



Diet of Bengal Tigers (*Panthera tigris tigris*) in Chitwan National Park, Nepal

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ABSTRACT

We studied the diet of the Bengal tigers (*Panthera tigris tigris*) in Chitwan National Park, Nepal, by identifying 109 prey items from 85 tiger scats. Tigers in this region fed upon eight different mammal species. Chital (*Axis axis*) was the major prey with a frequency of 45% of the Tigers' diet. The occurrence of other prey species included sambar (*Cervus unicolor*, 23%), wild pig (*Sus scrofa*, 15%), hog deer (*Axis porcinus*, 9%), barking deer (*Muntiacus muntjak*, 4%), and gaur (*Bos gaurus*, 2%). Tigers also hunted livestock, but this prey comprised a small component of the relative biomass (buffalo 5% and cow 2%). Our study suggests that the tiger depends mostly upon wild prey for its subsistence in the Chitwan National Park, but will also sporadically hunt livestock.

KEYWORDS

chital, diet, livestock, scat analysis, Bengal tiger

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INTRODUCTION

The endangered Bengal tiger (*Panthera tigris tigris*) is one of the top predators of the forest and grassland ecosystems (McDougal 1977). Historically, tigers were distributed across the lowland Himalayan forests (Smith et al. 1998), but now exist only in the lowland forests on the slopes of the Siwalik range (< 1000 m) and among the rich alluvial grasslands and riverine forests in a series of valleys. Today, these belts of lowland forests have become highly fragmented due to the expanding human populations, increasing road construction, and other anthropogenic pressures, which have resulted in the fragmentation of the tigers' major habitat.

Tigers are solitary animals and they are capable of capturing a wide variety of prey from large prey such as adult gaurs (*Bos gaurus*, 450 kg) (Karanth and Sunquist 1995) to smaller prey such as langur (*Semnopithecus hector*, 8 kg) (Stoen and Wegge 1996). The diet of tigers includes predominantly deer species, which contribute up to 75% of the prey biomass

in most parts of its range (Stoen and Wegge 1996; Sunquist 1981; Wegge et al. 2009). In addition to wild prey, the tigers are known to prey on domestic livestock. When wild prey, especially medium and large-sized ungulates, become scarce due to population decline or seasonal migrations or human intervention, felids increase predation on livestock to survive (Zhang et al. 2013; Baker et al. 2008; Khorozyan et al. 2015). Because this predation inflicts economic loss on rural livelihoods, tiger populations are severely damaged by retaliatory and preventive persecution (Khorozyan et al. 2015). This increasing human-carnivore conflict particularly impacts small households near protected areas, challenging the synergy between rural development and biodiversity conservation (Khorozyan et al. 2015; Reddy and Yosef 2016).

Understanding the diet of tigers is essential for long term population management. Scat analysis provides information on prey consumed by large felids, which ultimately determines the prey distribution. Based on the variety of their diet

across their range, tigers appear to be non-selective predators, whose morphology and solitary hunting strategy imposes limitations on the prey it can capture most efficiently with minimal risk (Hayward et al. 2012). In this paper, our objective was to elucidate the proportion of wild prey compared to livestock in the diet of Bengal tigers in Chitwan National Park, Nepal.

1. MATERIALS AND METHODS

The Chitwan National Park (CNP) covers an area of 932 km² in lowland, Nepal (Fig. 1) and holds the largest population of tigers in the country (Karki et al. 2013). The park is adjacent to Parsa Wildlife Reserve (PWR) in the East and the Barandabhar corridor forests and Himalayan Mahabharat Mountains in the north. CNP accommodates 50 mammal species, over 526 bird species, 49 reptiles and amphibians, and 120 species of fish (Karki 2011).

We differentiated tiger scats from those of sympatric species by size, morphology, and associated signs such as tracks, pugmarks, and scrapes (Seidensticker 1976b; Sharma et al. 2005; Bagchi et al. 2003). Tiger scats are larger, with a lower degree of coiling and a relatively larger distance between two successive constrictions within a single piece of scat, and they are deposited on the grassy strips at the centre or edges of forest roads (Biswas and Sankar 2002; Andheria et al. 2007). We collected a total of 85 tiger scats during 2014 by opportunistic survey along forest roads and trails and along the grasslands

and river banks of the park area. Unidentified scats were not collected.

We washed the collected scats on a sieve under running water and separated indigestible prey remains such as hair, teeth, claws, and bones. A total of 20 hairs were randomly picked from each scat for slide preparation. We examined the mounted slides using a compound stereoscopic microscope under 400X magnification. We recorded our microscopic examination of the hair and their characteristics, such as medullary and cuticular patterns, and compared our observations with reference slides. We based our identification on the general appearance of the hair including its colour, relative length, relative width, texture, and medullary width as described by Moore et al. (1974); Ramakrishnan et al. (1999); Bagchi et al. (2003) and Bhattarai and Kindlmann (2012).

We used the correction factor developed by Ackerman et al. (1984) to estimate the relative proportion of biomass of different prey species consumed by tigers in the study area. The equation we used is: $Y = 1.98 + 0.035X$; where Y is the biomass of prey consumed (kg) to produce a single field collectable scat and X is the average body weight of the prey species (kg). We used the program SCATMAN to test the null hypothesis, which suggested prey selectivity by tigers (Link and Karanth 1994; Karanth and Sunquist 1995). To estimate the expected contribution of individual prey items, we performed 1000 bootstrap iterations using the program SCATMAN. When two prey species were detected in a scat, we counted each as

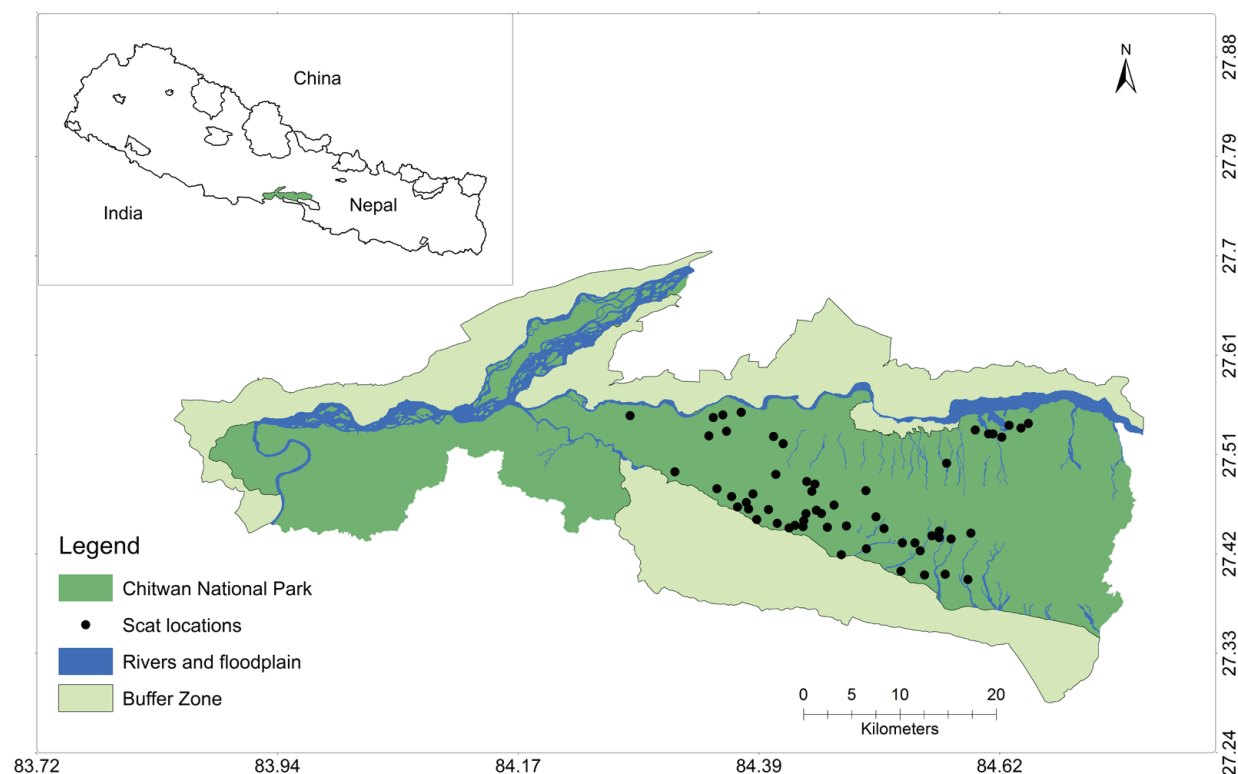


Figure 1. Chitwan National Park, Nepal.

0.5 (Biswas and Sankar 2002). We referred to both published and unpublished articles to determine the density of major prey species of the tiger in Chitwan National Park and sources of the mean live weight of the prey species (Dhakal et al. 2014; Dinerstein 1980; Ramesh et al. 2009). We followed published guidelines (Karanth and Sunquist 1995; Stoen and Wegge 1996) for relative biomass killed = (Frequency of Occurrence X Correlation Factor) / \sum (Frequency of Occurrence X Correlation Factor) and relative number of individuals killed by tigers = (Relative Biomass/Estimated Weight) / \sum (Relative Biomass/Estimated Weight).

2. RESULTS

We identified 109 prey items of eight different species in the 85 scats. Sixty tiger scats (70.58%) consisted of a single prey species, 23 scats (27.05%) consisted of two prey species, and two scats (2.35 %) consisted of three prey species. The chital was the dominant (44.95%) prey species hunted by Chitwan tigers. The second was the sambar, with a frequency of 22.93% and a relative biomass of 32.14% (Table 1).

In this study, the lowest body weight among eight species consumed by Chitwan tigers was the barking deer (20 kg) and the highest was of the gaur (450 kg) (Table 1). Not all prey of CNP were found in the scats, implying that tigers do not consume all animal species present. Livestock was previously reported in the diet of tigers in CNP; however, they represent a relatively small proportion of the diet (relative biomass – 4.63% buffalo and 1.64% cow).

Wild prey, on the other hand, comprised of 94% of the total relative biomass. Negative selection was evident for Chital because it was preyed on less than expected ($\chi^2 = 32.597$; d.f. = 4; $P < 0.05$), while Sambar ($\chi^2 = 16.070$; d.f. = 4; $P < 0.05$), wild boar ($\chi^2 = 9.702$; d.f. = 4; $P < 0.05$), and hog deer ($\chi^2 = 4.764$; d.f. = 4; $P < 0.05$) were selected more than expected. Barking

deer was not a significant prey item, possibly due to its limited availability in the environment ($\chi^2 = 0.013$; d.f. = 4; $P > 0.05$). Of all the prey species, gaur showed the least relative number of individual species killed by tigers; however, the gaur's relative biomass within samples was higher than that of barking deer, hog deer and livestock.

3. DISCUSSION

Food habits of large carnivores are central to the ecological niche they occupy and play an important role in explaining their social systems, behaviour and factors affecting the predator density (Kumaraguru et al. 2011). Eating habits vary depending on the habitat conditions and availability of prey species. Prey species in the CNP include chital, sambar, wild pig, gaur, barking deer, hog deer, and primates, and the overall prey density estimated for CNP is 73.63 animals/km² for all small to large size prey species (Dhakal et al. 2014). Chital is one of the major preys of the tigers (Karanth and Sunquist 1995; Stoen and Wegge 1996). Chitwan tigers displayed a significant selection for larger prey. A majority of prey killed by tigers in CNP was chital and sambar, both of which were consumed more frequently in CNP than other protected areas such as Parsa Wildlife Reserve (Maharjan 2011) of Nepal. In the Parsa, chital usually represents a small portion (Occurrence 20%) of the tiger's diet, but it was the dominant prey species in our study. Earlier studies (Karanth and Sunquist 1995; Stoen and Wegge 1996) report that chital is underutilized by tigers based on their availability (Bhattarai and Kindlmann 2012). The gregarious nature of chital is also considered to be one of the reasons why it is underutilized by tigers (Karanth and Sunquist 1995). In general, sambar is the most abundant prey species for tigers (Karki 2011; Dhakal et al. 2014). Lamichhane and Jha (2015) reported that sambar contributed the highest biomass (43.75%) to the diet of tigers in CNP. However, in our study, sambar was less

Table 1. Prey species' composition in tiger scats (n = 85) and their frequency of occurrence, calculation of relative biomass, and relative number of prey individuals killed by tigers, based on the scats collected in the Chitwan National Park.

Prey	No of Prey Items	Frequency of Occurrence	Relative Number of Individuals Killed	Estimated Weight (kg)	Relative Biomass	Correlation Factor
Chital	49	44.94	47.88	45	35.25	3.555
Sambar	25	22.92	15.34	125	32.14	6.355
Wild boar	16	14.65	17.18	38	10.7	3.31
Hog deer	10	9.16	11.66	33	6.33	3.135
Barking deer	4	3.65	6.13	20	2.15	2.68
Gaur	2	1.82	0.61	450	7.11	17.73
Buffalo	2	1.82	0.61	273	4.63	11.535
Cow	1	0.9	0.55	180	1.64	8.28
	109	100	100	100		

Table 2. Studies of tigers' prey items based on scat analysis in protected lowland areas of Nepal.

Area	Wild Prey	Livestock (RBK %)	Others (*)	Major Prey	References
BNP	P	A	P	CH and HD	Stoen and Wegge (1996)
BNP	P	P (3.56)	A	CH and HD	Grey (2009)
CNP	P	A	A	CH and SA	Lamichhane and Jha (2015)
CNP	P	P	A	CH and SA	Bhattarai and Kindlmann (2012)
CNP	P	P (6.26)	A	CH and SA	This study

* Not identified, it could be wild prey, livestock, small mammals or birds; P: Presence; A: Absence; CH: Chital; HD: Hog deer; SA: Sambar; RBK: Relative Biomass Killed.

frequent than chital in respect to bulk and the relative number of individuals killed. According to Bhattarai and Kindlmann (2012), the frequency of occurrence and relative biomass of chital was 33.41% and 30.14% respectively. Our study demonstrated that chital was not only the largest frequency of occurrence (44.94%) and bulk (35.25%) but also the most frequently consumed prey (47.88%) in CNP.

Tiger prey varies in different protected areas of Nepal. Wegge et al. (2009) concluded that sambar was rare in Bardia National Park (BNP) and was not found in the diet of BNP tigers (Stoen and Wegge 1996). By comparison, the biomass of sambar to the tigers' diet was relatively high in CNP. Overall, chital was reported as the major prey species of the tiger in Nepal (Table 2), which may possibly be attributed to their wide distribution and high density.

Our study reported that wild boar was higher both in relative biomass (10.7%) and the relative number of individuals killed (17.18) than that of species such as barking deer (relative biomass – 2.15% and relative number of individual killed – 6.13), gaur (relative biomass – 7.11% and relative number of individual killed – 0.61), and livestock (relative biomass – 6.27% and relative number of individuals killed – 1.66) in CNP. The solitary nature of wild boar may lead to increased tiger predation (Seidensticker 1976a; Biswas and Sankar 2002). The largest prey, gaur, was reported in the tiger's diet in CNP with a relative frequency of 1.09 (Bhattarai and Kindlmann 2012); but in our study, the relative frequency of gaur was higher at 1.82. In Nepal, the only gaur populations overlapping with tiger ranges occur in CNP and PWR (Dhakal et al. 2014). Tiger prey choice for gaur suggests a preference for larger prey but that is not always strong enough to cause injury during its capture (Karanth and Sunquist 1995). Some species such as the Tarai gray langur (*Semnopithecus hector*), rhesus monkey (*Macaca mulatta*) and goat (*Capra aegagrus*) were absent during our study. According to Bhattarai and Kindlmann (2012), the relative frequencies of occurrence of livestock in the tiger's diet in CNP were 0.22 for goat, 0.87 for cow, and 0.87 for buffalo.

The disturbance of wildlife habitats by people and their domestic animals, the greater is the chance of domestic animals being attacked by tiger (Bhattarai and Kindlmann 2012), which consequently increases the conflict with local people.

Grey (2009) concluded that domestic animals contribute 3.56% of the total diet of the tiger in BNP. Reddy et al. (2004) stated that domestic livestock in the diet of the park tigers was 6.2%, where there were low densities of wild prey and high densities of livestock (60% of the ungulate density within the reserve) in Nagarjunsagar-Srisailem Tiger Reserve, India. According to Bagchi et al. (2003), livestock contributes 10–12% bulk of tigers' diet in the Ranthambhore National Park, India. Increasing livestock densities within protected areas are also believed to increase the chances of domestic animals being preyed upon by predators (Sekhar 2003). Sunquist (1981) reported that when livestock is available, tigers will readily prey on it. Bhattarai and Kindlmann (2012) mentioned that predators killed domestic animals and even people in the human disturbed CNP areas, where the abundance of wild prey species is low.

An overall comparison of the selection of livestock in the diet of Chitwan tigers with other protected areas in terms of total biomass consumed in the diet explored that CNP's biomass is also challengeable. Presence of livestock in the tigers' diet could be minimized if illegal grazing was avoided in and around the park area. This study suggests that if there is a choice, large carnivores will selectively kill larger prey, and non-selective predation patterns occur due to the insufficiency of large prey. We agree with the researchers who concluded that with the absence of large prey species, the tiger feeds on smaller prey species, including livestock. Hence, it is necessary to study the overlap of habitat used by prey species (wild and livestock) and tigers in CNP; thus, regular monitoring of tigers and their prey populations is required in order to ensure the continued survival of the tiger populations.

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