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The carnivore community in a dry tropical forest mosaic in Huai Kha Khaeng Wildlife Sanctuary, Thailand

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ABSTRACT. An assessment of carnivore species richness and food habits was carried out in a 100 km^2 area of dry tropical forest in Huai Kha Khaeng Wildlife Sanctuary, Thailand. Twenty-one carnivore species of five families were found to be feeding on at least 34 mammal species, as well as birds, lizards, snakes, crabs, fish, insects, and fruits. Forty-four percent of the prey identified in faeces of larger carnivores, primarily leopards, consisted of barking deer, *Muntiacus muntjak*. Sambar deer, macaques, wild boar, porcupine, and hog badger were important secondary prey items. In faeces from small carnivores (<10 kg), murid rodents accounted for 33% of identified food items. The two most frequently encountered mammalian prey species were the yellow rajah rat, *Maxomys surifer*, and the bay bamboo rat, *Cannomys badius*. Non-mammal prey accounted for 21.3%, and fruit seeds for 12.4%, of all food items found in small carnivore faeces.

KEY WORDS: carnivore, community ecology, dry tropical forest, Thailand.

INTRODUCTION

Carnivore species help control prey populations (Schaller 1967, 1972, Smuts 1978), influence prey behaviour (Rice 1986, Schaller 1967, 1972), and aid in seed dispersal (Rabinowitz, in press (a)). As parks and sanctuaries become more restricted and subject to greater human use, carnivores are often more severely affected by developmental activities than other groups of animals (Johnsingh 1986). Therefore, an understanding of the structure and dynamics of carnivore communities is essential for tropical forest management and conservation.

Despite some excellent research concerning some of the larger Asian carnivores and predator-prey relationships in the protected areas of India (Johnsingh 1983, Ramachandran *et al.* 1986, Rice 1986, Schaller 1967), Nepal (Seidensticker 1976, Sunquist 1981), and Sri Lanka (Eisenberg & Lockhart 1972, Muckenhirn & Eisenberg 1973) there has been little investigation into south-east Asian carnivore communities. This paper presents an overview of carnivore species richness and food habits compiled between 1987–1989 while conducting research in a dry

tropical forest mosaic of Huai Kha Khaeng Wildlife Sanctuary in central Thailand. Mammal taxonomy follows that of Lekagul & McNeely (1977) with changes made by Musser (1979, 1981) and Musser & Newcombe (1983) to the genus *Rattus*.

STUDY AREA

Huai Kha Khaeng Wildlife Sanctuary, an area of 2575 km^2, encompasses the Huai Kha Khaeng and part of the Huai Thap Salao watersheds (99° 00′–99° 30′ N, 15° 00′–15° 45′ E). The study area comprised 100 km^2 around Khao Nang Rum Research Station, in the eastern portion of the sanctuary, and contained parts of two stream systems, Huai Chang Tai and Huai Ai Yo. Most of the study area ranged in elevation from 400–600 m, but included part of the Khao Khieo Mountain up to 1350 m.

Vegetation in the study area was a mosaic of four forest types as described by Bhumpakkapun *et al.* (1985) and Thitathamakul (1985). These forest types included:

(1) Mixed deciduous forest, comprising 33% of the study area, and found primarily on moderately sloping and flat areas near streams. It was dominated by the tree genera *Lagerstroemia*, *Terminalia*, *Dalbergia*, *Bombax*, *Pterocarpus*, *Cratoxylon*, *Vitex*, *Schleichera*, *Grewia*, and *Dillenia* spp. Ground cover, consisting of shrubs and creepers such as *Viburnam*, *Ixora*, *Harrisonia*, and *Congea*, was often dense in the rainy season but more open after dry season fires.

(2) Dry deciduous dipterocarp forest, comprising 23% of the study area, had a more open canopy and dominant tree genera that included *Shorea*, *Dipterocarpus*, *Terminalia*, *Lithocarpus*, *Lagerstroemia*, and *Eugenia*. Ground cover consisted of grasses such as *Schleria* and *Imperata*. This forest type was at least partially maintained by annual fires as described by Stott (1986, 1988).

(3) Dry evergreen forest, comprising 35% of the study area, was a denser forest type found on both sloping ground above 600 m, and along permanent waterways from 400–600 m. Major tree genera at lower elevations included *Paranephelium*, *Hopea*, and *Dipterocarpus*; at elevations of 600–1000 m, tree genera included *Polyalthia*, *Dipterocarpus*, and *Bacaurea*; at elevations 800–1000 m, tree genera included *Cinnamomum* and *Musa*. Ground cover, consisting mainly of seedlings and annuals, was dense only in gap areas.

(4) Hill evergreen rain forest, comprising only 7% of the study area, was found over 1000 m on the top of Khao Khieo Mountain. It was dominated by trees of the family Fagaceae, namely *Quercus*, *Lithocarpus*, and *Castanopsis*.

Temperature and rainfall records from 1983–1987 indicated April was the hottest month averaging 27.5°C (range: 24.9–34.2°C), and December the coolest month averaging 19.2°C (range: 13.4–24.7°C). October was the wettest month

with an average rainfall of 335 mm (range: 194–703 mm), and January the driest month averaging 2.6 mm rainfall (range: 0–13 mm). Fire season was generally from December through March or April (Stott 1986). During parts of the dry season, many waterways dried up causing local drought conditions; during the wettest months, there was localized flooding.

METHODS

The presence of particular carnivore species and their relative abundance was assessed by trapping, visual sightings, and identification of spoor. Box traps were placed along roads and trails where spoor of carnivores were observed (Rabinowitz 1989). Roads, trails, and waterways were walked regularly to collect and record faeces, scrapes, and tracks.

Food habits were assessed through the analysis of faeces known to be from carnivore species. The most readily identifiable faecal remains were hairs. These were examined visually and/or by microscopic comparison with a reference collection of hairs obtained from skins stored at the National Research Council of Thailand (NRCT), Bangkok. Other body parts found in the faeces and used for identification included: pieces of mandible with incisors and cheek teeth from rodents; scales from pangolin, lizard, and snakes; claws from hog badger and lizards; nails from primates; hooves from barking deer; feathers from birds; exoskeletal remains from crabs and insects. Body parts were identified by comparison with the NRCT collection or with preserved specimens at the Khao Nang Rum Research Station, and through the use of keys, distribution maps, and descriptive data presented in Lekagul & McNeely (1977).

Quantification of food items found in the faeces is presented in terms of frequency occurrence (the number of times a particular species is found in relation to all prey items identified). Because faeces could not often be assigned to a particular species, they were grouped as belonging to either large or small carnivores. Large carnivore faeces were those with average diameters of 2 cm or more; small carnivore faeces were those with average diameters less than 2 cm. This classification allowed the separation of carnivores into two general size categories, less than or greater than 10 kg in weight ($X^2 = 9.24$, DF = 1, prob. = 0.002), and helped single out important food items for the more diverse group of smaller carnivores. Earthworms were occasionally identified in small carnivore faeces but were improperly recorded. They are listed as a prey item but were not used in calculations involving frequency of occurrence. Data from faeces and carnivore sightings in other parts of the sanctuary were used for comparison with data from the study area.

RESULTS AND DISCUSSION

Twenty-one carnivore species of five families were found in the 100 km^2 study area around Khao Nang Rum (Table 1). Five additional carnivore species were

Table 1. List of Carnivora that occur around Khao Nang Rum Research Station in Huai Kha Khaeng Wildlife Sanctuary, Thailand. Taxonomy follows Lekagul & McNeely (1977).

	Common name	Weight (kg)[1]	Evidence[2]
Canidae			
Canis aureus	Asiatic jackal	8–9	1
Cuon alpinus	Asian wild dog	10–20	1
Family Ursidae			
Selenarctos thibetanus	Asiatic black bear	100–160	3
Helarctos malayanus	Malayan sun bear	40–60	2
Family Mustelidae			
Martes flavigula	Yellow-throated marten	2–3	1
Arctonyx collaris	Hog badger	7–14	1
Aonyx cinerea	Small-clawed otter	1–3	2
Family Viverridae			
Viverricula malaccensis	Small Indian civet	2–4	1
Viverra zibetha	Large Indian civet	8–9	1
Viverra megaspila	Large spotted civet	8–9	3
Arctogalidia trivirgata	Small-toothed palm civet	2–3	1
Paradoxurus hermaphroditus	Common palm civet	2–5	1
Paguma larvata	Masked palm civet	3–5	1
Arctictis binturong	Binturong	9–20	1
Herpestes urva	Crab-eating mongoose	3–4	1
Family Felidae			
Felis bengalensis	Leopard cat	3–5	1
Felis chaus	Jungle cat	4–6	3
Felis temminicki	Asian golden cat	12–15	3
Neofelis nebulosa	Clouded leopard	16–23	3
Panthera pardus	Asiatic leopard[3]	45 -75	1
Panthera tigris	Tiger	180–250	2

[1] From Lekagul & McNeely (1977).
[2] 1 = Sighting by authors; 2 = Observed evidence (spoor, marks, etc.); 3 = Sighting by workers.
[3] Both spotted and black colour phases observed.

recorded in adjacent parts of the sanctuary (Table 2). The carnivore community within the study area was feeding on at least 34 mammalian prey species from 16 families, as well as birds, lizards, snakes, crabs, fish, insects, earthworms, fruit, and grass (Tables 3 and 4). Because most of the faeces were collected along roads

Table 2. Additional Carnivora recorded from nearby areas of Huai Kha Khaeng Wildlife Sanctuary, Thailand, but not confirmed in Khao Nang Rum study area. Taxonomy follows Lekagul & McNeely (1977).

	Common name	Weight (kg)[1]
Family Mustelidae		
Melogale personata	Burmese ferret-badger	1–3
Lutra perspicillata	Smooth-coated otter	7–11
Family Viverridae		
Herpestes javanicus	Javan mongoose	0.5–1
Family Felidae		
Felis viverrina	Fishing cat	7–11
Felis marmorata	Marbled cat	2–5

[1] From Lekagul & McNeely (1977).

Table 3. Frequency of occurrence of animal species identified in large carnivore faeces around Khao Nang Rum (KNR) (N = 438) and other areas (N = 167) of Huai Kha Khaeng Wildlife Sanctuary, Thailand. Mammal taxonomy follows Lekagul & McNeely (1977).

Species	KNR Station		Other areas	
	(N)	(%)	(N)	(%)
Cervidae				
Muntiacus muntjak	192	44.0	109	65.0
Cervus unicolor	28	6.4	2	1.2
Suidae				
Sus scrofa	24	5.5	9	5.4
Cercopithecidae				
Macaca nemestrina	4	1.0	2	1.2
Macaca spp.	22	5.0	8	4.8
Presbytis phayrei	13	3.0	6	3.6
P. cristata	1	0.2		
Hylobatidae				
Hylobates lar	3	0.7		
Hystricidae				
Hystrix hodgsoni	37	8.4	7	4.2
Atherurus macrourus	6	1.4	1	0.6
Mustelidae				
Arctonyx collaris	22	5.0	4	2.4
Viverridae				
Paguma larvata	1	0.2	2	1.2
Arctictis binturong	3	0.7		
Canidae				
Canis aureus	1	0.2		
Manidae				
Manis javanica	6	1.4		
Rhizomyidae				
Rhizomys sumatrensis	7	1.6		
Sciuridae				
Ratufa bicolor	3	0.7	1	0.6
Callosciurus spp.	1	0.2		
Callioscriurus flavimanus			1	0.6
Petaurista petaurista	1	0.2		
Muridae				
Maxomys surifer	6	1.4	1	0.6
Leopoldamys sabanus	1	0.2	1	0.6
Unidentified spp.	4	0.9	3	1.8
Bird	4	0.9	1	0.6
Lizard	6	1.3		
Snake	4	0.9	1	0.6
Crab	1	0.2		
Medium-large mammal	2	0.4	2	1.2
Small mammal	2	0.4		
Unknown mammal	33	7.5	6	3.6

and trails, the proportions of different prey species found in the faeces are biased in favour of those carnivore species that often travelled such routes. This bias was especially prevalent with the large carnivore faeces; 63% of those collected within the study area, and 84% of those collected outside the study area, were known to be from large cats, primarily leopards, *Panthera pardus* (Rabinowitz 1989).

Table 4. Frequency of occurrence of animal species identified in small carnivore faeces around Khao Nang Rum (KNR) (N = 657) and other areas (N = 98) of Huai Kha Khaeng Wildlife Sanctuary, Thailand. Mammal taxonomy follows Lekagul & McNeely (1977) with changes made by Musser (1979, 1981), and Musser & Newcombe (1983) to the genus *Rattus*.

Species	KNR Station		Other areas	
	(N)	(%)	(N)	(%)
Cervidae				
Muntiacus muntjak	23	3.2	5	5.0
Cervus unicolor			1	1.0
Suidae				
Sus scrofa	2	0.3		
Cercopithecidae				
Macaca spp.	7	1.0	2	2.0
Presbytis phayrei	6	0.8	1	1.0
Hylobatidae				
Hylobates lar	1	0.1		
Leporidae				
Lepus peguensis	1	0.1		
Hystricidae				
Hystrix hodgsoni	6	0.8		
Atherurus macrourus	1	0.1		
Mustelidae				
Arctonyx collaris	5	0.7	6	6.1
Viverridae				
Paguma larvata	1	0.1		
Herpestes urva	1	0.1		
Canidae				
Canis aureus	3	0.4		
Manidae				
Manis javanica	3	0.4		
Rhizomyidae				
Rhizomys sumatrensis	5	0.7		
Cannomys badius	51	7.2	8	8.1
Sciuridae				
Ratufa bicolor	1	0.1		
Callosciurus spp.	9	1.3	3	3.0
Callosciurus flavimanus	2	0.3	1	1.0
Petaurista spp.	3	0.4		
Petaurista petaurista			1	1.0
Menetes berdmorei	22	3.1	5	5.0
Tamiops mcclellandi	1	0.1		
Hylopetes phayrei	1	0.1		
Tupaiidae				
Tupaia glis	8	1.1	2	2.0
Erinaceidae				
Hylomys suillus	2	0.3		
Soricidae				
Crocidura spp.	1	0.1	1	1.0
Muridae				
Maxomys surifer	108	15.2	10	10.1
Leopoldamys sabanus	9	1.3		
Rattus rattus	11	1.5	2	2.0
Unidentified spp.	106	14.9	9	9.1
Mus spp.			1	1.0
Chiropodomys gliroides	1	0.1		

Table 4. *Continued*

Pteropodidae			1	1.0
Bird	15	2.1	3	3.0
Lizard	40	5.6	1	1.0
Monitor lizard	1	0.1		
Snake	35	4.9	1	1.0
Crab	19	2.7	1	1.0
Medium-large mammal	1	0.1		
Small mammal	55	7.7	8	8.1
Unknown mammal	15	2.1	1	1.0
Fish	1	0.1		
Insects	41	5.8	1	1.0
Seeds	88	12.4	24	24.2
Earthworms[1]				

[1] Occasionally seen in faeces but recorded irregularly.

Large carnivores

Spoor and sightings of large cats, particularly leopards, were the most frequently observed evidence of larger carnivores. Capture and tracking indicated a resident big cat population of four leopards (three spotted, one black) and one tiger, *Panthera tigris*, in the 100 km^2 study area (Rabinowitz 1989). Other large cats utilized the area but were not resident.

Evidence of dholes, *Cuon alpinus*, was not as frequently encountered as that of the large cats, but sightings indicated a density of at least twice that of the leopards. Dholes were observed six times during the study; a lone individual was observed on four occasions, a pair was seen together once and, on one occasion, a pack of 'about ten' were reported feeding on a sambar deer at the edge of the study area. Sightings occurred in all forest types during the daytime hours and were widely spread throughout the study area.

In areas of more open grassland habitat, where dholes coexist with tiger and leopard, they often occur in larger packs and do not show a predilection for travelling along roads (Rice 1986). In such areas, packs of dholes can chase and run down larger ungulates (Johnsingh 1983) and range up to 40 km^2 (Johnsingh 1982). In areas which are more heavily forested, dholes take a greater proportion of small prey items such as rodents, and thus are more successful hunting as individuals or in small groups (Cohen *et al.* 1978). Sightings of mostly solitary individuals in the study area may be indicative of feeding behaviour that includes large numbers of small prey items, and thus smaller home ranges (Gittleman & Harvey 1982).

Evidence of the two bear species was rare, although signs of the Malayan sun bear, *Helarctos malayanus*, were observed more often in the study area than the Asiatic black bear, *Selenarctos thibetanus*, which was reported only once. Occasional bear faeces were found in the evergreen forest during the rainy season. Thought to prefer 'thick jungle' (Yin 1967), the limited areas of evergreen forest and seasonal burning might have helped restrict bear densities. It was felt that both species were relatively uncommon in the study area.

The Asian golden cat, *Felis temminicki*, and the clouded leopard, *Neofelis nebulosa*,

were each sighted only once during the study. However, track evidence indicated at least one medium-sized cat regularly using roads and trails in parts of the study area. Both species were thought to be resident in the area at low densities.

Binturongs, *Arctictis binturong*, a secretive, semi-arboreal species inhabiting dense, tall forest (Yin 1967), rarely travelled along roads and trails. A chance sighting along Huai Chang Tai waterway, and the discovery of their remains in several large carnivore faeces suggested a moderate abundance and a preference for the denser evergreen forest areas.

Hog badger, *Arctonyx collaris*, was relatively common in the study area. It was sighted on several occasions and its remains were frequently found in carnivore faeces (Tables 3 and 4).

Barking deer, *Muntiacus muntjak*, was the most common prey species identified in the large carnivore faeces (N = 438), accounting for 44% of the total. Macaques, *Macaca* spp., sambar deer, *Cervus unicolor*, wild boar, *Sus scrofa*, crestless Himalayan porcupine, *Hystrix hodgsoni*, and hog badger *Arctonyx collaris*, were important secondary prey items, together accounting for 31.3% of the total (Table 3). These preferences were similarly shown in faeces collected outside the study area (N = 167).

In one instance, tiger and leopards were observed feeding on a banteng, *Bos javanicus*, carcass that had been killed by hunters, while on another occasion, tiger and leopard tracks indicated feeding over a gaur, *Bos gaurus*, carcass. Yet neither gaur nor banteng was ever identified in faecal samples. This might have been due to the difficulty of finding identifiable remains from large meaty meals and could have contributed to the relatively large 'unknown' category (7.5%) for the large carnivore faeces (Table 3).

The fact that barking deer seemed to be eaten more frequently than other ungulates, might have been due to several factors. Leopards, which contributed the largest number of large carnivore faecal samples, prefer prey items less than 50 kg in size (Schaller 1967, Seidensticker 1976, Sunquist 1981). Sambar deer, gaur and banteng were too large to be easily taken by leopards and occurred at lower densities than barking deer (Srikosamatara, in press). Wild boar were sparse and patchy in the area, due to both a preference for wetter forest and more permanent waterways (Lekagul & McNeely, 1977) and because they were a favourite target of illegal hunters in the area.

Small carnivores

The most common sightings and spoor of the small carnivores along roads and trails were from the leopard cat, *Felis bengalensis*, Asiatic jackal, *Canis aureus*, and some of the civet species. Among the civets, the large Indian civet, *Viverra zibetha*, was seen along roads most often, although the other terrestrial and semi-terrestrial civets were also captured or occasionally seen on the ground (Rabinowitz, in press (a)). Jackals were encountered on several occasions, usually alone, though sometimes in pairs, observations similar to those in parts of India, where they were known to feed primarily on rodents (Schaller 1967, Rice 1986). All the

above species were considered relatively common in the study area.

The arboreal small-toothed palm civet, *Arctogalidia trivirgata*, was sighted on six occasions, always in trees in the evergreen forest (Rabinowitz, in press (a)). This species, like the binturong, was thought to be moderately abundant in areas of appropriate habitat.

Sightings and sign of yellow-throated marten, *Martes flavigula*, and crab-eating mongoose, *Herpestes urva*, indicated they were relatively common in the study area but, because of their restricted habitat preferences (Lekagul & McNeely 1977), probably did not contribute significantly to the smaller carnivore faeces that were collected.

A latrine site from what was believed to be the small-clawed otter, *Aonyx cinerea*, was found along a small tributary of Huai Chang Tai. Faeces observed at these latrine sites contained only crab remains.

In small carnivore faeces (N = 571), the murid rodents accounted for 33% of all prey items identified. The yellow rajah rat, *Maxomys surifer*, and the bay bamboo rat, *Cannomys badius*, were the two most frequently encountered species, accounting for 22.4% of the prey items (Table 4). *Maxomys surifer* was the most commonly captured small mammal species in the study area (Walker & Rabinowitz, in preparation), while *Cannomys badius*, weighing nearly 1 kg, was relatively abundant and contributed significantly to the small mammal prey biomass available to carnivores (Srikosamatara, in press). The difficulty of identifying some of the murid rodents based on hair and skeletal fragments alone, contributed to a large unidentified category (14.9%) for this group.

Non-mammal animal prey accounted for 21.3% of prey items, with lizards (5.7%) and insects (5.8%) comprising over half of this category. Seeds from edible fruits comprised 12.4% of total food items. At least 10% of the small carnivore faeces were known to be from one of the six civet species identified in the study area. These civets were feeding on at least 18 different fruiting tree species (Rabinowitz, in press (a)).

The food preferences indicated from small carnivore faeces in the study area (N = 657) appeared similar to those from the much smaller sample of faeces collected from other parts of the sanctuary (N = 98) (Table 4). The occurrence of large prey species in some small carnivore faeces could have been due to scavenging of large carnivore kills by species such as jackals and civets.

Carnivore community structure

The diverse carnivore community in the study area is a result of a relatively abundant and diverse prey community. While prey abundance is an important factor for carnivore species densities, the availability of prey in different size classes is of greater importance for maintaining a stable and complex carnivore community (Seidensticker 1976, Wilson 1975). Despite what appears to be considerable overlap in food preferences among various carnivore species in the study area, predators take prey that is dictated, in part, by their own size (Rosenzweig 1966). Both the mean and range of food size can increase with an

increase in predator size (Wilson 1975).

The relative abundance and behaviour of particular carnivore species is also influenced by habitat configuration. The dry tropical forest mosaic in the study area, ranging from open dipterocarp to denser evergreen and mixed deciduous forest, allows for a greater carnivore diversity. Open, woodland species such as the common palm civet, can exist alongside dense forest species such as the binturong. However, such a mosaic also creates a patchiness that restricts the movements and abundance of small, specialized species, such as the arboreal small-toothed palm civet, and even of small, wider-ranging species such as the leopard cat (Rabinowitz, in press (b)). The rare, forest-dwelling marbled cat, *Felis marmorata*, was not even documented in the study area, although it was known to be in adjacent areas of more extensive mixed deciduous-evergreen forest.

Large, wide-ranging species can also be affected by the habitat. Leopards were more abundant than tigers in the study area, despite the reverse being true in other parts of the sanctuary. This is because leopards can use trees, survive on smaller prey, hunt in secondary growth and burnt areas, and survive with less water than the tiger (Johnsingh 1983). The two bear species periodically used the evergreen forest patches in the study area but preferred larger areas of mixed evergreen forest in other parts of the sanctuary.

In order to protect and maintain natural biodiversity, there must be a clear understanding of community structure and dynamics. Carnivores are some of the most wide-ranging and specialized members of the wildlife community and often influence the abundance and behaviour of the prey species upon which they feed. Yet they are often one of the least understood components of forest systems. Detailed knowledge of the carnivore community is critical in helping formulate a balanced, long-term forest management policy for any protected area.

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