was tested in an aqueous solution (50% water, 50% monopropylene glycol) at 10% and 40% in a trigger spray which was used to apply approximately 1g of liquid onto the inside of the lid of the bait box before closure. Performance was benchmarked against a control where an equivalent amount of water had been sprayed inside a control bait box. Trial 2 tested a Cocoa extra powder ex Berkem in the same manner as Trial 1.

Trial 3 investigated three common household food-flavouring ingredients simultaneously: almond, vanilla and peppermint flavourings all bought from a major supermarket chain.

Hole Proofing

For this trial, a rectangular (90 cm x 60 cm) Perspex enclosure was introduced into the pen. This enclosure was 60cm high. Three perspex tubes were inserted into one side of this enclosure, 5cm apart. The tubes were 3.5 cm in diameter. Each tube was filled to a depth of 2.5 cm with a variety of proofing materials on the end of the tube facing into the pen – so the mice had to penetrate the proofing material in order to enter the tube and thus the inside of the enclosure. Approximately 50 g of pelleted RM1 diet was also placed in the centre of the enclosure.

Three potential proofing materials could be tested simultaneously. Daily checks were made for signs of damage, and when it appeared that a material had been penetrated this was confirmed with CCTV footage of the pen. The failed material was then replaced with a fresh tube containing the next proofing material and this process continued until all materials had been tested. If a material resisted for 90 days this was considered sufficient to prove efficacy.

The materials tested were:

- Polycell Multi-Purpose Quick Drying Polyfilla – a ready to use cement sealing product.
- Sakarat Rodent Barrier – commercial rodent proofing product from Killgerm.
- Sakarat Rodent Stop – commercial rodent proofing product from Killgerm.
- Mouse Stop – mouse proofing product from iPest Control B.V.Coarse Steel Wool.

3M Coarse Synthetic Steel Wool – synthetic material alternative to steel wool Expanding Polyurethane Foam. Unibond Super All-Purpose Silicone Sealant –silicone sealant in a caulking tube. Coarse Builders Sand – filled to depth of 5 cm while still wet.

RESULTS AND DISCUSSION

Attractants

Table 1 gives the mean daily bait take from all replicates for trials 1 and 2 (vanilla and cocoa extract powders). No statistics have been applied as it is obvious, based on this data that there is no evidence that either extract has increased bait take and therefore no evidence for a useful attractant effect. Table 2 shows the mean daily bait take from all replicates of trial 3. It is clear that no claim for an attractant effect on the basis of increased bait take can be made for any of these food-flavourings.

Table 1. Mean daily bait take (g) over three days from bait boxes sprayed with different concentrations of vanilla and cocoa extract vs. a control sprayed with water.

Concentration of extract in aqueous solution	Vanilla Extract	Cocoa Extract
40%	10.7	11.3
10%	11.7	12.1
Control (water)	12.0	14.5

Table 2. Mean daily bait take (g) over three days from bait boxes sprayed with different food-flavourings vs. a control sprayed with water.

Almond	Vanilla	Peppermint	Control (water)
11.7	16.1	5.6	19.7

Other results in our laboratory (not published) have found similar results with a range of commercially available attractants, the conclusion being that whilst a novel food scent might divert the attention of a mouse to investigate, this does not necessarily equate to an increase in bait take – or detecting mice on the basis of spotting bait take. Indeed, a surprising result is that peppermint may have potential as a particle repellent, which is worth investigating further.

Table 3. Number of days proofing materials prevented mice access to the centre of a test chamber.

Proofing Material Tested	Number of Days
Polyfilla	Lasted entire 90 days
Rodent Barrier	Lasted entire 90 days
Mouse Stop	Lasted entire 90 days
Silicone Sealant	70
Synthetic Wire Wool	60
Expanding Foam	30
Steel Wool	26
Rodent Stop	1*
Coarse Sand	1

* This time was so short it was repeated twice – with the same result

Hole Proofing

Table 3 shows the number of days that different proofing materials lasted before mice were able to penetrate through them and access the centre of the chamber. Three materials lasted the full 90 days of the trial - although all three did show a small degree of gnawing damage, this was the benchmark set for success.

The performance of steel wool and Rodent Stop was surprisingly poor. Steel wool may sometimes be used to fill a gap before applying a cement filler, and this may still be effective. Mice were seen pulling this material out strand by strand until the remaining plug of material was pulled out in one piece. It is clear that not all materials are good for proofing against mice, but two commercial products (Rodent Barrier and Mouse Stop) did last the full 90 days of the test; however, so did a commercially available cement gap filler. This is a very simple test to run, which produces clear and unequivocal results, in order to evaluate any future proofing products. There is no need to entrap mice or remove food sources as a drive to explore appears sufficient motivation – and this experimental design was chosen as it is more relevant to a situation likely to be encountered in the field.

CONCLUSION

Recent research in rodent control has focused on producing more palatable / effective bait products, and more latterly alternative control options such as lethal traps. But this emphasis on innovating lethal control measures has meant a lack of studies of the effectiveness of other IPM measures such as proofing, housekeeping, and monitoring techniques, in order to protect premises. It is the author's opinion that a future rodent control service will involve the use of all these techniques to provide a service that moves the industry from pest control to pest prevention.

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FIELD EVALUATION OF TWO SINGLE FEEDING ANTICOAGULANT RODENTICIDES AGAINST *MUS MUSCULUS* IN A CONFINED SWINE FACILITY

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Abstract Three commercial rodenticide bait blocks were tested at a confined swine facility in Lafayette, Indiana to compare efficacy for control of the house mouse (*Mus Musculus*). The three products were Talon® Ultrablok rodenticide (brodifacoum 0.005%), Final® All-Weather Blox™ (brodifacoum 0.005%), and Contrac® All-Weather Blox (bromadialone 0.005%). Pretreatment monitoring with non-toxic bait blocks and tracking pads determined that mouse populations were equivalent in the three buildings used as treatment sites. Each building was treated with toxic bait for 15 days. Bait consumption and tracking pad activity were monitored. After a three-day rest period the sites were monitored again with non-toxic bait and tracking pads for eight days. Following the monitoring, multi-catch mouse traps were placed in each building to trap mice remaining in the building. Consumption of Contrac bait (7136 grams) was significantly greater than for Talon (2454 grams) and Final (1094 grams). Consumption of Talon brodifacoum was significantly greater than Final. Following the 15 day toxic baiting period, bait consumption and tracking pad activity were significantly lower for the Talon treatment, (1% bait consumption and tracking pad activity), than for the Final (38 % bait consumption, 27% tracking pad activity) and Contrac (91% bait consumption and 78% tracking pad activity). Trap catches following baiting were 6 mice for Talon, 44 mice for Final, and 57 mice for Contrac. Results indicate that there was probably bait aversion to the Final bait and rodenticide resistance to bromadialon, the active ingredient in Contrac. DNA analysis showed that 67% of the trapped mice were homozygous for Y139C mutation for anti-coagulant resistance, and 33% were heterozygous for the same mutation. In addition 33% of the mice were homozygous for L128S mutation for anti-coagulant resistance. The test confirms the presence of single feeding anticoagulant resistance in a house mouse population in the United States.

Key words Brodifacoum, bromadialone, resistance, DNA, Y139C, L128S.

INTRODUCTION

The house mouse, a commensal rodent pest, is common in animal production facilities. Control of these pests is difficult in these situations because of the abundance of harborage and food, and a controlled temperature environment. Growers typically rely on the use of chemical rodenticides, principally the single feeding anticoagulant rodenticides, for control of these rodent pests. Two factors can influence the success of mouse baiting programs, the acceptability of the bait and physiological resistance to the active ingredient. Physiological resistance to single feeding anticoagulant rodenticides has been identified in several locations around the world (Buckle, 2012). This study was initiated to compare three rodent bait formulations for acceptance and control of a house mouse infestation in a confined swine facility.

MATERIALS AND METHODS

Three rodenticide bait blocks were compared for consumption, speed of control, and effectiveness of reduction of a house mouse infestation in a confined swine facility. The test was conducted at the Swine Unit of the Animal Sciences Research and Education Center (ASREC), a commercial swine farm operated by the Department of Animal Sciences at Purdue University in West Lafayette, Indiana. Three separate buildings were used. Each building received one of three treatments.

The three treatments were Talon® Ultrablok (0.005% brodifacoum), Contrac® All Weather Blox™ (0.005% bromadialone), and Final® All Weather Blox™ (0.005% brodifacoum). Baits were placed in the buildings in the areas of highest mouse activity as determined by visual inspection. Baits were placed in tamper resistant mouse bait stations (Bell Protecta® Mouse Station). Tracking pads were placed at both entrances of the bait stations. Tracking pads were 6 inch by 6 inch PVC tiles coated with blue construction chalk.

The study consisted of 3 phases. Phase I was pre-baiting with non-toxic bait blocks (Detex® Block, Bell Labs) and monitoring with tracking pads. Each building was continuously baited for 8 days and bait was replaced every 48 hours as needed. Bait consumption and tracking activity were measured in each building. During phase II each building was baited with one of the three treatments and tracking was monitored with tracking pads. Phase II began 3 days after the completion of phase I. Each building was baited continuously for 15 days and bait was replenished every 48 hours as needed. Bait consumption and tracking activity were measured. Phase III began 3 days after the end of phase II. Phase III was baiting with non-toxic bait blocks and monitoring with tracking pads. Each building was continuously baited for 8 days and bait was replaced every 48 hours as needed. Bait consumption and tracking activity were measured in each building. At the end of the 8 days of baiting live catch traps (JT Eaton 420CL Repeater™ Multiple Catch Mouse Trap) were placed throughout each building to determine if any mice remained active in the buildings.

To check for the presence of anti-coagulant rodenticide resistance a one inch section of the tail of mice that were captured at the end of the study was collected from 12 mice and submitted to the Rodent Research Lab at Reading University (Reading, UK) and a genetic analysis was conducted to look for the presence of the two anti-coagulant resistant mutations, Y139C and L128S.

Data Analysis. Differences between tracking activity, bait consumption, and mouse trapping were analyzed by one way Analysis of Variance using SPSS Software. Differences were significant at the $p < 0.001$ level.

RESULTS AND DISCUSSION

Consumption of non-toxic bait for all three buildings during phase I averaged 96.3% of bait applied +/- 1.5%. Mean percent tracking during phase I for all three buildings was 87% +/- 1.7% (Figure 1). There was no significant difference in mouse activity between the three buildings.

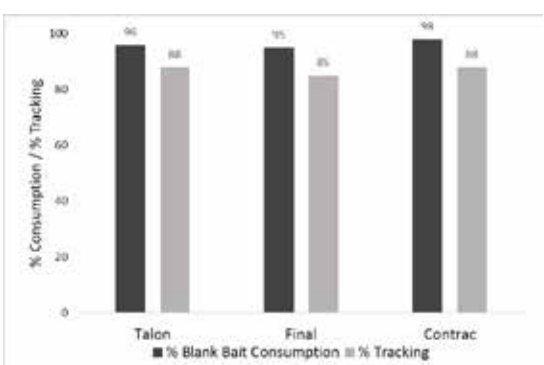

Figure 1. Phase I, Percent Consumption of non-toxic bait and Percent Tracking by Treatment.

Bait consumption during phase II was; Talon 2454 grams, Final 1094 grams, and Contrac 7136 grams (Figure 2). Consumption of Contrac bait was significantly greater than consumption of Talon and Final baits. Consumption of Talon was significantly greater than consumption of Final. No Final was consumed after the 2nd day of baiting. Tracking during phase II was significantly lower for Talon than for Contrac and Final Figure (3).

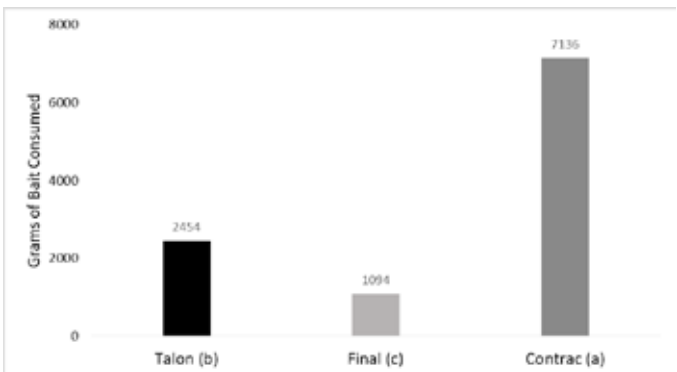

Figure 2. Phase II, Total grams of bait consumed for each treatment during 15 days of continuous baiting. No Final All Weather Blox were consumed after the second day of baiting.

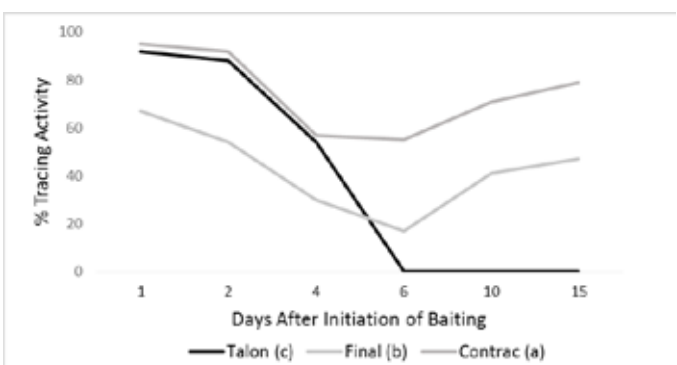

Figure 3. Phase II Percent tracking during the 15 days of baiting

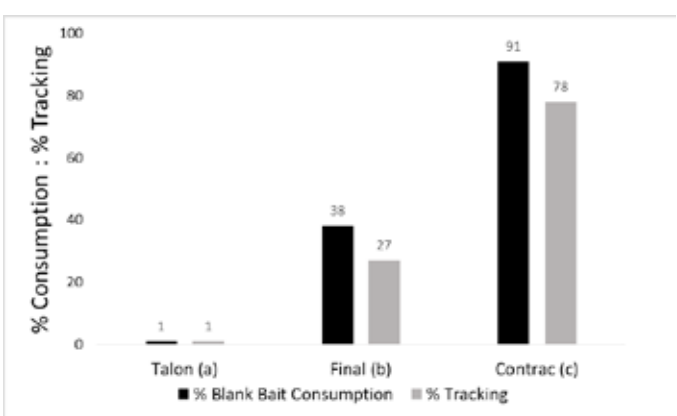

Figure 4. Phase III, Percent Consumption of non-toxic (blank) bait and Percent Tracking by Treatment.

Consumption of non-toxic bait during phase III was 34 grams for the Talon treatment, 1808 grams for the Final treatment, and 2697 grams for the Contrac treatment. Average tracking activity during phase III was 1% for the Talon treatment, 27% for the Final treatment, and 78% for the Contrac treatment (Figure 4). Consumption and tracking for the Talon treatment were significantly less than for the Final and Contrac treatments. Consumption and tracking for Final was significantly less than for Contrac.

At the conclusion of the test 6 mice were trapped in the Talon treatment, 44 mice were trapped in the Final treatment, and 57 mice were trapped in the Contrac treatment. The number of mice trapped in the Talon treatment was significantly lower than trapped in the Final and Cotrac treatments.

DNA analysis showed that 67% of the mice analyzed were homozygous and 33% were heterozygous for the Y139C mutation for anti-coagulant resistance. In addition another 33% of the mice were homozygous for the L128S mutation for anti-coagulant resistance.

CONCLUSIONS

The high rate of consumption of Contrac bait with a low level of control is indicative of physiological resistance to the anti-coagulant active ingredient bromadialone. The results of the DNA analysis confirm the presence of the mutation for anti-coagulant resistance in this mouse population. As this mouse population is fairly isolated is it not indicative that bromadialone resistance is wide spread in the region where the test was conducted.

The low consumption of Final bait with moderate control and no feeding after the second day of baiting indicates bait aversion in the mouse population. As a formulation of bait very similar to Final has been used for years at the facility the selection for aversion is highly probable.

The moderate consumption of Talon bait with a very high level of control indicates that there is as yet no physiological resistance to brodifacoum in this mouse population. The attractiveness of a novel bait formulation resulted in good consumption and a high level of control.

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