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Mammalian Diet and Broad Hunting Strategy of the Dingo (*Canis familiaris dingo*) in the Wet Tropical Rain Forests of Northeastern Australia¹

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ABSTRACT

The diet of dingoes (*Canis familiaris dingo*) in the Australian Wet Tropics was examined by analyzing 383 dingo scats collected throughout the region for the presence of mammal prey remains. The scats yielded 29 native and 4 introduced mammal prey species from 14 families. The most important species in terms of percentage occurrence in the scats were *Melomys cervinipes* (22.2%), *Isoodon macrourus* (17.0%), *Perameles nasuta* (12.5%), and *Thylogale stigmatica* (12.5%). The most important families were Muridae (37.1%), Peramelidae (29.5%), and Macropodidae (25.8%). Examination of small-scale habitat preferences revealed species that preferentially use the forest edge ranked significantly higher in the diet than those that do not, and species that are terrestrial ranked higher in the diet than those that are arboreal. Relative abundance was also a significant factor in the ranked dietary occurrence of each species, with abundant species ranked significantly higher than those that are less abundant. These results suggest that dingoes in the Australian Wet Tropics are opportunistic predators of a wide variety of mammal species, with abundant terrestrial and forest edge-dwelling taxa the most susceptible to predation.

Key words: Australia; dingo; hunting strategy; predator diet; prey preferences; tropical rain forest.

RAIN FOREST IN THE AUSTRALIAN WET TROPICS REGION OCCURS along a relatively narrow strip (no more than 80 km wide) on the coastal plain and coastal ranges of northeastern Queensland between Townsville and Cooktown (Bell *et al.* 1987). Over most of its length, the rain forest grades into wet sclerophyll forest on the upland plateau to the west (Winter 1988). Much of the coastal lowland forest and rain forest on the Atherton Tableland have been cleared, resulting in a mosaic of cleared and forested lands (Winter *et al.* 1987). In addition, the larger forested blocks are typically bisected by roads, logging tracks, and power line corridors that create substantial edge effects.

The Wet Tropics supports one of the most diverse mammal communities in Australia and accommodates 109 species, 13 of which are endemic to the region (Williams *et al.* 1996). Within the Wet Tropics region, the dingo (*Canis familiaris dingo*)

is the largest, most widespread, and probably the most significant predator of the mammals that occur there. In southeastern Australia, dingoes hunt primarily at night and often do so along forest edges, particularly where dense forest habitat abuts cleared pasture or roadsides (Newsome 1983). Several of the mammal species that occur in the Wet Tropics region have a preference for a zone around the edge of the forest, where the density of vegetation increases significantly before abruptly giving rise to open areas (Laurance 1991). Some of these species prefer the dense edge zone inside the forest edge (*e.g.*, *Melomys cervinipes*) while others restrict their activities to the adjacent open habitat (*e.g.*, *Rattus rattus*). Some species, such as the bandicoots and wallabies, only venture out of the forest into open areas at night to feed.

Dingoes are thought to typically prey upon medium-sized and large mammals (Newsome & Cooman 1989). Most studies to date have reported that macropodoid marsupials (kangaroos and wallabies) occur more frequently in the diet of dingoes than other mammalian prey (Whitehouse 1977; Newsome, Catling *et al.* 1983; Newsome, Corbett *et al.* 1983; Robertshaw & Harden 1985a, b; Brunner & Wallis 1986; Brown & Triggs 1990; Lunney *et*

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al. 1990; Evans 1992; Thompson 1992). Occasionally, other smaller prey have been dominant (Friend 1978, Triggs *et al.* 1984, Corbett & Newsome 1987, Corbett 1995a), and like macropodoids, these species typically share the traits of being ground-dwelling mammalian fauna that are common in the area under investigation.

Within a particular region, dingoes alter their group sizes and hunting strategies to maximize hunting success on the most commonly available wildlife (Corbett 1995b). In arid central Australia, packs often include up to ten individuals, whereas in the seasonally wet Kakadu region, dingoes are more often solitary or in groups of two (Corbett 1995c). Nothing is known about typical pack sizes in the Wet Tropics; however, persecution by pastoralists possibly favors smaller or less stable associations. Although dingoes are generally thought of as opportunistic predators and scavengers (Whitehouse 1977, Newsome, Catling *et al.* 1983, Newsome & Coman 1989, Brown & Triggs 1990, Lunney *et al.* 1990), the hunting strategy in the tropical rain forests of northeastern Australia cannot be inferred from other studies in the dry tropics or southern temperate regions of the continent. This paper is the first to describe the diet of dingoes in the Australian Wet Tropics. The results of this dietary analysis are examined in the light of prey habitat preference and abundance in order to propose a broad hunting strategy of dingoes in the Wet Tropics region.

MATERIALS AND METHODS

STUDY REGION, SCAT COLLECTION, AND ANALYSIS.—Scats were collected between January 1987 and December 1995, from either rain forest, the rain forest/pasture boundary, or the wet sclerophyll forest that forms the narrow western boundary to much of the Wet Tropics. All collection sites were along unused logging tracks that bisect relatively intact rain forest blocks or from along roads or tracks that separate forest edges from adjacent cleared areas. The primary collection locality was the Atherton Tableland (where rain forest abuts pasture) while the remainder of scats came from localities where rain forest and wet sclerophyll are adjacent to each other on the Windsor Tableland, Carbine Tableland, Lamb Range, Cardwell Range, and the Seaview Range (Fig. 1). The dingo is a large, mobile predator that can move several kilometers during a night of foraging (Lunney *et al.* 1990), and available evidence suggests that scats are deposited non-randomly in order to scentmark within a territory

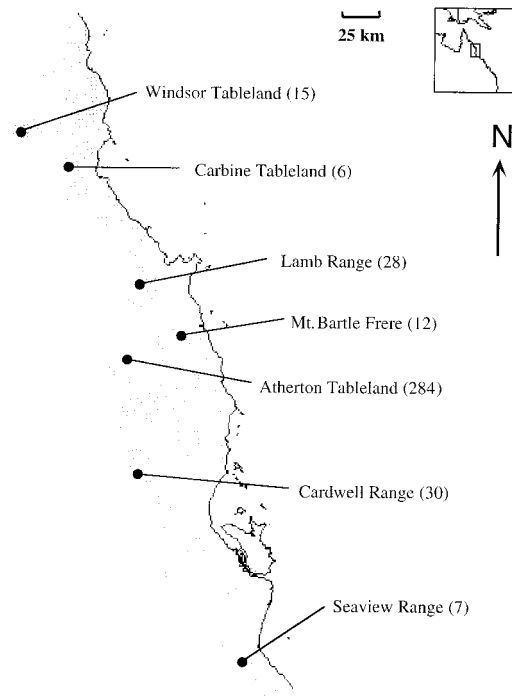


FIGURE 1. The Wet Tropics region showing the location of collection sites and the number of samples collected. The shaded area represents the extent of rain forest in the region. Wet sclerophyll forest extends in a narrow band along the western margin of the rain forest throughout most of the region.

(Newsome & Coman 1989, Corbett 1995c). We believe that the proximity of rain forest and wet sclerophyll forest in much of the region and the likelihood that dingoes use roads and forest edges both as a means of easily traversing their territory and as obvious landmarks for scat deposition, required the pooling of scats from all habitats and collection localities.

Scats were examined microscopically for mammalian remains. Hair extracted from scats was analyzed using diagnostic features of, *inter alia*, cross section, profile, medulla arrangement, and scale pattern of primary guard hairs. When possible, fragments of bone and teeth were also used to aid identification. For detailed description of the technique used, see Triggs *et al.* (1984). All mammalian remains were identified to species level. On rare occasions, plant material ($N = 2$), feathers ($N = 11$), or reptilian remains ($N = 1$) were found in scats in conjunction with mammalian remains. No attempt was made to identify this material further.

In a few cases, confirmation that the scat came from a wild canid was difficult due to the absence of grooming hairs or the lack of a distinctive size or shape of the scat. These scats were excluded from analyses. Wild dogs (*Canis familiaris*) and dingoes (*Canis familiaris dingo*) are known to hybridize in many regions of Australia (Corbett 1995c). Hybrid dingoes probably fulfill a similar ecological function as pure dingoes and the two forms are unlikely to differ greatly in diet (L. Corbett, pers. comm.). Given that it is impossible to distinguish between scats from hybrid and pure dingoes, the term "dingo" in this paper refers to both wild canid types. Furthermore, since it was largely impossible to tell whether dietary occurrences were the result of predation or scavenging, the term "prey" refers to both possibilities.

DATA ANALYSIS.—Dietary results are expressed as percentage occurrences (*i.e.*, the number of scats in which a particular prey species was found as a percentage of the total number of scats). A prey species was defined as "important" to the diet if it had a percentage occurrence in the scats of >10 percent. Mann-Whitney *U*-tests (Zar 1984) were used to test for the difference in the percentage occurrence in the scats of species that (a) frequent the forest edge and pasture compared to those that do not concentrate in such habitats; and (b) are arboreal rather than terrestrial. Kruskal-Wallis single-factor analysis of variance by ranks (Zar 1984) was used to test for the difference in the percentage occurrence of prey species in the scats based on their relative field abundance. Due to the difficulty of knowing the exact relative abundance of one species to all others, a broad ranking system incorporating three ranks was used. These ranks were (1) high abundance, (2) moderate abundance, and (3) low abundance. Our observations and those of other workers (Winter 1988; Laurance 1992, 1994; Vernes *et al.* 1995; Williams & Marsh 1998) using a variety of direct census techniques (primarily mark-recapture and line transect) were used to classify species as forest dwellers or forest edge/pasture dwellers and to rank species into abundance categories.

RESULTS

PREY SPECIES.—The study yielded 383 scats that could be assigned to the dingo. Analysis of these scats indicated that dingoes frequenting forest and forest edges in the Australian Wet Tropics prey upon a minimum of 29 native and 4 introduced

mammal species (Table 1) from 14 families (Table 1). The most important prey species overall were *M. cervinipes* (22.2%), *Isodon macrourus* (17.0%), *Perameles nasuta* (12.5%), and *Thylogale stigmatica* (12.5%, Table 1). The most important prey in terms of families of mammal were Muridae (37.1%), Peramelidae (29.5%), and Macropodidae (25.8%; Table 1). An additional 8 native and 3 introduced mammal families contributed to the diet (Table 1).

HABITAT PREFERENCES OF PREY SPECIES.—Ten of the 14 species of mammal most abundant in the dingo scats spend the nocturnal period on or outside of the forest edge, while only 3 of the remaining 19 less abundant species in the scats are categorized in this way (Table 1). These forest edge-dwelling species ranked significantly higher in the diet of the dingo based on the scats collected ($U_{(2),13,20} = 53.0$, $P = 0.004$). There was also a weaker relationship in the ranked abundance of terrestrial versus arboreal species in the scats ($U_{(2),22,11} = 75.5$, $P = 0.081$; Table 1); however, it should be noted for this last analysis that the brushtail possum (*Trichosurus vulpecula*) spends much of its time foraging at ground level (How & Kerle 1995) and when this species is classified as terrestrial, the significance of the relationship is considerably strengthened ($P = 0.027$).

ABUNDANCE OF PREY SPECIES.—The abundance of prey species, based upon the ranking of prey into three abundance categories (Table 1), was a significant factor in the percentage occurrence of these species in the dingo scats collected ($H_{11,18,4} = 17.72$, $P = 0.0001$). This result suggests that dingoes typically preyed upon the most abundant species more than upon those that were less abundant.

DISCUSSION

Dingoes in the Australian Wet Tropics prey upon at least 33 species of mammal, of which 29 are native species. Field abundance of prey and the habitat preferences of the individual prey species appear to be important factors in the occurrence of prey in the scats sampled. Species that are common, ground-dwelling, or routinely use the edge of the forest were typically ranked higher in dingo scats than those less abundant, arboreal, or not associated with the forest edge. The species that fulfill all of the former categories are particularly vulnerable to dingo predation, a relationship clarified by

TABLE 1. *Mammalian prey species detected in the diet of the dingo (Canis familiaris dingo) from several locations throughout the Wet Tropics. Species are listed in order of percentage occurrence within family, in all scats combined (N = 383).*

Species	Common name	Habitat ^a	Abundance ^b	Occurrence
Family Tachyglossidae				
<i>Tachyglossus aculeatus</i>	short-beaked echidna	TN	3	0.3
Family Dasyuridae				
<i>Antechinus flavipes</i>	yellow-footed antechinus	AE	3	0.3
Family Peramelidae				
<i>Isodon macrourus</i>	northern brown bandicoot	TE	1	17.0
<i>Perameles nasuta</i>	long-nosed bandicoot	TE	1	12.5
Family Burramyidae				
<i>Cercartetus caudatus</i>	long-tailed pygmy possum	AN	3	0.3
Family Petauridae				
<i>Dactylopsila trivirgata</i>	striped possum	AN	2	1.0
<i>Petaurus breviceps</i>	sugar glider	AN	2	0.5
Family Pseudocheiridae				
<i>Pseudocheirus herbertensis</i>	Herbert River ringtail possum	AN	2	2.6
<i>Pseudocheirus archeri</i>	green ringtail possum	AE	2	2.6
<i>Pseudocheirus peregrinus</i>	common ringtail possum	AN	2	1.3
<i>Pseudocheirus cinereus</i>	Daintree River ringtail possum	AN	3	0.8
Family Phalangeridae				
<i>Trichosurus vulpecula</i>	common brushtail possum	AE	1	6.0
Family Potoroidae				
<i>Hypsiprymnodon moschatus</i>	musky rat-kangaroo	TN	2	1.6
<i>Bettongia tropica</i>	northern bettong	TN	2	0.8
<i>Aepyprymnus rufescens</i>	rufous bettong	TN	2	0.5
Family Macropodidae				
<i>Thylogale stigmatica</i>	red-legged pademelon	TE	1	12.5
<i>Wallabia bicolor</i>	swamp wallaby	TE	2	4.2
<i>Dendrolagus lumholtzi</i>	Lumholtz's tree kangaroo	AN	2	2.6
<i>Macropus parryi</i>	whiptail wallaby	TN	2	1.8
<i>M. robustus</i>	common wallaroo	TN	2	1.6
<i>M. agilis</i>	agile wallaby	TN	2	1.3
<i>M. giganteus</i>	eastern grey kangaroo	TN	2	1.3
Family Pteropodidae				
<i>Pteropus conspicillatus</i>	spectacled flying fox	AN	1	0.8
Family Muridae				
<i>Melomys cervinipes</i>	fawn-footed melomys	TE	1	22.2
<i>Rattus fuscipes</i>	bush rat	TN	1	8.9
<i>Mus musculus</i> ^c	house mouse	TE	1	2.9
<i>R. rattus</i> ^c	black rat	TE	1	2.6
<i>Uromys caudimaculatus</i>	giant white-tailed rat	TN	1	1.8
<i>R. leucopus</i>	Cape York rat	TE	2	1.3
<i>R. lutreolus</i>	swamp rat	TN	2	0.8
Family Bovidae				
<i>Bos taurus</i> ^c	domestic cattle	TE	1	4.2
Family Suidae				
<i>Sus scrofa</i> ^c	feral pig	TN	2	2.9
Family Canidae				
<i>Canis familiaris</i>	dingo	TE	2	0.8

^a Habitat types: T = terrestrial; A = arboreal; E = edge-dwelling; and N = non-edge-dwelling.^b Abundance categories: 1 = high abundance; 2 = medium abundance; and 3 = low abundance.^c Introduced species.

examining the habitat preferences and abundances of the 4 most important prey species.

The fawn-footed melomys (*M. cervinipes*) occurred in almost one-quarter of all scats collected, making it the most commonly occurring species in the dingo scats examined. *Melomys cervinipes* typically forages at ground or lower subcanopy level (Williams 1990) and is common throughout the Wet Tropics region (Williams *et al.* 1996). Its preference, however, is for the disturbed forest edge (Laurance 1994), presumably because this area is characterized by a high proportion of vines, creepers, and dense saplings (Laurance 1991) that provide additional substrates for climbing and foraging (Wood 1971). The two species of bandicoots (*I. macrourus* and *P. nasuta*) detected in scats were the next most important species, and both commonly associate with pasture adjacent to the forest edge as well as regrowth forest and human habitation (Laurance 1994). Both species were commonly encountered within the study area (K. Vernes, A. Dennis, J. Winter, pers. obs.). The red-legged pademelon (*T. stigmatica*) was an equal third in percent occurrence in the scats. This species has a high population density on the Atherton Tableland (Vernes 1999) and spends most of the nocturnal period on pasture close to the rain forest edge, returning to the forest each morning just prior to dawn (Vernes *et al.* 1995).

Three of the mammals detected infrequently in the scats are potentially underrepresented due to their restricted distributions within the region. Scats containing the spectacled flying fox *Pteropus conspicillatus* were collected from a single rain forest fragment on the southern Atherton Tableland where a large colony of this species has an encampment. Although this species occurs throughout the Wet Tropics, dingoes are most likely to encounter individuals as prey or carrion beneath such camps. The distribution of the Daintree River ringtail possum *Pseudochirulus cinereus* is restricted to the northern part of the study region, an area where relatively few scats were collected (Fig. 1). Similarly, the northern bettong *Bettongia tropica* is largely restricted to a narrow band of wet sclerophyll forest on the Lamb Range (Winter & Johnson 1995), an area representing only a small portion of the entire study area. Once again, relatively few scats were collected in this area (Fig. 1).

Some species in the Wet Tropics respond poorly to fragmentation, becoming rare or disappearing entirely from fragmented rain forest (Laurance 1991). The effects of forest fragmentation may account for the low percentage occurrence of the

musky rat-kangaroo *Hypsiprymnodon moschatus* in the scats (Laurance 1994), although it could be argued that other potoroids typically make up a small component of dingo diets (Hill & Triggs 1985, Scotts & Seebeck 1989). The feral pig *Sus scrofa* did not occur in any scats collected from rain forest fragments on the Atherton Tableland, although it was found in scats from most other areas. This species is often absent from smaller patches of rain forest largely as a result of pest control measures implemented by surrounding landholders (K. Vernes, pers. obs.).

Dingoes in the Wet Tropics prey upon at least ten species of macropodid; however, only two of these (*T. stigmatica* and the swamp wallaby *Wallabia bicolor*) are considered to contribute importantly to the diet. In overall terms, macropodoids were less important to the diet (25.8%) than were rodents (37.1%) and bandicoots (29.5%). High occurrence of macropod prey in the diet of dingoes has been documented by several authors (Whitehouse 1977, Newsome, Corbett *et al.* 1983, Robertshaw & Harden 1985a, Evans 1992, Thompson 1992). In most of these studies, the assumption was that macropods are simply the most commonly encountered prey.

Corbett and Newsome (1987) suggested that at their central Australian study site, smaller prey were preferred by dingoes because they were relatively abundant, widespread, and easily captured. Similarly, a study of dingo diet in the monsoon forests of northern Australia identified the dusky rat (*Rattus colletti*) and magpie goose (*Anseranas semipalmata*) as the most common prey species due to their high seasonal availability (Corbett 1995a). In the Wet Tropics, rodents and bandicoots are a common, terrestrial and typically forest edge- or pasture-dwelling component of the mammalian fauna. In comparison, the larger species are generally either less common, arboreal, non-edge associating, or a combination of these characteristics.

The results of this study suggest that terrestrial and highly abundant mammals were consumed more than those that are arboreal or occur in lower numbers. Furthermore, dingoes preyed upon edge-dwelling mammals at a higher frequency than non-edge-dwelling mammals. Nevertheless, that a bias toward edge-dwelling species in the scats was a reflection of our collection biases cannot be discounted. We collected scats along tracks and roads that bisected rain forest blocks or ran adjacent to them largely because of the difficulty in locating samples within undisturbed rain forest. Dingoes are known to regularly use roads and tracks as scent posts,

sometimes doing so to indicate hunting grounds that are shared with other individuals (Corbett 1995c). Because of this scent-marking behavior, we feel that the scats collected are representative of dingo diet in the broad areas sampled.

Nevertheless, we recognize that dingo diets within large tracts of intact rain forest where effects of fragmentation (*i.e.*, roads and forest edges) are rare or absent would likely be different than that reported here. There currently exists *ca* 1427 km of roads and highways and 324 km of power line corridors within the 900,000 ha Wet Tropics rain forests (Goosem 1997). Inclusion of minor logging tracks and other "ghost roads" probably result in linear corridors exceeding 3000 km (S. Turton, pers. comm.). In addition to the present mosaic of cleared land and rain forest characteristic of much of the region, these data suggest that few if any dingoes would not have access to roads, power line corridors, or forest edges for scent marking and home range traversal.

Results of this study suggest that dingoes in the Wet Tropics hunt along rain forest edges, where rain forest typically gives way to pasture, roadsides, or the more open wet sclerophyll forest. In doing so, dingoes encounter the common, terrestrial, and edge-dwelling fauna, and thus could be thought of as opportunistic predators, preying upon species at a rate similar to the expected rate of encounter.

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