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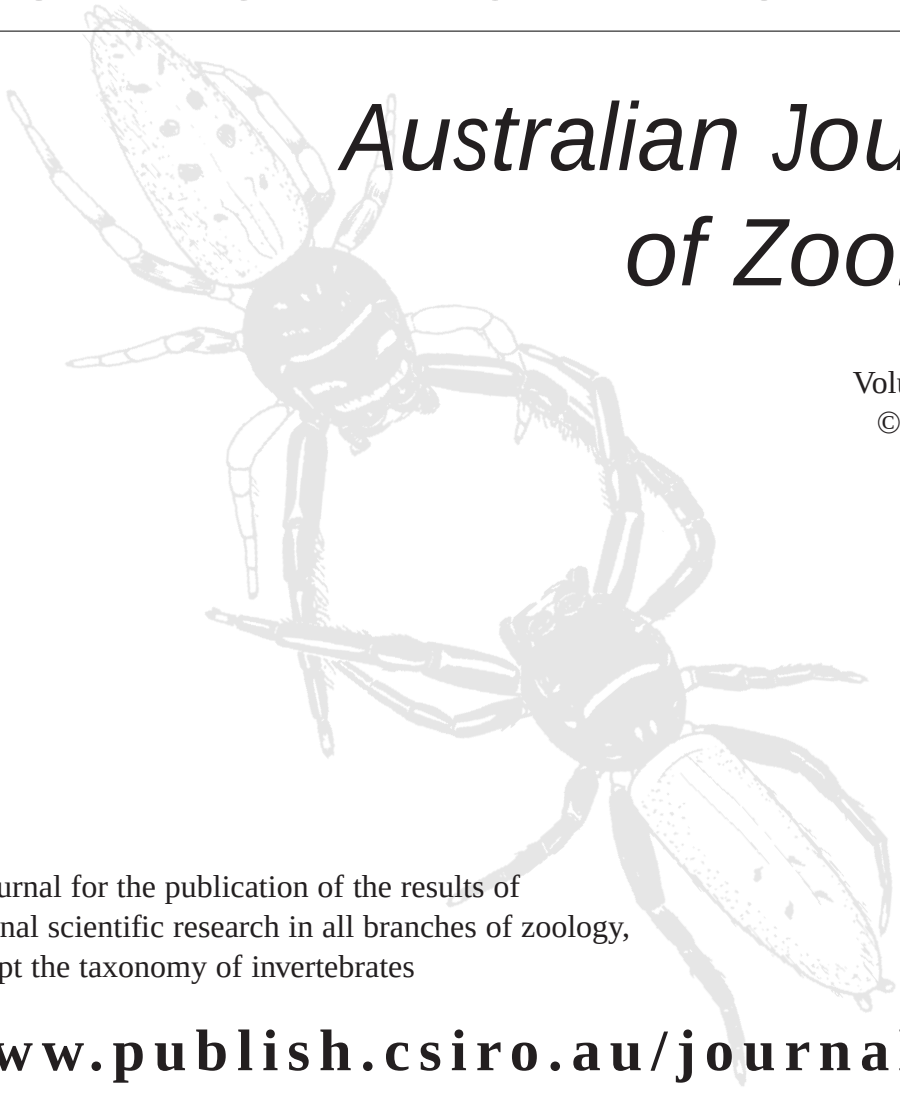

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Possums in the park: efficient foraging under the risk of predation or of competition?

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Abstract

Many eutherian mammals adjust their foraging behaviour according to the presence or threat of predators. Here, we examine experimentally whether an urban population of brushtail possums, *Trichosurus vulpecula*, similarly adjust their foraging behaviour. Our field experiments manipulated the quantity of food items in artificial feeders placed at different distances from trees. These experiments showed that the possums remained longer at feeders placed far from the trees, but their foraging behaviour did not change with the initial amount of food. The scanning behaviour of possums did not simply increase with distance from the trees, as predicted from studies of other vertebrates. Nevertheless, the number of physical conflicts between individuals increased as the amount of available food decreased. These data suggest that the changes in the foraging behaviour of the possums in this population do not reflect a simple trade-off between foraging efficiency and the risk of predation or competition.

Introduction

Foraging theory predicts that animals will balance the costs and benefits of different foraging behaviours in order to maximise their fitness (Stephens and Krebs 1987). These costs and benefits will depend upon the nutritional state of the animal, the value and spatial distribution of the resource, competition between foragers and the risk of predation (e.g. Abrams 1993). The observed behaviour may therefore reflect a trade-off between several competing interests, such as compromising foraging efficiency in order to reduce the risk of predation (Lima and Dill 1990; Lima 1998). For example, animals under threat of predation may attempt to reduce that risk by selecting less profitable food items, and/or spending less time in exposed areas (Lima 1998). While many studies have examined how the risk of predation may influence the foraging behaviour of natural populations of eutherian mammals (e.g. Bowers 1990; Lima *et al.* 1985; Newman and Caraco 1987; Giraldeau *et al.* 1994; see also Lima 1998), no field experiments have been conducted on marsupials, despite their evolutionary signficance (see Coulson 1996).

In some circumstances, it may be difficult to distinguish between the influence of predators and that of intraspecific competitors on the foraging decisions of animals (see Brown *et al.* 1994). For example, in a classic field experiment, Lima *et al.* (1985) experimentally manipulated the value of food items and risk of predation to squirrels foraging on the ground by placing biscuits of different sizes in feeders that were located at different distances from trees. Squirrels use the trees as a safe haven from terrestrial predators, but individuals foraging further from the tree face greater travel costs. Lima *et al.* (1985) found that squirrels ate the small food items at the feeder, but took the larger items back to the safety of the tree. Additionally, the squirrels were more likely to consume the biscuits at the feeder when it was placed further from the tree. Lima *et al.* (1985) interpreted this result as a trade-off between foraging efficiency and the risk of predation.

However, a similar result could arise if the squirrels were attempting to avoid detection by rival squirrels rather than predators. Squirrels feeding at a feeder may alert others to the food source, and thus risk consuming less food. Returning to the tree with large food items may

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reduce this risk. Indeed, the squirrels were more likely to take either food items to the tree when foraging in groups, perhaps because it is more difficult for squirrels to physically wrest food from rivals when they are in a tree (Lima *et al.* 1985). Consistent with this idea, Giraldeau *et al.* (1994) found that chipmunks collected more food items and travelled more quickly between burrow and food source when in the presence of competitors than when foraging alone (see also Slotow and Paxinos 1997).

The common brushtail possum, *Trichosurus vulpecula*, is a nocturnal and predominantly arboreal marsupial that sometimes forages on the ground (Fitzgerald 1984; MacLennan 1984; Evans 1992). Brushtail possums are common in urban parks in Australia, where they may be attacked by dogs and perhaps humans. When possums forage on the ground, they frequently scan the environment and tend to run to trees at the sight or sound of dogs and sudden noises. The density of possums in these parks can be high and foraging possums are often seen concentrated around human-derived sources of food. Antagonistic interactions between individuals are not uncommon in these situations.

Here, we examine the foraging behaviour of urban brushtail possums at artificial feeders. Specifically, we investigate whether possums adjust their foraging decisions in order to balance foraging efficiency against the risk of competition and/or predation, by providing different quantities of food items placed close to and far from the safety of a tree. We expect possums to spend similar times at the feeders in the absence of competition or predation. However, possums under the risk of predation or competition should spend relatively less time foraging at the feeder closer to the tree (following Lima *et al.* 1985). Moreover, if competition is important the possums should avoid losing food to rivals by spending more time at the feeder with few food items; such adjustments are not expected if their behaviour is modified by the risk of predation only. We also examine the variation in several non-foraging behaviours in order to gain further insights into the influence of the risk of predation or competition on their foraging decisions.

Methods

The study was conducted during April 1998, in the Fitzroy Gardens, East Melbourne, Victoria, Australia. Fitzroy Gardens is a large urban park, bordered by busy roads. It has a large number of native and exotic trees that provide refuge for a thriving population of common brushtail possums, which are often fed by humans. The possums were observed on dry evenings between 1900 and 2200 hours, with temperatures ranging between 11°C and 19°C.

We selected four mature trees (*Ulmus* sp.) from throughout the park, ensuring that they had similar foliage cover, suffered minimal human disturbance, and were further than 15 m from another tree. The four trees were no less than 70 m apart. The possums were trained to collect food items of apples divided into one-eighth pieces from delimited areas (30 cm by 30 cm ‘feeders’) on the ground adjacent to each of the four trees. Our observations of the possums at these feeders during this training period indicated that possums rarely, if ever, moved between the four trees, at least within the 2–3-h observation period. Thus, it is unlikely that we observed the same possums at different feeders during a single evening.

We observed possums feeding under four experimental treatments, in which a feeder was placed either 2 m or 7 m from the trunk of the tree, and either 8 or 24 pieces of freshly cut apple were placed in the feeder. Each piece was roughly 1/8 of a medium-sized apple. No other trees were within 10 m of the feeder. For each replicate, the choice of tree and feeding treatment was chosen randomly. A different tree and treatment was then chosen for subsequent trials, with a period of 30 min elapsing between trials. Eight trials were completed for each treatment. While it is possible that the same possums could be observed more than once during the course of the entire experiment, the frequency of pseudoreplication is likely to be minimal because the population of possums in the park is large, and sequential trials were conducted at different trees.

The foraging behaviour of the possums was observed from a distance of at least 15 m, using binoculars. We commenced recording their behaviour 5 min after the food was placed in the feeder. We noted the time at which each possum arrived at, and departed from, the feeder; the time at which any food item was consumed; the frequency that any possum raised its head and surveyed the environment; and the frequency and nature of any conflicts between possums. We also noted whether possums that departed from the feeder remained within the vicinity of the feeder (i.e. within 1 m of the feeder), climbed into the nearby tree or left the vicinity. We also recorded the time possums spent in the vicinity of the feeder. These data were collected

for 20 min, or less if all food had been consumed. The trial was abandoned if no possums began foraging within 10 min of commencing the trial, and a new site was selected. Any food remaining at the end of a trial was counted and then removed from the site.

Results and Discussion

Typically, possums walked to the feeder and the first few possums to arrive immediately commenced feeding. Later arrivals to the feeder usually hesitated briefly before feeding. Usually, the possums consumed the food in the vicinity of the feeder, although sometimes they carried food items away.

The mean time that possums spent at the feeder was influenced by the distance of the feeder from the tree but not by the amount of food (Fig. 1). A two-way ANOVA revealed that possums remained foraging at the feeder for longer if it was further from the tree ($F_{1,28}$ = 21.09, P < 0.001), but the variation in time was not explained by the amount of food in the feeder ($F_{1,28}$ = 0.90, P > 0.3) or an interaction of these factors ($F_{1,28}$ = 1.63, P > 0.2). These data suggest that the possums' decision to remain at the feeder was determined by the relative travel costs of moving between feeder and tree. However, this decision was apparently not influenced by the initial quantity of food available and, by inference, the risk of competition.

There was little indication that the potential risk of predation influenced the behaviour of possums. Individuals further from a tree may be more vulnerable to predators because they are more exposed or will take longer to reach the safety of the tree. Thus, individuals that cease foraging should spend relatively less time in the vicinity of the feeder when it is located far from the tree. However, the possums in this study spent relatively more time in the vicinity of the feeder when it was further from the tree (Fig. 2). A two-way ANOVA revealed that possums remained within the vicinity of the feeder for longer if it was further from the tree ($F_{1,28}$ = 6.89, P < 0.02), but the variation in time was not explained by the amount of food in the feeder ($F_{1,28}$ = 0.89, P > 0.3) or their interaction ($F_{1,28}$ = 0.09, P > 0.7).

Foraging possums raise their heads and scan the environment, a behaviour that is widely assumed to have an anti-predator function and typically increases under elevated risks of predation for a wide range of species (Elgar 1989; Lima and Dill 1990). However, there was no evidence that the possums foraging further from the tree increased their scanning behaviour. A two-way ANOVA revealed that the scanning rate of individual possums was influenced by an

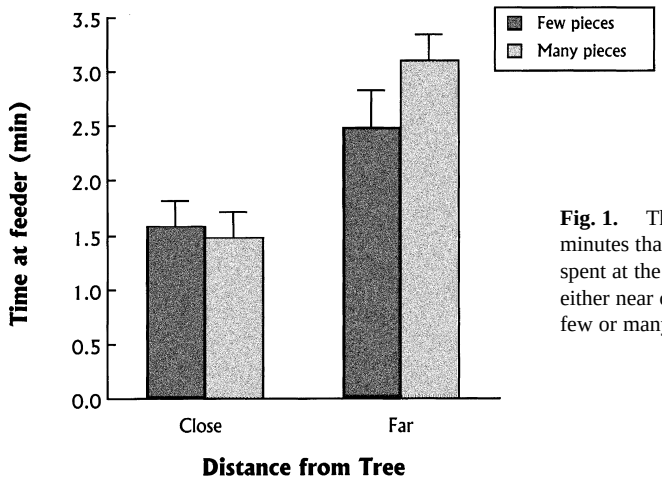

Fig. 1. The mean (±s.e.) number of minutes that individual brushtail possums spent at the feeder, which was placed either near or far from the tree and with a few or many pieces of apple.

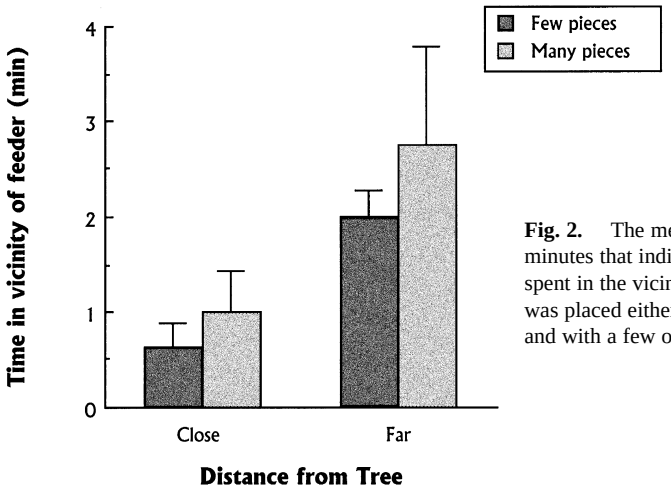

Fig. 2. The mean (±s.e.) number of minutes that individual brushtail possums spent in the vicinity of the feeder, which was placed either near or far from the tree and with a few or many pieces of apple.

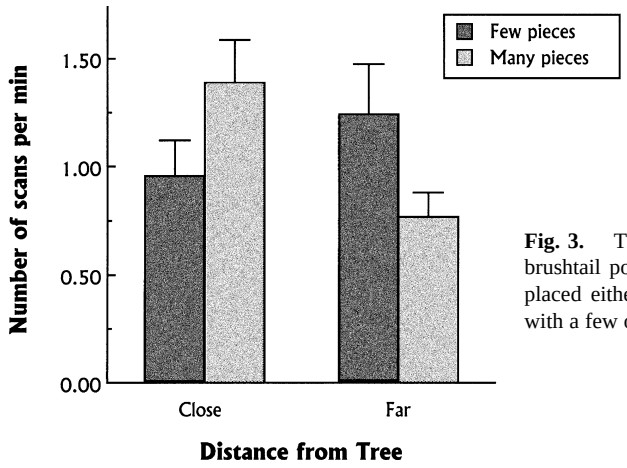

Fig. 3. The mean (±s.e.) scanning rate of brushtail possums at the feeder, which was placed either near or far from the tree and with a few or many pieces of apple

interaction between the position of the feeder and the quantity of food in the feeder ($F_{1,28} = 6.05$, $P < 0.025$) (Fig. 3). Possums provided with less food did not adjust the frequency of scanning with distance from the tree, but possums provided with more food scanned relatively less frequently when the feeder was further from the tree (Fig. 3). These data suggest that possums either did not perceive an increase in the risk of predation when foraging further from the tree, or failed to adjust their behaviour accordingly.

It is surprising that the possums did not adjust their foraging behaviours according to the quantity of food, because we observed several competitive interactions between possums in the Fitzroy Gardens. These included displays in which both animals stood on their hind legs, and physical conflicts in which the animals would bite and scratch each other. The frequency of physical conflicts between possums was negatively correlated with the amount of food remaining in the feeder (Fig. 4). We summed, across those trials that started with 24 pieces of apple, the number of conflicts observed during each time interval between the consumption of

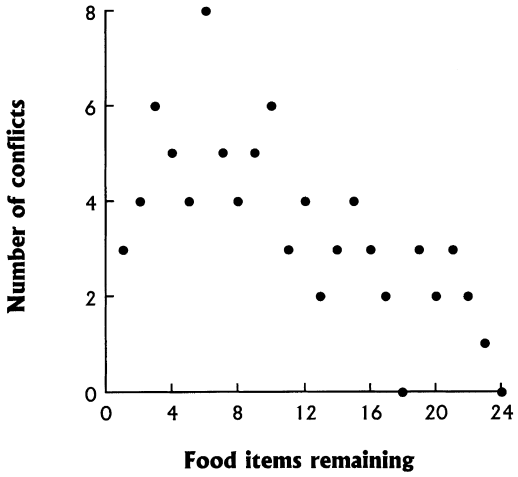

Fig. 4. The relationship between the number of conflicts between brushtail possums at the feeder and the number of food items remaining in the feeder. The data are combined across all replicates ($r = 0.711$, $n = 24$, $P < 0.01$).

consecutive food items. These data showed that there were more conflicts when there was less food available: almost 70% of the conflicts occurred when less than half the food remained and 87% occurred when there were less than eight pieces of apple remaining.

Evidently, the possums in this population do not adjust their foraging decisions according to a simple balance between foraging efficiency and the risk of predation or competition. Several non-feeding behaviours were not influenced by the risk of predation, suggesting that it may not be an important factor. Perhaps the possums close to the tree attempt to be less conspicuous to competitors by spending less time at the feeder, while possums feeding further from the tree cannot avoid being detected and remain at the feeder longer because travel costs are higher. Similar studies of possums in rural populations with different frequencies of predation and population densities may offer more insights.

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References

Abrams, P. A. (1993). Optimal traits when there are several costs: the interaction of mortality and energy costs in determining foraging behavior. *Behavioral Ecology* **4**, 246–253.

Bowers, M. A. (1990). Exploitation of seed aggregates by Merriam's kangaroo rat: harvesting rates and predatory risk. *Ecology* **71**, 2334–2344.

Brown, J. S., Kotler, B. P., and Valone, T. J. (1994). Foraging under predation: a comparison of energetic and predation costs in rodent communities of the Negev and Sonoran Deserts. *Australian Journal of Zoology* **42**, 435–448.

Coulson, G. (1996). Anti-predator behaviour in marsupials. In 'Comparison of Marsupial and Placental Behaviour'. (Eds D. Croft and U. Gansloßer.) pp. 158–186. (Filander Verlag GmbH: Fürth.)

Elgar, M. A. (1989). Predator vigilance and group size in birds and mammals: a critical review of the empirical evidence. *Biological Reviews* **64**, 13–33.

Evans, M. C. (1992). Diet of the brushtail possum *Trichosurus vulpecula* (Marsupialia : Phalangeridae) in central Australia. *Australian Mammalogy* **15**, 25–30.

Fitzgerald, A. E. (1984). Diet of the possum (*Trichosurus vulpecula*) in three Tasmanian forest types and its relevance to the diet of possums in New Zealand forests. In 'Possums and Gliders'. (Eds A. Smith and I. Hume.) pp. 137–143. (Surrey Beatty and Sons: Sydney.)

Giraldeau, L., Kramer, D. L., Deslandes, I., and Lair, H. (1994). The effect of competitors and distance on central place foraging eastern chipmunks, *Tamias striatus*. *Animal Behaviour* **47**, 621–632.

Lima, S. L. (1998). Stress and decision making under the risk of predation: recent developments from behavioral, reproductive and ecological perspectives. *Advances in the Study of Behavior* **27**, 215–290.

Lima, S. L., and Dill, L. M. (1990). Behavioural decisions made under the risk of predation: a review and prospectus. *Canadian Journal of Zoology* **68**, 619–640.

Lima. S. L., Valone, T. J., and Caraco, T. (1985). Foraging-efficiency–predation-risk trade-off in the grey squirrel. *Animal Behaviour* **33**, 155–165.

MacLennan, D. G. (1984). The feeding behaviour and activity patterns of the brushtail possum, *Trichosurus vulpecula*, in an open eucalypt woodland in southeast Queensland. In 'Possums and Gliders'. (Eds A. Smith and I. Hume.) pp. 155–161. (Surrey Beatty and Sons: Sydney.)

Newman, J. A., and Caraco, T. (1987). Foraging, predation hazard and patch use in grey squirrels. *Animal Behaviour* **35**, 1804–1813.

Slotow, R., and Paxinos, E. (1977). Intraspecific competition influences food return–predation risk trade-off by white-crowned sparrows. *Condor* **99**, 642–650.

Stephens, D. W. and Krebs, J. R. (1986). 'Foraging Theory.' (Princeton University Press: Princeton, New Jersey.)

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