BAITING TECHNOLOGIES – VERTEBRATES

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INTRODUCTION

The use of baits to control pest vertebrates is a technique that is thousands of years old. The Romans used the bulb of the red squill plant, *Urginea maritima*, which contains the cardiac glycoside, scilliroside, mixed with foodstuffs to control rodents. Purified forms of scilliroside are still used in some parts of the world today. Essentially the concept of mixing a chemical with a foodstuff and feeding it to a pest is no different now. We do know more about feeding behaviours of the animals we are attempting to control and, of course, more sophisticated active ingredients are used but the technology has changed little.

In this paper it is proposed to discuss the various elements involved when baiting against selected vertebrate pests, especially the commensal rodents – house mice (*Mus domesticus & Mus musculus*), brown rats (*Rattus norvegicus*) and black rats (*Rattus rattus*). Other vertebrate pests are mentioned but information on these is more scant.

COMMENSAL RODENTS

Obviously when one is considering a baiting operation it is imperative to know what the target species prefers to eat and how it feeds. This has been generally well established for the commensal rodents. In general all the species will eat most cereals most of the time, although they are all somewhat omnivorous. Therefore the vast majority of rodent baits are based on cereals.

Regardless of species, it can be said that the dominant force in rodent feeding behaviour is survival, particularly the avoidance of predation. However, the mechanism of feeding is different for the different species. Brown rats may be said to be 'wary' feeders, mice are 'inquisitive' feeders and black rats somewhere in between. Thus different baiting strategies have to be adopted, even if the same bait is used.

Rattus norvegicus (Brown rat)

Brown rats have been extensively studied and perhaps the most important feature of their behaviour is their neophobic response to any new objects and situations, including food and food containers, in their environment. A major effect of neophobia is that food consumption is severely curtailed and it can be several days before it gets back to normal. When a new food source, such as a bait, is made available to brown rats it can take several days before they touch it. Then they only take it tentatively. If the bait contains an acute active ingredient and only a sub-lethal dose is ingested then symptoms will rapidly occur. The rat has the ability to associate the symptoms with the food it has just eaten and it will ignore it in the future ensuring its survival. This phenomenon is known as "bait shyness" or "bait aversion". It can be overcome by pre-baiting which is simply laying unpoisoned bait base to allow the rats time to get used to eating it, then mixing in the rodenticide when the neophobic response has been overcome. This may take some time. With anticoagulant rodenticides pre-baiting is unnecessary as they are slower acting and tend to act as their own pre-bait.

When baiting for rats it is important to locate harbourages and runways so that the rats can be intercepted on their way to their usual food source. Rats tend to be creatures of habit and take quite large amounts of food from only a few selected locations. Therefore large numbers of baits are not always necessary but there should always be enough bait present to last between treatments.

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One proposed technique which offers a different approach to brown rat control is "pulse baiting". This consists of laying a smaller than usual amount of bait at the beginning of a treatment. In theory, all this will be eaten by the more dominant rats, who then die. Dominant rats have first choice of feeding time and site. Later, another relatively small amount of bait is laid and the next wave or 'pulse' of rats is killed, including those which took only a sub-lethal dose on the first occasion. This continues until all rats are dead. The value of this technique has yet to be proven with confidence and the situation can be envisaged where some rats continue to take sub-lethal doses over a number of 'pulses'.

Mus domesticus/M. musculus (House mouse)

In contrast to brown rats, the evidence for neophobic responses in house mice is at best equivocal. If neophobia does exist it is certainly not strong and is normally easily overcome. Mice readily accept new food, sometimes in preference to an existing source.

Mice appear to feed quite randomly, although it may be that a few feeding areas are more heavily exploited during the course of one night than others, but the sites of the more heavy feeding do vary from night to night. They are also not necessarily the closest to the harbourage.

Mice leave their harbourage, dash to a food source, take a small amount of food and then return to their harbourage. They repeat this sequence many times during the course of a night, frequently going to different food sources. If available, they may visit 20–30 different sources in one night.

If only one food source is available they may visit it up to 200 times during the night. For all practical purposes mouse feeding can be said to be totally unpredictable.

Thus baiting strategies against mice should always involve large numbers of baits – although it is not necessary to have large quantities of bait at each point. Sometimes only one wheat grain may be taken from a particular source.

Also, when moving, mice prefer to keep contact with a solid object for security so baits should invariably be placed against solid objects eg at wall/floor junctions.

A recent phenomenon occurring in small areas centred on Birmingham and parts of London has been noted in mice. They refuse to eat all the foodstuffs, particularly cereals, poisoned or otherwise, which are normally associated with mouse diets. Control by baiting was impossible until it was discovered what food they will eat. The foods involved were almost ignored by "normal" mouse populations. The phenomenon has been named "behavioural resistance" and is thought to have a genetic basis. Further work is being carried out to clarify the situation.

Rattus rattus (Black rat)

The feeding behaviour of black rats is intermediate to that of brown rats or mice. There is some evidence of a neophobic response but like mice they do tend to feed from many feeding points. However, they do not necessarily return to their harbourage between feeding bouts. Therefore large numbers of small baits should again be used. As black rats tend to be arboreal runways tend to be high up in buildings and baiting can prove difficult.

Even if the baiting is carried out perfectly if the active ingredient used is not satisfactory then failure will ensue.

RODENTICIDES

It is comparatively easy to find a suitable bait base for a rodenticide but the number of active ingredients is very limited.

Essentially they are restricted to the relatively slow acting anticoagulants, which cause death by internal haemorrhage and are by far the most widely used group. The others are a diverse group of compounds with differing modes of action which generally are less efficient than the anticoagulants.

Examples of anticoagulants are warfarin, coumatetralyl, bromadiolone, difenacoum, brodifacoum, flocoumafen and difethialone.

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Non-anticoagulants include alphachloralose, a mouse killer with a sedative and hypothermic action; calciferol which causes death by hypercalcaemia, ie the calcification of soft tissue. Bromethalin, which is not widely available and causes death by increasing cerebro-spinal fluid pressure and affecting the oxidative phosphorylation process. Perhaps the most widely used non-anticoagulant is zinc phosphide.

All of these latter compounds suffer from one problem or another. However, where resistance to the anticoagulants occurs, and this phenomenon appears to be increasing, there is no chemical option but to use these compounds in baits.

Types of bait include ground cereal (meal), broken cereal, whole cereals, "pastes" which usually contain cereal with fat and/or "waxes", pellets and blocks based on paraffin wax or similar. Concentrates, either liquid or meal based, are useful where ready-to-use baits are not readily being taken. The concentrate can be incorporated into foodstuffs the rodent is known to be eating.

The ideal rodenticide

A number of features have been suggested that would make for the ideal rodenticidal active ingredient.

1. It must be palatable to rodents.
2. It must be lethal in a 'normal' amount of food.
3. Symptom onset should be relatively slow to avoid bait shyness.
4. It should be specific to the target species.
5. There should be no difference in susceptibility to the compound due to variation in sex, age or strain.
6. There should be no secondary poisoning hazard.
7. Resistance should not develop.
8. There should be no danger to man and domestic animals (even when misused).
9. It should be easily degradable in the environment.
10. It should be easily formulated.
11. It must be "humane".
12. It should be cheap.

Unfortunately, the rodenticide that meets all these criteria does not, and is not likely to, exist. The closest are the anticoagulants, hence their widespread use.

Safety

The above list emphasises that active ingredients should be 'safe' to non-target species. In practice all existing rodenticides pose a potential risk to non-target species. They are all mammalian poisons and to a greater or lesser extent will affect any mammal which contacts them. Consequently the safe placement of baits is imperative and they should always be used in inaccessible locations. These days, more use is being made of tamper resistant bait stations to protect baits. It is unfortunate but occasionally the use of these bait stations can detract from the efficacy of a rodent control operation, for example it may take brown rats longer to start feeding because of their neophobic response.

Human taste deterrents such as denatonium benzoate can also be added to baits. At concentrations aversive to humans they are undetected by rodents. Unfortunately they do not deter domestic animals except at higher concentrations which are also detectable to rodents.

Bait attractants

There is little information available on the use of true attractants, i.e. attracting by odour, in baits and none are available commercially. However, a number of materials that when added to baits do seem to sometimes improve acceptance. These include various edible oils and sugar. However, on occasion these can also appear to detract from palatability. Obviously any oils or similar should be prevented from going rancid. Various proprietary formulations claim to include materials which increase take but do not always do so.

Liquid baits

Some rodenticidal active ingredients are amenable to being formulated as liquid baits. In dry conditions, these can be a useful, adjunct to conventional baits. Both rat species must drink water regularly whereas house mice can exist without liquid moisture if foodstuffs contain more than 14% water but they will drink readily when liquid is available.

The future of rodenticides

Owing to costs and the restraints of registration procedures throughout the world there is unlikely to be any new rodenticidal active ingredients in the foreseeable future. There will undoubtedly be improvements in formulations of existing baits and it may be possible to find and develop true attractants.

Perhaps sex pheromones could be utilised in some way to improve acceptance of baits. Alternatively an as yet unknown foodstuff or food extract may prove 'irresistible' to one or other species. Much more work is required in this area.

However, in reality, it is very likely that no major breakthrough in rodent control will be made in the short and medium terms. Should an efficient attractant be found at some stage then the effort to develop it will possibly concentrate on its use in non-chemical control methods eg live trapping. There is a growing lobby against the use of toxic chemicals and a growing demand for what are deemed more environmentally acceptable methods of pest control.

OTHER MAMMALS

Rats and mice are unquestionably the major urban vertebrate pests worldwide. However, in various parts of the world many other mammals, including stray dogs, cats, possums, raccoons, foxes, monkeys etc can be considered pests from time to time and place to place. In the Middle East, for instance, lumps of meat laced with sodium monofluoroacetate (1080), an extremely toxic compound, has been used to control stray dogs around slaughter houses on the edge of towns. This practice is not to be recommended for safety reasons!

In the UK the only mammals which might be considered urban or suburban pests for which baiting treatments *might* be appropriate are moles and squirrels.

Moles

Moles (*Talpa europaea*) can be pests of amenity lawns, golf courses, parks etc and are often difficult to control. They are very fastidious feeders. A major component of their diet is fresh earthworms which they meticulously clean before consuming. Baiting moles consists of dipping fresh earthworms into a highly toxic strychnine solution (the supply of which is very strictly controlled) which is absorbed onto the worm. The worms are dropped into mole runs where they are eaten. The cleaning process cannot remove the absorbed poison. Particulate active ingredients are easily removed and attempts to persuade moles to eat "artificial earthworms" or long dead worms have failed. Hence most mole control these days is carried out by fumigant tablets placed in runs.

Grey squirrels

Grey squirrels (*Sciurus carolinensis*) can be pests in urban and suburban areas particularly in roof voids and the like. Baiting techniques are similar to those used for brown rats and the same baits can be used, particularly those based on cereals. However, in the UK, there is some controversy about the legality of carrying out this operation. It does appear that in some circumstances despite squirrels not being mentioned on the label the use of certain rodenticides would be legal.

Baiting against all other mammals is illegal in the UK.

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BIRDS

The major pest species of birds in urban areas are pigeons (*Columba livia*), sparrows (*Passer domesticus*), and starlings (*Sturnus vulgaris*).

Management of these birds in many countries is strictly controlled by legislation. Usually only methods which are selective are allowed and frequently this simply means moving the birds on without actually harming them. Outright poisoning is invariably banned because of the risk to non-target protected species. However, stupefying baits, which sedate rather than kill the birds, are sometimes used against pigeons and sparrows. This operation can be carried out only with the appropriate licence under very strict control in the UK.

The technique is not allowed to be used against starlings as they are only in towns to roost at night. During the day they scatter far and wide into the countryside to feed.

For pigeons, mixtures of whole cereals and legumes are used as bait to which alphachloralose is added. This is laid before dawn at locations where the birds are known to feed. The birds are very hungry at this time and the idea is to get them to eat as much as possible in as short a time as possible. Birds become narcotised within 15–30 mins and are then collected and humanely destroyed. Pigeons exhibit 'resource partitioning' in their feeding behaviour hence the need to use a mixture of seeds as the bait base. Some birds will preferentially favour different seeds – hence the greater the variety the more chance of all the birds feeding.

Sparrows are sporadic feeders, darting from one feeding point to another and it is preferable to try to get them used to feeding at set points by pre-baiting before placing narcotised bait. Sparrow bait should be very fine and the alphachloralose well mixed in. Their eyesight is very good and they will become wary if the treated bait looks in any way different to the pre-bait.

Experimental attempts to bait Herring gulls have been carried out whilst they are sitting on eggs in the nest. Bread, treated with alphachloralose, is placed in the nest whilst the bird is sitting. This bird eats the bait, becomes stupefied, is collected and more treated bait left in the nest for the partner to feed on when it returns to the nest. This operation is potentially very expensive, time consuming and dangerous!

In other parts of the world baits containing alarm agents, particularly 4-aminopyridine, have been used against flocking birds. In theory one bird eats the bait, becomes very distressed and generates alarm amongst the rest of the flock causing them to move on. In practice, many birds, including protected species can eat the bait and a proportion are actually killed.

Other techniques involving bait incorporating chemosterilants have been carried out in a number of European cities against pigeons. In no case has the pigeon population been significantly reduced.

CONCLUSION

The use of baiting strategies against vertebrate pests is long established and the principle has changed little. It must be recognised that different techniques and possibly different baits should be used against the various rodent species. Baiting is not simply laying poisoned food and hoping the pest will feed on it. The animals' behaviour patterns must be exploited.

The use of toxic baits against other vertebrate pests, including birds, is limited, particularly by legislation but exactly the same principles apply.

"The greatest single factor in successful treatment of infestation . . . is the possession of skill in the operation of the disinfestation technique" (W M Gracie). This was written in 1955, but it is still valid today even with improved baits. In other words, *it is not what you use, but how you use it.*

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