TECHNICAL CONTRIBUTION

SUCCESSFUL GROUP HOUSING OF WILD-CAUGHT BRUSHTAIL POSSUMS *(TRICHOSURUS VULPECULA)*

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The common brushtail possum (Trichosurus vulpecula), *introduced from Australia about 150 years ago, has become a major pest threatening the native biota of New Zealand. It is also an important disease vector, acting as a wildlife reservoir of infection. Conventional methods of control have had little effect on reducing the national population, so there is a quest to find more effective and humane methods. This has led to an upsurge in research aimed at increasing our knowledge of the biology of this marsupial, with an attendant increase in requirements for access to colony-housed animals.*

Possums kept for research purposes have often been housed in individual cages, and several colonies have experienced high mortality rates. After capture, possums have shown inappetence, weight loss and a predisposition to infection, suggesting that this species is susceptible to post-capture stress. For our reproductive studies, research animals are only useful if maintained under conditions that ensure behavioural and physiological processes remain normal. We have adopted an 'animal husbandry' approach for our possum colony, where social interaction and the ability to exhibit instinctive behaviour patterns are considered as important as adequate nutrition and housing.

In this colony, group-housed possums show no signs of post-capture stress, and mortality rate has been less than one per cent (of > 600 animals housed to date). Virtually all possums gain weight over the first month of captivity. Procedures for monitoring, handling and the collection of data from these animals, are carried out with little apparent stress to either animals or staff.

Keywords: *animal welfare, brushtail possum, group housing, social well-being, stress*

Introduction

The common brushtail possum *(Trichosurus vulpecula,* Marsupialia) was introduced to New Zealand from its native Australia in the 1830s, for the sole purpose of establishing a fur industry (Pracy 1974). A number of liberations were necessary to overcome the initial introduction problems, but aided by legislative protection until the 1940s, the species eventually became established and it is now widespread throughout more than 90 per cent of the country. The possum is the major conservation pest of New Zealand, imposing a significant threat to native biota (O'Donnell 1994). An estimated 60–70 million animals consume approximately 21,000 tonnes of vegetation daily, causing extensive damage to

native and exotic forests, pasture, crops, orchards, vineyards and domestic gardens. A long-standing concern is that possums significantly reduce native bird populations (Leathwick *et al* 1983). Flowers of many native plants – important sources of nectar for honeyeater species of bird (Meliphagidae) – feature high on the possum's preferred diet. There is also increasing evidence of possum predation on birds' eggs, birds and mammals (Brown *et al* 1993). In addition, the possum is an important vector of several diseases, of which leptospirosis (Hathaway *et al* 1978) and bovine tuberculosis (Ekdahl *et al* 1970) are the most important. The possum is now considered to be a major wildlife reservoir of *Mycobacterium bovis* (Livingstone 1991).

Current methods of controlling possums include shooting and trapping, and the use of poisons. These are effective in reducing populations within discrete areas, often eliminating more than 90 per cent of the animals present. However, the effect is short-lived as repopulation, by migration from surrounding areas and from increased reproductive success that results from decreased competition, is rapid (Little & Cowan 1992). Although a sustainable reduction in the national population of possums may be technically possible with these conventional methods of control, economically this is impractical (Hartford 1994). In addition, there is also public disquiet at the killing of vertebrate pests, the lack of specificity of poisons and their impacts on non-target species. There are increasing demands for more humane methods of possum control. The two alternative approaches to controlling a pest species are to increase mortality rates (which all traditional methods target) or to decrease reproductive rates. Controlling possum populations by suppressing their reproductive rate is likely to be more effective and more humane. Consequently, current research efforts are aimed at inhibiting reproduction in this species. A number of control methods have been suggested, from the use of baits containing compounds that impair reproduction to speculation on the possible use of immunocontraception mediated by viral vectors (Jolly 1993; Tyndale-Biscoe 1994). This search for new reproductive technologies has highlighted a current poor knowledge base of the physiology of this species. Several research groups are currently investigating reproductive processes in the possum, but this is sometimes hampered by lack of access to suitable research animals. In the past, possums kept for research purposes have often been housed in individual cages, and several colonies have experienced high animal mortality rates. Newly-captured possums often lose weight over the first few weeks of captivity (Presidente 1984; Buddle *et al* 1992), and in some colonies many animals die over the immediate post-capture period. For these reasons, an adaptation period of several weeks has been recommended before animals are used in experimental studies (Buddle *et al* 1992; Jolly *et al* 1995). In reproductive studies, it is imperative that physiological processes and animal behaviour are not compromised as a result of captivity.

We have recently extended our own reproductive research programme to include the study of possums. As our background is with farm animals, we have adopted a strategy that is somewhat different from many earlier approaches. Rather than attempting to adapt the possum to serve as a laboratory animal by imposing restrictions in its housing and care, we have taken an 'animal husbandry' approach – attempting to define the basic requirements of the animal and develop a housing system to ensure that these are satisfied. We have tried not to limit this to simply providing for the physical needs of the animal (basic nutritional and housing requirements), but have put considerable emphasis on its social and psychological well-being.

Social and feeding behaviour of the brushtail possum

The possum is a nocturnal, predominantly arboreal marsupial with strong claws and a prehensile tail. It has a mature body weight ranging from 1.4 to 6.4kg (Fraser 1979) and there is little difference in size or weight between the sexes (Green & Coleman 1984). It is considered that possums are largely solitary animals with no strong pair bonding or social grouping (Cowan 1990a). In general, they do not defend exclusive territories although dominant animals may exclude intruders (Triggs 1982). In New Zealand, possums occupy a wide and diverse range of habitats, including indigenous forests and grasslands, exotic forests, shelter belts, scrublands, orchards, crops and urban areas (Cowan 1990a). Forests are the major habitat, but the forest/pasture interface often supports very dense populations. The possum tolerates an annual rainfall ranging from 350mm to >8000mm, and altitudes ranging from sea level to 2400m.

Typically, possums emerge from their dens shortly after sunset and return just before dawn in summer, or several hours earlier in winter. Of the total time out of the den, perhaps 45 per cent is spent sitting or otherwise inactive (MacLennan 1984). Little time is spent on active social interaction, except during the breeding season (Winter 1976). They generally feed for one to two hours each night, often at several different sites and in two or three sessions (MacLennan 1984).

Possums are selective browsers, showing clear preferences for the leaves of particular native plants (Gilmore 1967; Fitzgerald 1976) and supplementing their diet with large quantities of fruits of native and exotic trees and shrubs (Cowan 1990b). Although they feed mainly on leaves, possums are best described as opportunistic herbivores, as buds, flowers, fruits, ferns, bark, fungi, grasses, herbs, sedges and invertebrates can make up a major part of their diet. There is an extremely wide variation in the foods that possums will eat, but at any one time their diet concentrates on only a few plant species, determined by availability in that location at that time (Cowan 1990a).

During daylight hours possums seek the refuge of a 'den' or nesting site. These are usually in hollow tree-limbs or tree-trunks, in clumps of vines, flax, gorse or toe-toe (*Cortaderia* sp.), at the base of hollow trees, under logs, in burrows of other animals, and in ceilings, sheds, haystacks or woodpiles. Availability can influence the type of den chosen. For example, in the Orongorongo Valley (Wellington) more than 95 per cent of nests were found to be above ground (Cowan 1990a), whereas on Mt Bryan O'Lynn (Westland) where few similar sites were available, more than 70 per cent were under logs or roots of trees (Green & Coleman 1987). Possums generally use more than one den over a given time period, but none appear to be exclusive to only one possum. Although occupied dens are usually defended against other possums (Cowan 1990a), den sharing is not uncommon (Fairweather *et al* 1987).

Individual recognition is based primarily on smell and secondarily on vision (Biggins 1984). Possums are well-endowed with scent glands and a number of scent-marking activities on branches and bases of trees have been observed. They also spend considerable time washing and grooming their fur with saliva which is a probable source of important olfactory signals (Biggins 1984).

Stress in the brushtail possum

Clinical signs of stress in captive possums are listed as depression, inappetence, and acute diarrhoea often resulting in rapid dehydration and death (Hope 1971; Presidente & Correa 1981; Morgan & Peters 1982). In addition, the manifestation of disease in wild-caught animals may largely be a consequence of the stress associated with capture, and adjustment to an 'unnatural' environment (Presidente 1984). The introduction of new animals to established groups, and overcrowding, have also been identified as major sources of captive stress (Peters 1979; Presidente 1984). Stress-related mortality is not always as a direct result of the effects of diarrhoea and dehydration, but may also occur indirectly, through a suppressed immunological response to infection. Changes observed in haematological values and in lymphocyte responses in stressed possums are associated with a depression in immunological competence (Buddle *et al* 1992).

Stress in experimental animals is of importance not only because of increased susceptibility to disease, but also because it may alter their physiology (Griffin 1989). This is of particular importance in studies of reproductive processes, where stress is known to disrupt the oestrous cycle, alter sexual behaviour, disrupt hormonal secretion, impair foetal development and inhibit lactation (Christian 1980). Therefore, we have endeavoured to establish a possum colony in which post-capture stress is minimized.

The Invermay possum facility

Our policy is to house all possums in groups. The animals are housed in large, wiremesh-covered pens, approximately 2.2m in height, and with plan dimensions that vary from approximately 2x4m to 4x7m. The pens are indoors or fully enclosed and are maintained at ambient temperature and lighting. Possums are never housed in 'bare' pens, but are introduced only after 'furnishing' is complete. All additions to a pen are made with the single aim of satisfying specific requirements of the possum.

For security, possums seek height. Therefore, a continuous 'runway' is fixed to the inside perimeter of the pen, approximately 0.5m from the top of the pen. Although the runway is relatively close to the ground, it allows individual animals to gain height advantage over (or at least parity with) their pen mates. It also enables animals to move around the pen with ease. The most important component of each runway is that possible 'escape' routes are always near at hand, in the form of either permanent ramps or tree-trunks that link the runway with the floor, or via branches that are periodically secured to it. This means that individual possums always have an escape path when they encounter other animals on the runway. In the wild, possums follow a specific route from their den site when foraging, establishing visible tracks in pasture and forest (Green & Coleman 1986). Thus, the runway system provides a permanent, familiar route for animals to traverse their pen. It also provides the security of height, an escape path from other animals, and a suitable site for periods of inactivity and grooming. For the latter activities, runways are set at a sufficient distance below the top of the pen that allows animals to sit or stand fully upright.

A further priority in satisfying the needs of the animal is food. Although the nutritional requirements of the possum are a prime consideration, of equal importance is that each individual can access food without the imposition of additional stress. It is crucial that animals do not need to 'run the gauntlet' of dominant pen mates in order to feed. For this

reason, each pen has several feed sites and all components of the diet are fed ad libitum. A mixed diet of fresh fruit and bread is supplied at two to five sites in each pen. In addition, cereal-based pellets (specially formulated, low-calcium possum pellets; Archers Stock Feed, Rangiora, New Zealand) are provided via self-feed dispensers. Several of these (5–10) are fixed in permanent sites at different heights throughout each pen. Fresh water is always available and easily accessible.

One of the most important additions to the pens is the provision of *Pinus radiata* foliage. Several fresh branches are provided in each pen, and these are replaced at approximately seven-day intervals. There are a number of reasons for providing foliage. The branches are firmly attached (by wire) to the runways, thus providing additional escape routes. They also provide thick cover, giving animals the ability to conceal themselves. In addition, the branches are a source of browse, and one that possums find attractive. The availability of browse not only provides an alternative food source, but the activity of browsing itself probably fulfils an innate requirement for this species.

In the provision of nesting sites the main criteria are that the type of nest provided, and its location, are likely to be consistent with the choices of possums in the wild. Of equal importance is that the use of these nests does not lead to unavoidable confrontation between animals. Hessian sacks hung from runways are the main type of nest provided. These have now been selected as the primary type of nest, as they are preferred by most possums. Solid wooden nest-boxes (25x25x20cm), placed either on the floor or attached at various heights throughout the pen, are also provided as some individuals consistently prefer this type of nest. The number of nest sites provided always exceeds the number of animals in the pen.

In our facility, possums are routinely housed as single-sex groups. This limitation is often imposed by the requirements of our research programme in which reproductive status must be known and is often manipulated. However, groups of females are often housed adjacent to groups of males, so some interaction between sexes is possible. Preliminary captive breeding programmes have been successfully undertaken.

Animal collection and routine monitoring

Possums are captured locally, with the use of wire-sided box traps. All traps are checked early each morning, and captured animals are transferred immediately to a hessian sack, as in its darkened interior possums quickly become calm. After transfer to Invermay, each animal is checked while under halothane-induced anaesthesia (Fluothane: ICI, Lower Hutt, New Zealand) administered by inhalation while the possum remains in the hessian sack. Prior to introduction to the facility, all animals are subjected to intensive screening to identify any injured or diseased individuals. Screening involves a general examination for lesions, abscesses or injury, with emphasis on palpation of lymph nodes. Animals with any indications of injury or infection, and those in poor body condition are euthanased immediately by intra-cardiac administration of barbiturate (Euthal: Delta Veterinary Laboratories Pty Ltd, Hornsby, NSW, Australia). All of these animals are sent for post-mortem examination. Possums that are considered to be healthy are ear-tagged to enable individuals to be recognized, and are given a prophylactic dose of antibiotic (Strepolin: Pitman-Moore Animal Health Ltd, Palmerston North, New Zealand) to eliminate potential leptospirosis infection (Hathaway *et al* 1978). Finally, the possum is weighed, the age of pouch young (if present) is recorded and the animal is transferred in the same hessian sack

(which now serves as a nest) to a pen. Animals captured at the same site are usually housed together in the same pen (see below for further detail). Group sizes range from 5 to 20 animals, with an average density of one possum per $4m^3$. Depending on requirements for experimentation, animals are resident in the facility for periods ranging from five weeks to five months. At completion of experimentation, all animals are euthanased by intra-cardiac injection of barbiturate (Euthal).

All animals are weighed at regular intervals (1–3 weeks), as an indirect measure of health and adaptation to captivity, and checked for signs of injuries indicative of fighting. Pens containing newly-captured possums are closely monitored. The amount of fruit and pellets consumed, the nesting sites in use and the rate of consumption of browse are noted. Any individuals not adapting to that pen or that group of animals are easily identifiable. Routine monitoring of animals (checking the general health of individuals, the presence, age or health of pouch young, individuals that are nest sharing etc) is carried out by careful manipulation of the sacks. Animals that nest in wooden boxes are transferred to sacks prior to handling. Animals remain quiet during these procedures and anaesthesia is not required.

Animal health and behaviour

Without exception, animals do not suffer an extended period of weight loss following introduction into the pens. Some possums do lose weight in the first week of captivity, but by two weeks this has usually been regained and thereafter they continue to gain weight. A 20 per cent increase in body weight within one month is not unusual. Many animals gain weight from the time of introduction, even though they were in good condition at the time of capture, and presumably had access to abundant food supplies in the wild. There is no evidence of the three or four-week period of adaptation to captivity that has been reported by others (Buddle *et al* 1992; Jolly *et al* 1995). Mortality rate of animals in this facility is less than one per cent, with over 600 possums having been housed to date.

As part of assessing responses to captivity, a number of animal behaviour parameters are monitored, during both routine (daytime) maintenance of the colony and during periodic night-time observations (manual and video recorded). Even when animals have been captured from different areas, or introduced to the pen at different times, a group hierarchy is quickly established and all animals appear to thrive. Although it was anticipated that such mixing of animals may lead to excessive aggression, this is not the case. The most obvious, and most regularly observed between-animal interaction is vocalization. This is routinely noted at encounters on the runway and when an 'intruder' attempts to inhabit an already occupied nest. The outcome is almost always retreat by one of the parties – fighting has never been observed and there is very little evidence of conflict (loose fur, bites or scratches are seldom observed).

Nest sharing is common. Particularly when a newly-captured group of animals is established in a pen, it is not unusual for one sack to be occupied by several (up to seven have been observed) possums. As the group becomes established, sharing usually involves only two or three animals per nest. However, the complete absence of any nest sharing in a pen is very rare.

Routine and regular observation consistently identifies a wide range of 'personalities' in individual wild-caught possums. Some animals show great curiosity. These possums will advance towards staff whenever they enter the pen, and take food from the hand, even within

the first few days after capture. Others will remain wary, often for several months of captivity. Such differences are apparent when animals are checked within the hessian sacks, with some individuals allowing close handling by staff. Others will always vocalize and adopt a defensive posture. At least some possums become accustomed to humans. For example, during hot weather, some animals sleep in the open on runways. When staff enter these pens for routine cleaning and feeding, their presence is noted but often ignored.

The effectiveness of our procedures for assessing the health of our group-housed animals has been emphasized by the discovery of a previously unknown disease of the brushtail possum (coined 'Wobbly Possum Syndrome', Mackintosh *et al* 1995). Screening of newly-captured possums has identified one animal with bovine tuberculosis.

Animals from this colony have been used in numerous studies of reproductive physiology, employing techniques such as hormonal treatments for oestrus synchrony, blood sampling and minor surgical procedures. There is no evidence that reproductive processes, or the response to treatments, differ between newly-caught animals and those that have been in captivity for several weeks. In studies using non-hormonal methods to synchronize oestrus, more than 92 per cent (36/39) of females have cycled normally (ovulation recorded at laparoscopy). All procedures, including the maintenance of the colony, are carried out with approval of the AgResearch Invermay Animal Ethics Committee, under the *Amendment to the Animals Protection Act 'Codes of Ethical Conduct' 1987* (Amendment 1987).

Conclusions

The level of success in maintaining wild-caught animals in apparent good health and with little indication of stress (even in the immediate post-capture period) in our colony has seldom been achieved with the brushtail possum. We suggest that this is not simply due to the use of pen housing rather than individual cages, as a high incidence of post-capture stress has been reported when possums are held in very large (8–16m^2) but relatively bare pens (Jolly *et al* 1995). Although the pens used in our colony are considerably smaller, and the numbers of animals held much greater, post-capture stress and death seldom occur. We suggest that 'enrichment' of pens – not for our own aesthetic reasons, but to enable the possum to express its *telos* (the characteristics of 'being' a possum, Rollin 1992) – is the key to this success. There is a great deal of information available regarding the biology of the possum in the wild. We should be making more use of this in our attempts to maintain captive populations of the species.

With our housing system, animal-to-animal interaction certainly results in a degree of confrontation, often expressed by loud and persistent vocalization. However, these affrays seldom, if ever, progress beyond the vocalization stage. As such animal-to-animal encounters would frequently occur in the wild, they may well contribute to 'normal' life and well-being of the possum and therefore, contribute to the success of this housing system. We would suggest that in our facility we attempt to simulate, as far as is possible, the biology of the animal in the wild. This provides the opportunity for the possums to express the 'five basic freedoms' listed in MAFF (UK) Animal Welfare Codes (see Broom & Johnson 1993). The five freedoms are: freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury or disease; freedom to express normal behaviour; and freedom from fear and distress. For colonies housing wild-caught animals, the freedom to express normal behaviour is often overlooked.

Animal welfare implications

Humane care is best defined as maintaining husbandry procedures that are in keeping with the traits which are species-specific to the animal concerned. In terms of agricultural farming systems, it has been suggested that the approach should be to 'fit the farm to the animals rather than fitting the animals to the farm' (Kilgour 1978). This is the approach that we have sought to follow for the possum.

In many instances, standards for laboratory animal care are limited to the animals' physical requirements, sometimes even to the exclusion of their social and behavioural needs. When this is true, concepts usually associated with 'factory farming' ('the rigid suppression of the natural', Harrison 1977) may equally well be attributed to research animal colonies. Despite the obvious restrictions of the pen size, we endeavour to provide an environment that will allow the possum to express all of its natural behaviours. We believe the apparent lack of stress in our colony is a direct result of following this policy.

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