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Food Habits of Leopard in Tropical Moist Deciduous Forest of Dudhwa National Park, Uttar Pradesh, India

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ABSTRACT

Scats analysis was used to determine the food habit of leopard (*Panthera pardus fusca*) in the tropical moist-evergreen forest of Dudhwa National Park (DNP) Northern India. A total of 74 scats were collected and analyzed. Scat contents were analyzed in terms of relative frequency of occurrence and the relative prey biomass consumed. A minimum of 20 different prey species were identified. Diet diversity in leopard scats was found to be 1.045. The average weight of the animal consumed by leopard in the intensive study area was 45 kg. In terms of biomass, the most important single prey species was chital (*Axis axis*) making up to 19.75% of biomass consumed followed by rodents (17.35%) and Nilgai (11.44%). Wild ungulates together accounted for 28.44% of all prey species consumed. Domestic livestock contributed only 5.08%. Study showed that leopard avoid direct competition from tiger by using peripheral forest in terms of space and by segregating prey species in terms of size. The ability of leopard to exploit smaller prey species gives them advantage over tiger when faced with human induced habitat changes.

Key Words: Diet Diversity, *Panthera pardus*, Scat Analysis, Biomass, Predation.

INTRODUCTION

The leopard (*Panthera pardus fusca* Linnaeus) is the most widespread member of the large felids (Myers 1986) and occupy a broad range of habitats, from rain forest to desert and from fringes of urban areas to remote mountain ranges (Nowell and Jackson 1996) illustrating that they can live wherever there is sufficient cover and adequately sized animals (Bertram 1999). This is largely due to its highly adaptable hunting and feeding behavior (Bertram 1999). They are well known as generalist predators (Nowell and Jackson 1996), which makes them able to live and thrive almost anywhere (Brander 1982). The leopard will kill and eat anything it can overpower with safety (Prater 1980). Leopards have the broadest diet of larger predators with 92 prey species recorded in sub Saharan Africa (Henschel et al. 2005). It is therefore not surprising that leopards have been recorded preying on species as small as birds and rodents (Ott 2004). This behavioral adaptation of dietary flexibility permits it to compete successfully with other large predators. Food habits comprise one of the major determinants of various life history strategies in carnivores including spacing pattern, movement, habitat selection, social structure, success of reproduction and geographical distribution (Krebs 1978, Bekoff et al. 1984, Sunquist and Sunquist 1989). Thus information on leopard food habits from disturbed and protected habitats would be critical for its management. The present study was carried out to investigate the food habits of leopard in Dudhwa National Park.

STUDY AREA

The study was conducted in tropical moist deciduous forest of Dudhwa National Park (DNP), which lies (28°18𝖭 N - 28°42𝖭 N, 80°28𝖤 E - 80°57𝖤 E) in the state of Uttar Pradesh and covers an area of 614.32 km^2. The study was carried out from December 2005 to April 2007. The annual climate cycle of DNP

includes three seasons: Summer (mid-March to mid-June), monsoon (mid-June to mid-October) and winter (mid-October to mid-March) and the area receives a mean annual rainfall of 150 cm. The temperature ranged from 8°C in winter to 45°C in summer during the study. The vegetation is chiefly moist deciduous forest, dominated by Sal (*Shorea robusta* Roxb.). Typical of terai, these forests are interspersed with tracts of low lying grasslands which tend to get flooded during the monsoon. About 60% of the park is woodland providing food and shelter to a vast variety of animals. These grasslands are the prominent feature of the National Park and cover about 19% of the National Park and can broadly be classified into two types: wet low lying areas are dominated by tall grass species such as *Schlerostachya fusca* Linn., *Phragmites karka* Trin., *Arundo donax* Linn. and *Saccharum spontaneum* Linn., while the drier high grounds are dominated by grasses like *Imperata cylindrica* Linn, *Desmostachya bipinnata* Miers, *Erianthus munja* Michx, *Cymbopogon martini* Linn (Sankaran 1990, Kumar et al. 2001). Potential prey species of tiger and leopard in the study area include barasingha (*Cervus duvauceli duvuaceli* Cuvier), chital (*Axis axis* Erxleben), nilgai (*Bosephalus tragocamelus* Pallas), wild pig (*Sus scrofa* Linnaeus), hog deer (*Porcunis axinus* Dufresne), barking deer (*Muntiacus muntjac Zimmermann*), common langur (*Presbytis entellus* Zimmermen), rhesus macaque (*Macaca mulatta* Zimmerann), Indian porcupine (*Hystrix indica* Kerr), rufous-tailed hare (*Lepus nigricollis ruficaudatus*) and hispid hare (*Caprolague hispidus* Pearson). Domestic livestock (cattle, buffalo and goat) occur in areas outside the National Park. Apart from leopard, tiger (*Panthera tigris* Linnaeus) and sloth bear (*Melarsus ursinus* Shaw) are two other large predator in the study area.

MATERIALS AND METHODS

Scat analysis is an indirect, non-destructive and cost effective method (Schaller 1967, Sunquist 1981, Johnsingh 1983) for recording frequency of occurrence of prey items in the diet of a carnivore. Leopard scats were collected whenever encountered. The forest roads and trails known to be used for scat deposition by large carnivores (Sunquist 1981, Johnsingh 1983, Karanth and Sunquist 1995) were searched by one of the author (KA) and field assistants. These scats were identified from other predators, particularly those of tiger, based on associated signs and tracks, size and appearance of scat. The scats of leopard have higher degree of coiling as compared to tiger and relatively lesser distance between the two successive constrictions within a single peace of scat. Scats which could not be identified were excluded from the analysis. Collected scats were washed and the remains such as hair, bones, hooves, quills and teeth of the prey consumed were separated for species identification following Sunquist (1981), Mukherjee et al. (1994a and 1994b), Karanth and Sunquist (1995), Biswass and Sankar (2002). Hairs from scats were compared with reference material taking their general appearance, colour, length, width and medullary configuration into consideration to identify the prey species. Quantification of the diet was based on both frequency of occurrence (proportion of total scats in which an item was found) and percent occurrence (number of times a specific items was found as a percentage of all items found) following Ackerman et al. (1984).

For estimation of sample size, we followed Mukherjee et al. (1994a and 1994b), 14 leopard scats were chosen randomly and their contents analyzed. This was continued until all the 74 scats in the sample had been analyzed. The cumulative frequency of occurrence of different prey species in the leopard scats over successive randomly drawn scats were then assessed to infer effect of sample size on the final results. Diet diversity in the leopard scats was calculated using Shannon Weiner Index (H$\mathbb{N}$) by using the formula

$$H\mathbb{N} = -\mathbf{E}pi \times \log pi$$

where, pi is the proportion of individual prey species.

Estimation of Biomass

Although frequency of occurrence of mammalian prey species in carnivore scats is most frequently used parameter in predation studies (Karanth and Sunquist 1995), but if prey sizes are highly variable, frequency of occurrence can considerably distort the relative numbers of different prey types in the diet. Therefore a method developed for mountain lions (*Puma concolor*) by Ackerman et al. (1984) was used to calculate the total biomass consumed of each prey species, assuming that the digestive system and feeding habits of leopard and mountain lion are comparable. Ackerman et al. (1984) conducted feeding trials and found a linear relationship between ingested biomass per deposited scats (Y) and the live weight of prey species (X). The

resulting linear relationship Y = 1.98 + 0.035 X can then be applied in the form of a correction factor, to convert frequency of occurrence to relative biomass consumed. The live weights of individuals of wild prey species were taken from Karanth and Sunquist (1995), Khan et al. (1996), and Henschel et al. (2005) and that of domestic livestock from Schaller (1967). To calculate the relative biomass consumed, a corrected frequency of occurrence was used to take account of multiple prey species occurring in a single scat because the quantity of meat consumed for a given species will decrease as the number of prey species per scat increases (Henschel et al. 2005). The corrected frequency of occurrence was obtained by counting each prey items as 1/2, if two prey items occurred in one scats, as 1/3, if three species occurred and so on (Karanth and Sunquist 1995).

RESULTS

Sample Size

We estimated the minimum number of scats required to adequately represent the diet of leopard in DNP. Initially a sample of 14 scats was chosen with a successive draw of 5 scats from a sample size of 74 scats and their contents analyzed (Table 1). We found that 59 scats were sufficient to reflect the diet of leopard in DNP. Thus we suggest that a minimum of 65 scats should be taken to understand the pattern of prey consumed by leopard in the intensive study area of DNP.

Species Composition of Leopard's Diet

74 scats, analyzed in this study, contained 103 different prey items. This yields an average of 1.43 prey items per scat. Although some species such as small Indian civet (*Viverricula indica* Desmarest), common mongoose (*Herpestes edwardsi* Geoffrey), small Indian mongoose (*Herpestes auropunc-tatus* Hodgson) could not be differentiated in scat analysis and therefore these species have been grouped together as small mammals. The average weight of an animal consumed by leopard in the intensive study area was 45 kg reflecting a preference for medium size prey species.

A total of 20 prey species were identified with diet diversity of 1.045, and it is probable that total number is likely to be more, because in some cases it was not possible to identify them at species level. The remains

Table 1. Percent occurrence of prey species in Leopard scats as seen through increments of five scats in DNP, Uttar Pradesh. CH = Chital, SD = Swamp deer, BD = Barking deer, HD = Hog deer, SB = Sambar, WB = Wild boar, NG = Nilgai, RD = Rodents, SM = Small mammal, HR = Hare, DG = Dog, CW = Cow, BF = Buffalo, PP = Porcupine, BD = Bird, LD = Lizard, SN = Snake, UN = Unknown, JK = Jackal, LN = Langur.

Scat No.	CH	SD	BD	HD	SB.	WB	NG	RD	SM	HR	DG	CW	BF	PP	BD	LD	SN	UN	JK	LN
14	33.33	16.67	0	8.33	8.33	25	8.33	8.33	16.67	16.67	0	16.67	0	0	8.33	8.33	8.33		8.33	0
19	23.52	17.64	5.88	5.88	5.88	17.64	5.88	11.76	11.76	11.76	0	23.52	0	0	5.88	5.88	5.88	0	5.88	0
24	22.72	13.63	4.54	4.54	4.54	13.63	13.63	9.09	9.09	13.63	0	22.72	0	0	13.63	4.54	4.54	0	4.54	0
29	25.92	14.81	3.7	3.7	3.7	11.11	11.11	11.11	7.4	11.11	0	18.51	0	0	14.81	3.7	3.7	3.7	3.7	0
34	21.87	18.75	6.25	3.12	6.25	12.5	12.5	12.5	6.25	9.37	0	12.5	0	0	15.62	3.12	3.12	3.12	3.12	3.12
39	27.02	16.21	5.4	2.7	8.1	10.81	13.51	16.21	5.4	8.1	0	13.51	0	0	16.21	5.4	2.7	2.7	2.7	2.7
44	30.95	14.28	4.76	2.38	4.76	9.52	11.9	16.67	4.76	7.14	0	11.9	0	0	11.9	4.76	2.38	2.38	2.38	4.76
49	27.65	12.76	4.25	2.12	4.25	8.51	10.63	25.53	4.25	6.38	0	10.63	0	0	17.02	4.25	2.12	2.12	2.12	4.25
54	25	11.53	3.84	3.84	3.84	7.69	7.69	26.92	5.76	9.61	0	9.61	0	1.92	15.38	3.84	1.92	1.92	1.92	3.84
59	22.8	10.52	3.5	1.75	3.5	7.01	7.01	28.07	7.01	8.77	1.75	8.77	1.75	1.75	14.03	3.5	1.75	1.75	1.75	3.5
64	22.58	9.67	3.22	1.61	3.22	6.45	6.45	32.25	6.45	8.06	1.61	8.06	1.61	1.61	16.12	3.22	1.61	1.61	1.61	3.22
69	20.89	8.95	2.98	1.49	2.98	5.97	7.46	32.83	5.97	8.95	1.49	7.46	1.49	1.49	14.92	4.47	1.49	1.49	1.49	2.98
74	20.83	8.33	2.77	1.38	2.77	5.55	6.94	34.72	5.55	8.33	1.38	8.33	1.38	1.38	13.88	4.16	1.38	1.38	1.38	2.77

of rodents with major proportion of Indian gerbille (*Tatera indica* Hardwicke) were found 29.86% in the diet of leopard. Wild ungulate species together accounted for 28.44% of all prey species consumed. In two scats scales of monitor lizard and in one scat scales of an unidentified snake were also found accounting for 0.69% and 2.54%, respectively. Domestic livestock contributed 5.08% and 2.32% of the prey items could not be identified. In two scats remains of leopard hair and grasses were also found. 66.67%, 26.39% and 6.94% of the scats contained one, two and three types of hair respectively. The count and percentage occurrence of different prey species derived from scats are shown in Table 2.

Table 2. Composition (%) of the leopard diet in the Dudhwa National Park, Uttar Pradesh.

Prey species	Count of occurrence	Frequency of occurrence	Percentage frequency
Chital	17	13.66	18.97
Barasingha	6	3.49	4.85
Sambar	3	2	2.78
Hog deer	1	0.5	0.69
Barking deer	2	0.84	1.17
Wild boar	4	1.49	2.07
Nilgai	6	3.34	4.64
Langur	2	1.34	1.86
Cow	6	4.66	3.69
Buffalo	1	1	1.39
Dog	1	1	1.39
Jackal	1	1	1.39
Porcupine	1	1	1.39
Wild birds	10	4.84	6.72
Hare	6	5	6.94
Small Mammal	5	3.34	4.64
Rodent	25	21.5	29.86
Lizard	3	1.83	2.54
Unidentified snake	1	0.5	0.69
Unknown	4	1.67	2.32

74 scats containing 103 food items (1.43 items per scat).

Relative Biomass Consumed

In terms of relative biomass consumed chital and rodents are the two most important diet items for leopards in the study area, making up 19.75% and 17.35% of total biomass consumed. Nilgai, barasingha and sambar contributed 11.02%, 9.41% and 6.10%, respectively. Hare and wild birds contributed 4.02% and 3.77% of relative biomass consumed. Domestic livestock made up 13.65% of the biomass of leopards diet (Table 3). In terms of biomass leopard consumed small and medium size prey species (Figure 1) as compared to large size (>175 kg) prey species.

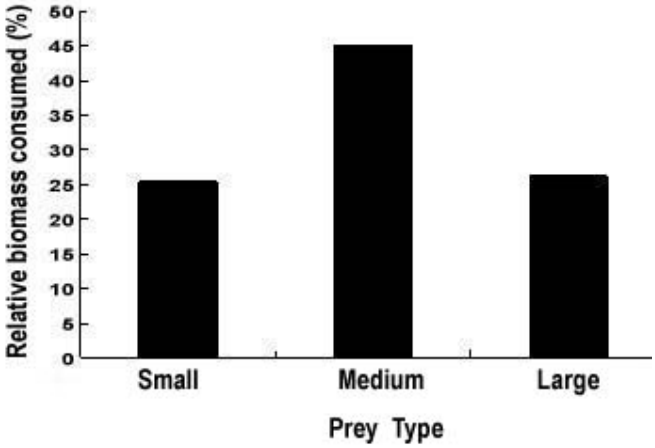

Figure 1. Distribution of different prey type classes in the diet of leopard. (Small >5, Medium 5-175, Large <175 kg).

DISCUSSION

The number of prey species found in the diet of leopard was 20 in DNP and it is the most diverse dietary spectrum recorded in India so far as Karanth and Sunquist (1995) and Ramakrishnan et al. (1999) recorded only 12 species and Sankar and Johnsingh (2002) recorded 11 species. Comparatively broader prey spectrum has been documented in African tropical forest (Hoppe-Dominik 1984, n=32 species, Hart et al. 1996, n=31 species, Ososky 1998, n=25 species, Ray and Sunquist 2001, n=17 species, Henschel et al. 2005, n=30 species and Bodendorfer et al. 2006, n=37 species). Owing to the opportunistic hunting behavior of leopard, the total number of prey species recorded depends very much on sample size (Bodendorfer et al. 2006). Chital was the most important prey species for leopards in the study area contributing 18.97% of diet and 19.75% of total biomass consumed. When compared with studies from other areas, the predation rate on this species by leopard was lower

Table 3. Calculation of relative biomass and ratio of individual consumed by a leopard population, based on 74 scats collected in Dudhwa National Park, Uttar Pradesh.

Prey	Average Body weight (X) in kg	Collectable scat/kill (a)	Prey Biomass consumed (b)	% Relative Biomass consumed (c)	No. of Individuals killed/100 scats
Chital	45.0	3.56	48.56	19.75	1.08
Barasingha	140.0	6.88	24.01	9.77	0.17
Sambar	166.0	7.79	15.58	6.34	0.09
Hog deer	25.0	2.86	1.43	0.58	0.06
Barking deer	20.0	2.68	2.25	0.92	0.11
Wild boar	32.0	3.10	4.62	1.88	0.14
Nilgai	184.0	8.42	28.12	11.44	0.15
Langur	8.0	2.26	3.03	1.23	0.38
Cow	180.0	8.28	38.58	8.96	0.12
Buffalo	273.0	11.54	11.54	4.69	0.04
Dog	12.0	2.40	2.40	0.98	0.20
Jackal	7.0	2.23	2.23	0.91	0.32
Porcupine	8.0	2.26	2.26	0.92	0.28
Wild birds	0.251	1.99	9.63	3.92	38.35
Hare	3.0	2.09	10.43	4.24	3.48
Small mammal	2.0	2.05	6.85	2.79	3.42
Rodent	0.113	1.98	42.66	17.35	377.48
Lizard	0.01	1.98	3.62	1.47	362.40
Snake	1.0	2.02	1.01	0.41	1.01
Unknown	5.0	2.16	3.60	1.46	0.72

a = Estimated weight of prey consumed per collectable scat (y = 1.980 + 0.035b), Total prey biomass consumed = 255.28.

than Kanha (Schaller 1967), Nagarhole (Karanth and Sunquist 1995) and Sariska (Sankar and Johnsingh 2002). Rodents as a whole were the second most important group, contributing 29.86% to diet of leopard and 17.35% of the total biomass consumed. The occurrence of rodents in scats of leopard in India has been documented by Sankar and Johnsingh (2002) and outside India (Grobler and Wilson 1972, Henschel et al. 2005). Rodents contribution in leopard diet was found to be 45.6% in Sariska which was 23.1% of the overall biomass consumed (Sankar and Johnsingh 2002). The reason for high contribution of rodents in leopards diets has been attributed to high rodent availability particularly the Indian gerbille (pers. obser.). Also the nocturnal habits of rodents makes them more vulnerable to leopard predation (Grobler and Wilson 1972). Birds and hare were the other important prey species. Leopard are known to prefer small to medium size prey within a weight range of 10-40 kg (Henschel et al. 2006) and such species are considered to be the energetically most profitable prey for the leopard (Sunquist and Sunquist 1989).

Domestic livestock contributed 5.08% to the diet of leopard. Livestock depredation by leopard was not recorded during this study. However livestock depredation by tiger was regularly recorded and once a leopard was found scavenging on cow killed by a tiger. The study recorded reptiles as a prey item and the same has been recorded in studies on felids elsewhere (Rabinowitz and Nottingham 1986, Emmons 1987, Nunez et al. 2000, Henschel et al. 2005). Predation on barasingha, sambar and wildboar was found to be low and it was probably due to their large body size, because leopard preferred medium sized prey species in all ecosystem in which they occur (Hayward et al. 2006). Presence of Nilgai, jackal and domestic dog in leopard scats indicated use of peripheral forest of the DNP as maximum numbers of scats were found in peripheral forest.

The diverse leopard diet showed that they have enough behavioral plasticity to take advantage of a wide variety of prey species like neo-tropics felids (Rabinowitz and Nottingham 1986, Emmons 1987, Taber et al. 1997) as prey choice is influenced by prey

availability, abundance and vulnerability (Emmons 1987, Nunez et al. 2000). The study showed that leopards ability of taking smaller prey species may give it an advantage over tigers, which mostly prey on large sized prey species in DNP (Ahmed 2007), because habitat change and decline of large prey species may place more pressure on tigers than leopard when faced with human induced habitat changes.

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