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House cats as predators in the Australian environment: impacts and management

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Abstract: This paper provides an overview of the predatory activities of the house cat (*Felis catus*) in Australia, focusing principally on the interactions of domestic and stray cats with native species of prey. Like their free-living, or feral, counterparts, domestic cats take a broad range of prey, with small mammals, birds, and human-derived foods forming the bulk of the diet. Domestic and stray cats have contributed to declines of suburban populations of eastern barred bandicoots (*Perameles gunnii*) and superb lyrebirds (*Menura novaehollandiae*) in Victoria, Australia. The effects of cats on prey communities remain speculative. In Sydney, artificial nests placed in trees in forest remnants suffered less predation where cat activity was high rather than where it was low, indicating that cats beneficially reduced damage by introduced rats and other nest predators. However, high cat activity was associated with reduced bird diversity. Legislation to encourage responsible cat ownership has been passed in Australia; it should have positive outcomes for both wildlife conservation and cat welfare.

Key words: Australia, *Felis catus*, house cat, human–wildlife conflicts

Over the last 20 years, there has been a surge of interest in the introduced house cat (*Felis catus*) in Australia and, in particular, the impact of the cat on native Australian fauna. Some studies have suggested that cats kill millions of native vertebrates each year (Paton 1990, 1991; Trueman 1991), and that certain species are represented disproportionately in the kill (Seebeck et al. 1991, Dowling et al. 1994). Predation from cats appears to have been a major contributor to declining populations of some threatened native species, such as the eastern barred bandicoot (*Perameles gunnii*) in Victoria and the rufous hare-wallaby (*Lagorchestes hirsutus*) in the Northern Territory (Dufty 1994, Gibson et al. 1994). Losses of such species have led to attempts to extirpate cats from local (<10,000 ha) or even regional (>10,000 ha) areas (Algar et al. 2002, Short et al. 2002, Short and Turner 2005), and many attempts have been made to design cat-specific traps, lures, or toxins (Algar and Burrows 2004, Wark 2004).

Other studies have argued, conversely, that the kill-rates of cats are lower than often is believed, especially in urban environments (Reark 1994), and that introduced vertebrates usually form the major part of their diet (Barratt 1997). Cats often are perceived to be beneficial as controllers of vermin on farms and rural properties (Ward 1994), and possibly to have positive effects on some native species by suppressing populations of introduced *Rattus* spp. (Tidemann et al. 1994). In Australia, where cats were introduced in large numbers in the eighteenth and nineteenth centuries (Abbott 2002), negative impacts have been highlighted most often. The strong public affection for cats (e.g., Murray and Penridge 1997, Grayson et al. 2002) and limited empirical evidence of their actual impacts have hampered attempts to manage them effectively.

Studies of cat impact often have drawn a distinction between 2 kinds of cats. On the one hand, domestic cats have been viewed as pet or house cats that live in close connection with a household where all their ecological requirements are intentionally provided by humans (Moodie 1995). Such cats do not rely on hunting for food, but they may still impact on native fauna by their predatory activities. On the other hand, feral cats are free-living; they have minimal or no reliance on humans, and survive and reproduce in self-perpetuating populations

House cat. (*Photo courtesy P. German*)

(Moodie 1995). Individual cats may sometimes move between these 2 extremes, occupying the category of stray if there is partial dependency on humans for the provision of resource requirements.

In the present paper, I discuss the predatory activities of cats in Australia and review the interactions of cats with populations and communities of native prey species. I address 5 questions:

1. What do cats eat?
2. Are cats specialist or generalist predators?
3. What are the effects of cat predation on prey populations?
4. What are the effects of cat predation on prey communities?
5. What management protocols can be implemented to mitigate the impacts of cats?

I focus primarily on predation by domestic and stray cats because the impacts of feral cats on native fauna have been much studied and reviewed (e.g., Dickman 1996*a*, *b*; Risbey et al. 1999, 2000) and are currently the subject of a national threat abatement plan in Australia (Environment Australia 1999). In addition, there is emerging evidence that owned and stray cats often disperse into the natural environment and help to sustain feral populations (Denny et al. 2002, Hutchings 2003), and so contribute more to impacts on native fauna than has been realized hitherto. There has been limited documentation of the effects of domestic and stray cats on native fauna (e.g., Potter 1991, Siepen and Owens 1993, Paxton 1994). I review this information here, but also present new information from my own studies where possible.

What do cats eat in Australia?

While cats take a broad range of prey, small mammals and birds often feature most prominently in their diet. In a summary of 22 studies of the diet of feral cats from 20 localities in mainland Australia, Dickman (1996*a*) found that introduced rabbits (*Oryctolagus cuniculus*) and house mice (*Mus musculus*) are major dietary items in semi-arid and arid habitats, whereas marsupials predominate in temperate forest habitats. In both forest and suburban habitats, the common ringtail possum (*Pseudocheirus peregrinus*) is depredated frequently. On islands of the Australia-Pacific region, birds often predominate in the diet of cats (Fitzgerald 1990, Dickman 1996*a*), although invertebrates also are a prominent part of their diet (Fitzgerald and Veitch 1985, Hayde 1992). Studies published since 1996 support the view that cats take a broad range of prey (Barratt 1997, Meek 1998, Murphy et al. 2004), including carrion, under certain conditions (Paltridge et al. 1997, Molsher et al. 1999).

Studies of cat diet in suburban and temperate forest habitats of the Sydney Basin, New South Wales, exemplify the range of prey taken by domestic and stray cats (Table 1). In the most suburban situation, at Cooper Park, Sydney, native vertebrates (small scincid lizards, birds, and the common brushtail possum [*Trichosurus vulpecula*]) together formed as little as 8–17% of the diet of cats by volume. Most of the diet was derived from human-provided sources of food. In contrast, at suburban North Head, Sydney, and in temperate forest at Olney and Kuringai on the city's northern fringe, mammals predominated in the diets, with 37 to 60% of the total volume being derived from native species (Table 1). Dietary differences among habitats probably reflect differences in prey availability. The common brushtail possum is the only terrestrial native mammal occurring in Cooper Park and surrounding areas, whereas native mammals predominate at the other sites (Matthews et al. 1999). Rabbits are likewise abundant at North Head, where they form 21% of the diet, by volume, of cats, but scarce at the other sites, where they form only 1 to 6% (Table 1). These results support previous findings (Fitzgerald 1988) that cats prey mostly on small vertebrates, especially mammals and birds. These results also are consistent with studies elsewhere in Australia (Wallis et al. 1996) and Europe (Goldschmidt-Rothschild and Lüps 1976, Borkenhagen 1979) that demonstrate large differences in the representation of prey species between suburban and less disturbed natural habitats.

Are cats specialist or generalist predators?

The predominance of small mammals and

Table 1. Diets of house cats (*Felis catus*) in suburban and temperate forest habitats of the Sydney Basin, New South Wales, shown as percentage volume of occurrence of food categories.

Food category	Suburban habitat		Forest habitat	
	Cooper Park (n[1] = 37)	North Head (n = 24)	Olney State Forest (n = 12)	Kuring-gai National Park (n = 28)
Rabbit	1.3	21.5	1.3	6.3
House mouse		1.3	1.0	1.9
Other rodent[2]	14.1	22.6	15.8	18.8
Bat				0.7
Marsupial	4.7	37.2	32.8	40.8
Bird	8.8	8.1	27.6	12.4
Reptile	3.6	3.9	4.2	6.0
Invertebrate	5.5	3.7	3.0	2.7
Scavenge	5.0		7.6	1.9
Other[3]	57.0	1.7	6.6	8.5

[1]Sample sizes, *n*, represent pooled results from analyses of feces at all sites and stomach contents at all sites except Cooper Park.
[2]In the suburban habitats, all "other rodents" ingested were introduced black rats (*Rattus rattus*), whereas in the forest habitats all "other rodents" taken were probably native bush rats (*R. fuscipes*).
[3]The category "other" represents cat fur, plant material, nonorganic items, unidentified materials, and foods likely to be of human origin, such as fish, bread, or commercial pet food. Full methodological details are given in Dickman (1996*a*).

birds in the diet of cats has led to the frequent assumption that these taxa are preyed upon selectively. However, dietary selectivity is more reliably indicated if a predator can be shown to take certain prey over others that are also available. Such selectivity may be demonstrated at the level of the individual predator or that of the population. In a particularly instructive study of population-level selectivity, Childs (1986) showed that cats in urban Baltimore, Maryland, USA, took small brown rats (*Rattus norvegicus*) weighing <200 g, while most (91%) of the rats available in the population weighed >200 g. In other studies, Barratt (1997) showed that cats in suburban Canberra, Australia, preferred house sparrows (*Passer domesticus*) and blackbirds (*Turdus merula*) to 9 other common species of birds, but avoided starlings (*Sturnus vulgaris*), possibly because starlings nest and roost high in trees and feed on the ground in flocks that can more readily detect approaching predators. Molsher et al. (1999) demonstrated that rabbits were being depredated selectively at Lake Burrendong, near Wellington, New South Wales, even after a 90% decline in rabbits' abundance due to rabbit calicivirus disease. At the individual level, cats have sometimes been shown to selectively take certain prey species and to adopt specialized hunting methods to obtain them. Often these are species of small mammals or birds (Bradshaw 1992), but large animals such as the rufous hare-wallaby (*Lagorchestes hirsutus*; Gibson et al. 1994) and unusual prey, such as bats (Churcher and Lawton 1989) and grasshoppers (Hochstrasser 1970), also have been targeted. Observations of hunting by domestic and stray cats near human settlement at 2 locations have revealed clear specializations among individuals. On Rottnest Island, Western Australia, 3 of 5 cats appeared to be accomplished mousers, catching every house mouse (*Mus musculus*) that they hunted, but achieving only a 50% catch rate for either birds or lizards. These cats adopted a sit-and-wait strategy (Turner and Meister 1988), pouncing on mice from behind cover under conditions of semi-light or darkness. In the same population, by contrast, 1 cat achieved high rates of capture success on lizards and another cat on birds. Both foraged diurnally, the first pursuing lizard prey actively in sparse coastal heath vegetation, the second pouncing on birds from dense cover. Similar selectivity was observed by 1 cat at North Head that specialized on rabbits.

What are the effects of cat predation on prey populations?

The population-level impacts of feral cats on native fauna have been much discussed in Australia (Dickman 1996*a*, *b*) and elsewhere (King 1984, Fitzgerald 1988, 1990). Surprisingly, the impacts of domestic and stray cats have remained poorly studied in Australia, with only 2 well-documented studies.

The first study concerned the eastern barred bandicoot (*Perameles gunnii*), a smal, rabbit-size marsupial, at the town of Hamilton, Victoria. Formerly widespread in southwestern Victoria and southeastern South Australia, this bandicoot had become restricted to the Hamilton area by the 1970s. During 1982 to 1983, the population comprised about 1,750 animals (Moon 1984), but had fallen to just 150 to 300 animals by 1989 (Lacy and Clark 1990). The precipitous population decline appeared to be driven by a high rate of mortality, especially of juveniles, with >42% of juvenile deaths being caused by cat predation (Dufty 1994).

The second case study concerned the superb lyrebird (*Menura novaehollandiae*) in Sherbrooke Forest, Victoria. The lyrebird population was about 130 animals in the 1960s, but had fallen to only 60 by 1988 (Bradley and Bradley 1990). Predation by cats, foxes (*Vulpes vulpes*) and domestic dogs (*Canis familiaris*) was identified as the major cause of the decline, with cats probably accounting for disproportionate mortality of young birds (Larkin 1989; H. Bradley, personal communication).

What are the effects of cat predation on prey communities?

Given the relatively small amount of information on the effects of cats on individual native species, it is not surprising that understanding of cat impacts on prey communities is meager. There is considerable speculation that cats may have indirect but deleterious effects on plant communities by reducing the abundance of avian pollinators, or by depleting rat kangaroos (*Bettongia* spp. and *Potorous* spp.) and other vectors of mycorrhizal fungi (Dickman 1996*a*). In contrast, circumstantial evidence suggests that cats may facilitate denser populations of forest birds by suppressing the numbers of predatory rats (Fitzgerald and Karl 1979, Ebenhard 1988, Tidemann et al. 1994).

One observational study on birds in Sydney illustrates the difficulty of disentangling the positive and negative effects of cats at the community level. In the first part of this study, in which I participated, Matthews et al. (1999) investigated the intensity of predation on artificial bird eggs and nests placed in trees in 24 forest patches throughout the Sydney metropolitan region. The predation rate, calculated as the percentage of nests attacked by predators, ranged from 45 to 100%. Avian predators were detected in all patches; black rats (*Rattus rattus*) attacked nests in 10 areas, and common ringtail possums and brown antechinus (*Antechinus stuartii*) damaged eggs in 2 areas each. In the second part of the study, I walked along foot tracks through each remnant and counted the numbers of cat feces encountered to obtain a rough index of cat activity. A plot of cat activity, expressed as feces-per-km of track, against nest predation rate revealed a strong negative correlation (Figure 1). As cats did not damage any nests in the 24 sites, the reduced levels of nest predation associated with high cat activity presumably reflect suppressive effects of cats on nest predators. Indeed, examination of the contents of the collected cat feces indicated that all of the nest predators noted above themselves fell victim to cats (Dickman, unpublished data), supporting the presumption that suppression is likely to have occurred. On their own, these findings indicate that domestic and stray cats may benefit tree-nesting birds in remnant forest patches in Sydney by reducing rates of nest predation.

In the final part of this study, the richness of all native species of birds was sampled in the same 24 forest patches by scoring species observed along foot tracks and plotting them against cat activity (Figure 2). The strong negative relationship suggests that cats reduce the total numbers of bird species that occur in forest remnants. Species that were absent from sites with high cat activity, but present elsewhere, included wrens (*Malurus cyaneus*), thornbills (*Acanthiza chrysorrhoa*, *A. pusilla*), wagtails (*Rhipidura leucophrys*), and other vulnerable small species that feed or nest close to the ground. These observations support the notion that cats depleted the avian community, presumably by direct predation. Confirmation awaits appropriate experimental studies.

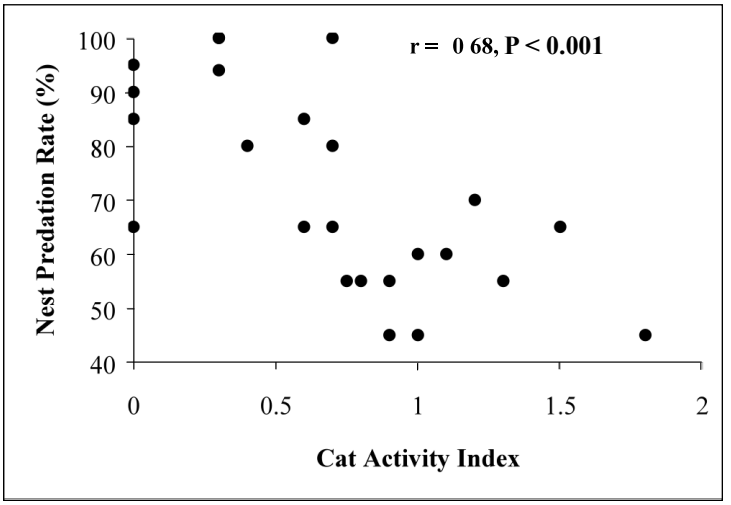

Figure 1. Relationship between house cat (*Felis catus*) activity and nest predation rate in 24 remnant patches of forest in Sydney, New South Wales, Australia. Cat activity is expressed as an index based on numbers of cat feces found per km of foot tracks within patches. Nest predation rate is expressed as the percentage of artificial nests depredated per patch. Based on Mattews et al. (1999) and Dickman (unpublished data).

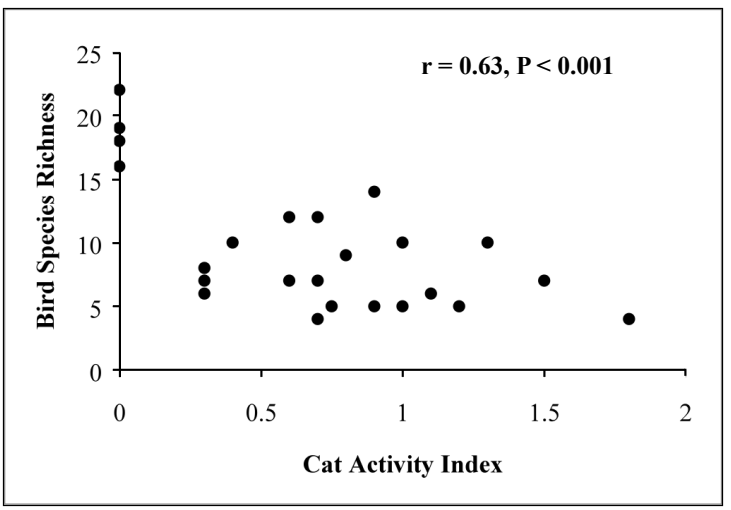

Figure 2. Relationship between house cat (*Felis catus*) activity and bird species richness in 24 remnant patches of forest in Sydney, New South Wales. Cat activity is expressed as an index based on numbers of cat feces found per km of foot tracks within patches. Bird species richness is expressed as the number of bird species heard or observed along foot tracks within patches pooled over 2 to 4 searches per patch.

What management protocols can be implemented to mitigate the impacts of cats?

Taken together, the findings of the above studies provide some evidence that domestic and stray cats impact negatively on some native species. If these cats help to establish and maintain feral cat populations in less disturbed habitats outside conurbations (Denny et al. 2002, Say et al. 2003), their impacts may be more subtle, but also more pervasive, than realized. Research on this issue is continuing (Denny 2005). In built-up urban and suburban environments, it is likely that any direct impact of cats on native fauna will be secondary to the more dramatic effects of loss and modification of native vegetation by the suburbs themselves. However, in less disturbed areas adjoining reserves, national parks, or in remnants of native vegetation adjoining new residential developments, predation by domestic and stray cats on native species may be quite damaging (Barratt 1997).

In response to community perceptions about marauding cats, city councils and governments in all Australian states and territories have debated or passed by-laws to encourage responsible cat ownership (Department of Local Government 1994, Seebeck and Clunie 1998). Many municipalities also provide information packs to increase the awareness of owners about cat–wildlife interactions. By-laws vary greatly from council to council, but most include provisions for registration of pet cats, incentives for sterilization, nighttime curfews, and stipulations for a maximum number of cats per property; some also allow for removal of unowned cats from parks and other areas of sensitive habitat.

Community surveys generally indicate strong support for legislation that promotes informed cat ownership, but weaker support for

proposals that restrict ownership or create cat-free zones (e.g., Grayson et al. 2002). Effective provisions should have twofold benefits. First, they should reduce the depletion of native wildlife in settled areas. Secondly, they should improve cat welfare by reducing the numbers of dumped, unwanted cats, and by reuniting lost pets with their owners. Despite the broad community support for education and control of cats, and the plethora of by-laws that has been passed in recent years, there has been no evaluation to date of the effectiveness of any existing programs. Such a review should be carried out as a matter of priority.

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