

Predation on house sparrows (*Passer domesticus*) and hedge sparrows (*Prunella modularis*) by brushtail possums (*Trichosurus vulpecula*) in captivity

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Abstract The incidence of predation on house sparrows (*Passer domesticus*) and hedge sparrows (*Prunella modularis*) by captive brushtail possums (*Trichosurus vulpecula*), and the bird tissues consumed following predation, were recorded over 26 weeks in a facility where possums were housed in single sex groups. A total of 44 sparrow carcasses was recovered; on average 1.7 birds were killed week⁻¹ (range 0–9 sparrows week⁻¹) in pens that each housed 8–12 possums. Tissue was eaten from fewer than half (48 %) of the birds killed. There were no significant differences in the incidences with which different tissues (brain, breast, legs, or viscera) were eaten. This study corroborates observations of bird predation by possums in the wild. Importantly, it shows that a high proportion of birds killed by possums are not eaten.

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INTRODUCTION

The brushtail possum (*Trichosurus vulpecula*), although often described as a folivore or herbivore, is best classified as an opportunistic omnivore. Possums in New Zealand are known to include a range of invertebrates in their diet (Fitzgerald & Wardle, 1979; Cowan & Moeed, 1987) and predation of small vertebrates including birds (Morgan 1981; Brown *et al.* 1993), mice (Cowan 1990), and several species of snail (cited in Sadlier 2000) ranging from the small carnivorous snail (*Wainuia urnula*) to large land snails (*Powelliphanta* spp.) have been recorded. There are reports of possums feeding off carrion (Thomas *et al.* 1993), of being caught in ferret traps baited with meat (Caley 1998), and of captive animals readily accepting meat (Cowan 1990). Collectively, these reports indicate that non-plant tissue may be an important component of, or at least a common supplement to, the brushtail possum diet. Furthermore, we have recently found that the concentrations of the corticosteroid hormone aldosterone in plasma, and the ratio of Na to K ions in urine, of newly-captured possums are both indicative of

animals on a moderate to high Na intake typical of an omnivorous diet, not the low Na intake that is characteristic of herbivorous diets (Butt *et al.* 2002).

Possums are arboreal and nocturnal so birds that are nesting or roosting in trees at night could provide an easily obtainable source of food. There is anecdotal evidence that possums prey on or scavenge a variety of bird species, including eggs, nestlings and fledglings of North Island kokako (*Callaeas cinerea wilsoni*), greenfinch (*Carduelis chloris*), Australasian harrier (*Circus approximans*), blackbird (*Turdus merula*), song thrush (*Turdus philomelos*), and Westland black petrel (*Procellaria westlandica*) (Brown *et al.* 1993). Direct evidence, including some video tape of possums preying on several native bird species including kokako, New Zealand pigeon (*Hemiphaga novaeseelandiae*), and North Island kiwi (*Apteryx australis mantelli*) has been summarised by Sadlier (2000).

Morgan (1981) first described an eyewitness report of a captive possum killing a house sparrow (*Passer domesticus*) and eating parts of its head and breast. More recently, Brown *et al.* (1993) offered carcasses of greenfinch, blackbird, goldfinch (*Carduelis carduelis*) and starling (*Sturnis vulgaris*) to 2 captive

possums held individually in small cages. One possum (male) ate tissue from all 4 birds offered. The other possum (female) did not eat the 1 bird offered. In a 2nd trial, 2 dead day-old domestic chickens (*Gallus gallus*) were offered to each of 40 individually-caged possums on 2 separate occasions (Brown *et al.* 1996). The chickens were at least partially eaten on 18% of the times offered.

In our possum facility (AgResearch Invermay, Mosgiel) the food fed to possums, especially bread, attracts sparrows that are able to gain access to the possum pens through small gaps between doors and walls. Unable or disinclined to find exit points, some sparrows remain in the pens overnight. Under these confined conditions, it is likely that birds would be vulnerable to predation by the captive possums. Over the past 3 years, we have found (on average) the remains of 1 or more sparrows each week in these possum pens. Some of the sparrow carcasses recovered had no outward signs of interference. The remaining birds showed wide variation in the extent of damage by possums. Some carcasses were wet with saliva and appeared to have been chewed, but were otherwise intact. Others had been eaten. In these birds, carcass damage ranged from removal of brain tissue or the whole head, of breast or leg tissue, of the bird being eviscerated, or the bird had been almost totally devoured, with only wing feathers and feet remaining. The variation in carcass damage observed raises the possibility that individual possums may prefer different parts of the sparrow carcass, or vary in their ability to gain access to specific tissues. For example, in a proportion of those sparrows whose carcasses had been damaged, only the brain tissue or head had been eaten. In some instances, the cranium had been opened with precision and remained attached by a skin flap, although the brain tissue had been removed. In others, the whole head, or the entire head except the beak, had been removed (Plate 5, p. 133). In the present study, we recorded the incidence of predation on sparrows, and the tissues of these birds that had been eaten, by examining the carcasses of sparrows killed by captive possums in our facility over a 6-month (26-week) period.

MATERIALS AND METHODS

The Invermay Possum Facility

For research programmes investigating possum reproductive physiology as well as the development of strategies for delivering potential biocontrol agents via the oral route, brushtail possums were housed routinely in high-density, single-sex groups (typically 6-15 possums pen⁻¹, c.1 possum 1.5-2.5 m²) in large, wire-mesh-covered pens. Each pen always contained fresh *Pinus radiata* branches provided for browse and the animals were fed cereal-based pellets (low Ca possum pellets; Archers Stock Feed, Rangiora), fruit,

bread, and fresh water, all *ad libitum*. Under these management conditions, newly captured possums showed no signs of post-capture stress, gained weight from the time of capture and the mortality rate in the colony was < 1% (McLeod *et al.* 1997).

Most research projects involved short-term experiments that invariably concluded with the collection of tissue from the experimental animals following euthanasia. Consequently, with few exceptions, individual possums were resident in the colony for only short periods (days, weeks) and the composition of the population of captive possums in the facility was changing continually.

The capture and housing of possums, and all experimental procedures performed, were approved by the AgResearch Invermay Animals Ethics Committee according to the 1987 Animals Protection (Codes of Ethical Conduct) Regulations.

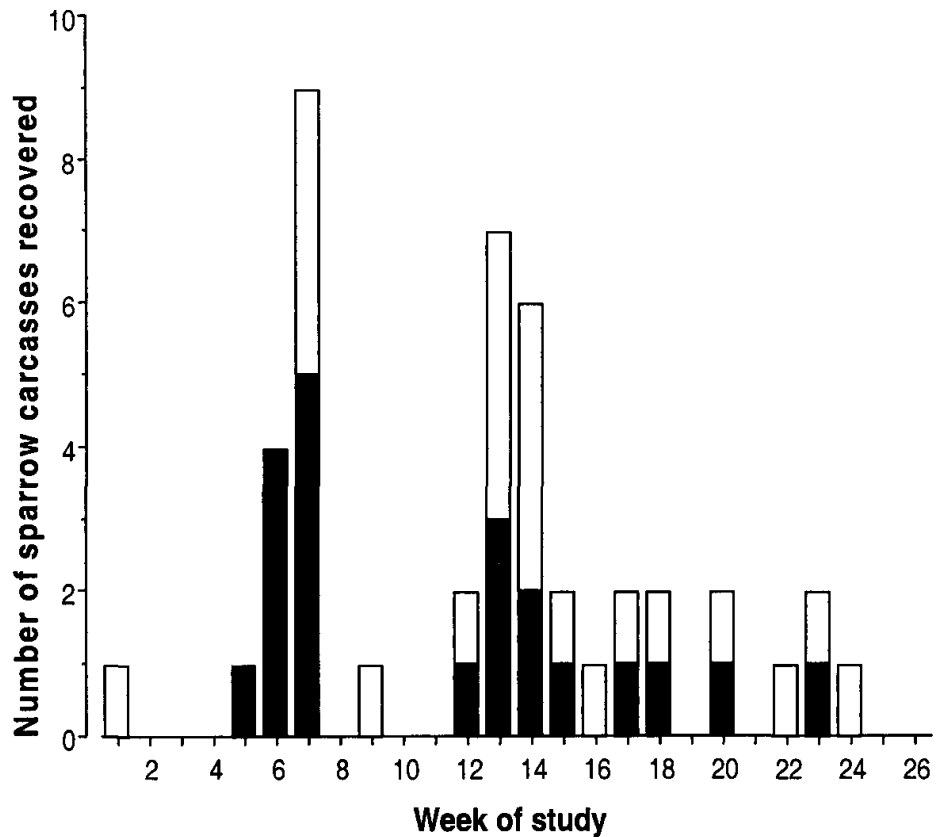
Monitoring predation on sparrows

To investigate predation on sparrows by captive possums, and their preferences for eating different tissues from the birds they killed, we examined all bird carcasses found in 10 possum pens over a 26-week period (October–April). These pens formed a covered 'outdoor' complex with 4 large pens (Pens 1-4, c. 4.0 × 3.5 × 3.0 m) separated from 6 smaller pens (Pens 5-10, c. 3.0 × 2.5 × 2.5 m) by a central passageway (1.5 × 13.5 × 2.5 m). The exterior walls of pens 1-4 were covered in netting, whereas those of pens 5-10 had solid exterior walls. Birds were able to gain access to the central passageway, and from the central passageway to all pens through gaps between doors and adjacent walls. In addition, birds could enter pens 1-4 directly, through shallow drains at floor level.

All pens were briefly inspected for sparrow carcasses on each weekday, and inspected carefully during routine twice-weekly (Tuesday and Friday) cleaning of the possum pens. Cleaning involved collecting all faeces, food remnants, and pine needles from the floor, running boards (McLeod *et al.* 1997) ledges, and nesting boxes in each pen by hand shovel and brush, before washing down with a hose. The thorough cleaning allowed even the smallest bird remains such as the wing tips and wing feathers, to be identified and collected and also for the pens to be inspected for faecal evidence of any rodent or mustelids.

The following details of bird carcasses were recorded: (i) date and pen in which the carcass was found; (ii) species, sex, and age (juvenile or adult) of bird; (iii) numbers and sex of possums in that pen; (iv) appearance of the carcass - either that there were no gross indications of damage, that it had been 'mouthed and chewed' and was covered in saliva, or that it had been partially eaten; and (v)

Fig. 1 Total numbers of house sparrow (*Passer domesticus*) and hedge sparrow (*Prunella modularis*) carcasses recovered (open bar), and the number of carcasses that had been eaten (filled bar) over a 26-week period.



for birds that had been eaten, details of the tissues removed.

Possoms in pens 1-10 over the 26-week study period included a total of 164 adult possums (99 males, 65 females). With the exception of 3 vasectomised males that were in residence throughout the study, all possums were present in these pens for less than the study period (1 day - 16 weeks).

Statistical analyses

Difference in the frequencies of sparrow predation among pens and between male and female possums, and among regions of the sparrow carcass that had been eaten, were tested using χ^2 tests.

RESULTS

Sparrows killed

Over 26 weeks, a total of 44 bird carcasses was recovered (42 house sparrows: 20 males, 22 females) and 2 hedge sparrows (*Prunella modularis*, 1 male, 1 female). From October to mid-December only 1 of 10 birds killed was a juvenile, but between mid-December and the end of the study (early April), more than 80% of 34 birds killed were juvenile.

Sparrow carcasses were recovered from all except 1 of the pens monitored. The single pen from which no sparrow carcasses were recovered (Pen 7), housed the 3 vasectomised male possums.

These animals were long-term residents (> 4 years in captivity) and were obese (all > 5 kg). Of the 44 birds killed, 31 were recovered from pens 1-4 in which only female possums were housed, and 13 were recovered from pens 5, 6 and 8-10 that housed either female (6 bird carcasses recovered) or male (7 bird carcasses recovered) possums, exclusively. There was no correlation between the numbers of possums housed in a pen ($\chi^2 = 3.42$, $df = 9$, $P > 0.25$), or between time of year ($\chi^2 = 7.26$, $df = 3$, $P > 0.05$), and the number of sparrow carcasses recovered. No carcasses were recovered in 9 of the 26 weeks and in other weeks the number of sparrows killed each week was 1-9.

Carcass damage

The total number of sparrows killed in each week of the study, and the number of carcasses that had been eaten, are shown in Fig. 1. Fewer than half (48%) of the birds killed had been eaten, although 8 of 23 that had not been eaten had had their skull crushed.

The tissues eaten from each of the sparrows killed are shown in Table 1. There were no significant differences between the regions of the carcass that had been eaten, with tissue being removed from the brain, head, breast, legs and viscera from 9, 8, 11, 12, and 11 birds, respectively ($\chi^2 = 1.04$, $df = 4$, $P > 0.25$). In 6 birds, all of these tissues had been eaten. In 1 bird from which brain tissue had been eaten, the cranium had been opened and remained attached by a flap of skin.

Table 1 Carcass damage to house sparrows (*Passer domesticus*) from which tissues were eaten, for each of the bird carcasses recovered over a 26-week period of recording.

| Bird | Tissue eaten | | | | | | Notes |
|------|--------------|------|--------|------|---------|-------|-------------------------------------|
| | Brain | Head | Breast | Legs | Viscera | Other | |
| 1 | √ | √ | √ | √ | √ | | only wings remain |
| 2 | √ | √ | √ | √ | √ | | only wings remain |
| 3 | | | √ | √ | √ | | completely defleshed, head intact |
| 4 | √ | √ | √ | √ | √ | | only wings remain |
| 5 | √ | √ | √ | √ | √ | | only wings remain |
| 6 | | | | √ | | | one leg eaten |
| 7 | √ | √ | √ | | √ | | only legs and wings remain |
| 8 | √ | √ | √ | √ | √ | | only wings remain |
| 9 | | | √ | √ | √ | | wings remain, head intact |
| 10 | | | √ | | | | entire carcass mouthed/saliva |
| 11 | | | | √ | | | head crushed, brain intact |
| 12 | | | | | √ | | chewed around cloaca |
| 13 | √ | √ | √ | √ | √ | | completely defleshed |
| 14 | √ | | | | | | back of skull missing |
| 15 | √ | √ | | | | | back of skull missing |
| 16 | | | | | | √ | back chewed open |
| 17 | | | | √ | | | eaten around cloaca |
| 18 | | | | | | √ | head crushed, wing eaten |
| 19 | | | √ | | | | breast completely defleshed |
| 20 | | | | √ | | | head crushed, little tissue removed |
| 21 | | | | | √ | | viscera removed through back |

DISCUSSION

In the Invermay possum facility, predation on sparrows was common. In the complex of 10 possum pens that housed 40-80 possums as single-sex groups at any given time, on average 1.7 sparrow carcasses were recovered each week. Possums ate tissue from < 50% of these birds. This may simply have been a reflection of the very easy access to large quantities of a variety of foodstuffs made available to these captive animals, as most possums gained weight from the time of their capture, with long-term inhabitants frequently increasing body weight by more than 33%. Underfed possums may kill more birds, or may eat more of the carcass of the birds they kill. We believe that it is unlikely that either rats, ferrets, or stoats, rather than possums, killed the birds in this study. All pens were inspected closely twice-weekly for faeces of these animals and none was ever seen.

Our research programmes dictated that individual possums were resident in the colony usually for only short periods of days or weeks and that the

population of captive possums was continually changing. Despite the systematic removal and replacement of possums in this colony, predation of sparrows continued throughout the study period. This suggests that a high proportion of wild-caught possums have learned or inherited the skills required for predation on birds. For example, the wide interval between the times of collection of each of the 3 sparrow carcasses shown in Plate 5, exclude the possibility of the same possum being involved in the predation of more than 1 of the birds.

The description of interference with day-old chick carcasses fed to captive possums in the study of Brown *et al.* (1996) closely paralleled our findings with sparrows. In that study, some carcasses were wet with saliva but were otherwise intact, and others had been partially eaten, with breast, leg, or brain tissue missing. Of particular note is that some chickens were eaten completely, leaving no remains. Hence, it is possible that some sparrows may also have been totally consumed in our studies, and the recorded incidence of predation was underestimated.

A major shortcoming of the study is that the number of birds in the possum facility was not controlled, which meant that we could not quantify the incidence of sparrow predation (percentage of birds present that were killed).

Most birds were killed in pens that housed female possums only. However, more pens housed females than males, and female possums were resident in the colony for longer than males. Furthermore, only female possums were kept in pens 1-4, which were larger than other pens (and therefore contained more possums) and had more access points for birds.

The prevalence of possums eating brain tissue from birds in the present study (43% of birds eaten had brain tissue removed) parallels earlier reports in relation to both predation on birds (Morgan 1981) and the feeding of dead bird carcasses to captive possums (Brown *et al.* 1993, 1996). Furthermore, 20 of 44 sparrows killed either had brain tissue removed or their skull crushed, raising the possibility that possums may prefer brain tissue. Dietary preferences have been reported for many mammalian species. For example, within outbred colonies of rats, some sub-populations exhibit inherent preferences for fat over carbohydrate (Cook *et al.* 1997). However, the present study failed to show that possums preferred brain, or for any other tissue.

Many questions remain to be answered on the impact of brushtail possums on bird populations in New Zealand. Of importance is the proportion of possums that do kill birds and the ability that possums have in capturing birds in the wild, compared with that we have observed in the confines of a captive-possum facility. Animal tissue may be a common supplement to the possum's diet. Other members of the Phalangeridae are carnivorous (Wroe 1999). Although there have been many studies of brushtail possums' diets, the consumption of only soft tissues of birds would leave little or no evidence in scats or stomach contents. Immunological or DNA studies would be needed to test for the presence of meat in the diet of wild possums. Our own studies on fluid and ion balance in the gut, indicates that brushtail possums in New Zealand have a moderate to high Na intake, not the low Na intake typically associated with folivores or herbivores.

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