International Journal of Ecology and Environmental Sciences 48: 715-720, 2022
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2022.6715

Food Habits of Tiger (*Panthera tigris*) in Tropical Moist Deciduous Forest of Dudhwa National Park, Uttar Pradesh, India

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ABSTRACT
Tiger (*Panthera tigris*) is an endangered felid on the IUCN list. Habitat loss, landscape fragmentation, prey depletion, and poaching have contributed to the decline of the tiger in its entire range in Asia. In India also, it survives only in well-protected tiger reserves and gone or decreased drastically in less-protected areas. The same situation is seen in the terai arc landscape. Thus, accurate knowledge of a species' diet is essential for effective conservation and is vital for conservation initiatives like habitat prioritization, protection, and restoration. Scats analysis was used to determine the food habit of tigers in the tropical moist-evergreen forest of Dudhwa National Park, northern India. A total of 116 scats were collected and analyzed. Scat contents were analyzed in terms of the relative frequency of occurrence and the relative prey biomass consumed. A minimum of 14 prey species were identified. In terms of frequency of occurrence and biomass, the most important prey species were barasingha (*Rucervus duvaucelii)* and spotted deer (*Axis axis*), making up to 55% of biomass consumed. Domestic livestock contributed almost 10% to the diet of the tiger. The study revealed that tiger and leopard (*Panthera pardus*), the two main predators in Dudhwa Tiger Reserve differentiate their niches by segregating the available resources as 55% of the tiger diet comprises barasingha and spotted deer. On the other side, leopard mainly feeds on spotted deer and rodents and may avoid direct competition from the tiger by shifting the space and diet, as revealed by another study in the same area.

Key words: Biomass, Dudhwa, Food habit, Scat,Tiger

INTRODUCTION

Large carnivores have a greater influence on the community structure through trophic cascades and resource facilitation, although naturally, due to energetic constraints, they remain in low densities (Lamichhane et al. 2019). The two large felids found in Dudhwa National Park (henceforth DNP), Uttar Pradesh, India, are tiger (*Panthera tigris tigris*) and leopard (*Panthera pardus fusca*), and their conservation needs to study their food habits. Since the inception of camera traps to estimate the density of large carnivores has increased over the past few years, the investigation into food habits studies of large carnivores has decreased. An understanding of prey consumption mechanisms by carnivores and predation restrictions helps us estimate the role of carnivores in an ecosystem. Therefore, this is crucial in designing effective management strategies for protecting and mitigating human-carnivorous conflicts (Chakrabarti et al. 2016). Dietary studies also helped to identify both interference and competition for exploitation as important mechanisms for developing ecological associations among large carnivores (Mbizah et al. 2012). This would make information on food habits of tiger critical for its management and long-term conservation. Moreover, there is scanty information on the food habit of tigers at Dudhwa Tiger Reserve and the lack of such information can be a major limitation in designing and implementing site-specific conservation measures (Karanth et al. 2004). Understanding the principal constituents of the food of the tiger diet is essential for planning effective conservation policies (Kerley et al. 2015). Thus, the current research aims to assess the food habit patterns of the tiger in the DNP. We believe that the present study is an add on to contribute to the conservation of an endangered and important flagship species.

MATERIAL AND METHODS

Study Area

The present study was conducted in the moist deciduous forest of Dudhwa National Park, which lies 28° 18′N -28° 42′N, 80° 28′ E - 80° 57′E) in the state of Uttar Pradesh and covers an area of 614.32 km^2 (Fig. 1). 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 receives a mean annual rainfall of 150 cm. During the study, the temperature ranged from 8ºC in winter to 45ºC in summer. The vegetation is chiefly moist deciduous forest, dominated by Sal (*Shorea robusta)*. Typical of terai, these forests are interspersed with tracts of low-lying grasslands that get flooded during the monsoon. About 60% of the park is woodland providing food and shelter to a wide variety of animals. These grasslands are the prominent feature of the National Park and cover about 19% of the DNP. It can broadly be classified into two types; wet low-lying areas dominated by tall grass species such as *Phragmites karka, Arundo donax, Saccharum spontaneum* and *Schlerostachya fusca.* In contrast, drier high ground is dominated by grasses like *Desmostachya bipinnata, Imperata cylindrica, Cymbopogon martini* and *Erianthus munja* (Ahmed 2007, Sankaran 1990).

Data Collection

Tiger scats were collected whenever encountered. The forest roads and trails are known to be used by large carnivores for scat deposition (Johnsingh 1983, Karanth and Sunquist 1995) had been searched. The distinction between tiger and leopard scats in the field was done following earlier studies (Karanth and Sunquist 1995, Biswas and Sankar 2002, Lovari et al. 2015). A total of 120 scat samples were collected, and 116 were used for diet analysis of tigers as six scats were not identified. All scats were collected, and species identity was confirmed based on the presence of secondary signs such as scrape marks and pugmarks (Puri et al. 2020). The diet quantification was done based on frequency of occurrence and percent occurrence of undigested food remains in the scats.

We identified prey species primarily based on the hair content in the scats. Only those signs which could be identified unambiguously were recorded to avoid issues of false-positive detections (Miller et al. 2011). Scat samples were processed following methods described in Karanth and Sunquist (1995), Mukherjee et al. (1994) and Athreya et al. (2014).

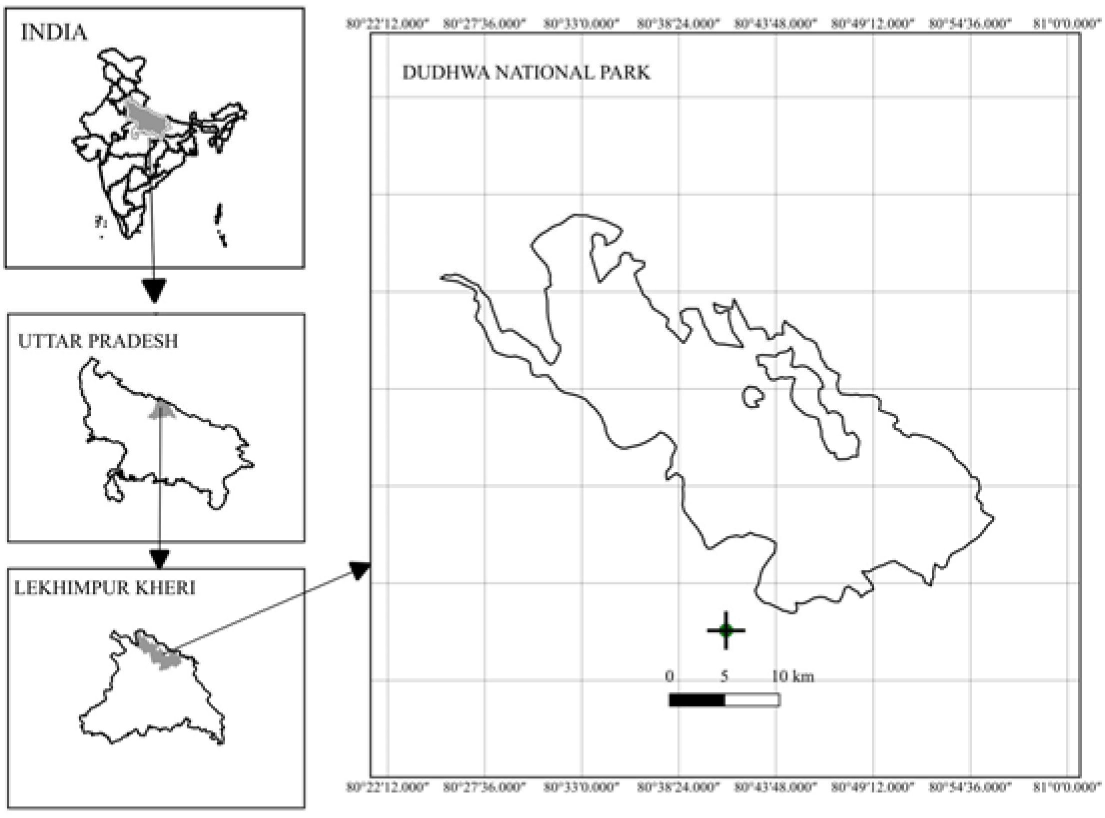

Figure 1. Map showing location of Dudhwa National Park Uttar Pradesh India

Prey species were identified based on the cuticular and medullary patterns (Bahuguna 2010), and reference slides of hair samples prepared at the Department of Wildlife Sciences Aligarh Muslim University, Aligarh. The frequency of occurrence of food items in scats was also recorded following Mukherjee et al. (1994). We used the frequency of occurrence of prey species in our analysis. If prey species differed in their body size, then the frequency of occurrence cannot give a proportion of the prey species consumed by predators (Upadhyaya et al. 2018). We followed Chakrabarti et al. (2016) to estimate biomass consumed per collectible scat. Live weights of wild prey species individuals were taken from (Karanth and Sunquist 1995, Khan et al. 1996, Henschel et al. 2005) and domestic livestock (Schaller 1967). We calculated corrected frequency of occurrence obtained by counting each prey item as 1/2 if two prey items occurred in one scat, and 1/3 when three prey items occurred and likewise(Karanth and Sunquist 1995). We could not perform molecular identification of tigers for identification of scats as it was beyond the scope when scats were collected and resources available. Moreover, an indirect sign survey is a well-established and widely implemented methodology, particularly when large areas need to be covered with limited financial resources and a skilled field workforce.

RESULTS

To detect cent per cent of mammalian prey species in a particular tiger scat with 95% certainty, the number of hairs required to be scanned per scat was between 18-20 hairs. Maximum scats (n = 65) were found to contain only one prey species (56%), although very few scats (n = 9) were found to contain three (6%) and four prey species (2%), respectively. During winter, the percentage of different prey items in the tiger scats indicated that they rely mostly on barasingha (*Rucervus duvaucelii*) and spotted deer (*Axis axis*), which accounted for 27.54 and 26.9% of their diet, respectively. In summer, the tiger mostly preyed on spotted deer, which accounted for 44.65% of its diet. A total of eight prey species were found in the tiger's diet during monsoon, of which barasingha and spotted deer accounted for 25 and 21.88%, respectively (Table 1). Annual predation as revealed by analysing 116 scats showed that the tiger preyed on 14 species. Domestic livestock contributed almost 10% in the diet of the tiger. During the study period, 18 fresh kills of the prey species were also spotted (barasingha n=8, hog deer (*Axis porcinus*) (n=4), spotted deer (n=3), buffalo (*Bubalus bubalis*) (n=3) in DNP.

Table.1. Composition of various prey species in winter (n=69), summer (n=31), and moonsoon (n=08) in Dudhwa National Park, Uttar Pradesh India. Fo - Frequency of occurrance; Po - Percentage occurrance

Species	Winter		Summer		Monsoon	
	Fo	Po	Fo	Po	Fo	Po
Barasingha (*Rucervus duvaucelii*)	19	27.54	4.83	15.58	4	25
Spotted deer (*Axis axis*)	18	26.9	13.84	44.65	3.5	21.88
Sambar (*Rusa unicolor*)	3	4.35	2	6.45	2	12.5
Hog deer (*Axis porcinus*)	6	8.70	0.5	1.61	1	6.25
Indian Muntjac (*Muntiacus muntjac*)	1.5	2.17	0.33	1.06	1	6.25
Indian Wild Pig (*Sus scrofa*)	4.5	6.52	2.5	8.06	-	-
Bluebull (*Boselaphus tragocamelus*)	3.5	5.07	2	6.45	1	6.25
Cattle (*Bos species*)	4	5.80	1.5	4.84	2.5	15.63
Domestic Buffalo (*Bubalus bubalis*)	1.5	2.17	2	6.45	-	-
Langur (*Semnopithecus entellus*)	2.5	3.62	-	-	-	-
Porcupine (*Hystrix indica*)	0.5	0.72	1.5	4.84	-	-
Small Mammal	2.5	3.62	-	-	1	6.25
Bird species	0.5	0.72	-	-	-	-
Unknown	2	2.90	-	-	-	-

DISCUSSION

Spotted deer and barasingha constituted a large portion of tigers' diet in terms of frequency occurrence and consumed biomass (Table 2). They constituted 55% of the diets of tigers of DNP together. Lovari et al. (2015) have found that the tiger used spotted deer and sambar (*Rusa unicolor*) as the most important prey in Suklaphanta Wildlife Reserve, Nepal. Carnivores tend to prefer the most abundant prey (Breuer 2005). In the present study, tiger's selective predation of spotted deer and barasingha indicates selection of the larger prey. Both these species occurred in higher densities in grassland and woodlands in Dudhwa National Park. The majority of collected fecal samples were found in these habitat types, suggesting the selection of a large prey species. The selective predation could also be related to optimal foraging theory (Stephens and Krebs 1986), which suggests that the selected prey could provide higher benefits in net biomass intake. This can reduce the cost of handling (stalking, subduing, and disemboweling of the prey) and injury risks (Scheel 1993). Hence, the predator must shift to profitable species, either medium-size or the one having high density, that make them easier to capture (Lamichhane and Jha 2015).

In the present study, sambar contributed only 4.59% of the diet (as revealed by scat analysis), due to their low abundance as carnivores are closely related to prey size and prey abundance (Karanth et al. 2004). Thus prey density is crucial to sustaining large populations of carnivores (Sankar et al. 2010).

The low percentage of barasingha in summer may be that it forms large groups in summer after the management of grassland through controlled burning by the forest department. As a result, many animals' mutual senses and higher vigilance behavior may work well to detect approaching predators. These factors reduce the probability that a predator will choose a given animal equal to the number of animals in the herd (Hirth 1977). The formation of larger groups breakthrough in winter, makes barasingha more vulnerable to predation. Besides, rutting, which occurs during late monsoon and early winter, is also the factor responsible for higher barasingha predation in these seasons. Since males can roam widely in these seasons, raising their chances of encountering predators (Karanth and Sunquist 1995).

Table 2. Annual prey represented in 116 scats of the tiger in Dudhwa National Park, together with frequency of occurrence (FOO), Percentage occurrence (PO) and relative prey biomass consumed (RPBC).

Species	WT/kg	FOO	PO	RPBC
Barasingha	140	27.83	23.99	24.29
Spotted Deer	45	35.34	30.47	30.84
Sambar	166	7	6.03	6.11
Hog Deer	25	7.5	6.47	6.54
Indian Muntjac	20	2.83	2.44	2.47
Indian Wild Pig	32	7	6.03	6.11
Bluebull	184	6.5	5.60	5.67
Langur	8	2.5	2.16	2.18
Cow	180	8	6.90	6.98
Buffalo	273	3.5	3.02	3.05
Porcupine	8	2	1.72	1.75
Rodents	0.113	2.5	2.16	1.16
Hare	3	1	0.86	0.87
Patridge	0.251	0.5	0.43	0.32

Our study shows that tiger and leopard, which are the two main predators in DNP distinguish their niches by segregating the resources available. As 55% of the tiger diet consists of barasingha and spotted deer, leopards, on the other side, mainly feed on spotted deer and rodents and avoid direct competition with tiger by shifting space and diet as reported by Ahmed and Khan (2008) in DNP using scat analysis. This observation has also been made by Pokheral and Wegge (2019) in Shuklaphanta National Park using camera traps.

Accurate knowledge of the diet of a species is important for effective conservation and is important for conservation initiatives like habitat prioritization, protection, and restoration (Kapfer et al. 2011). The present study on the food habit of the tiger is important for understanding prey consumption mechanisms by tigers in DNP. This information is crucial in designing effective management strategies for protection of tigers as well as their vulnerable schedule-1 prey species such as barasingha. Based on our results, we suggest that future studies on the diet of tiger should be of longer duration that covers a wide area to understand the spatiotemporal variation in their diet.

ACKNOWLEDGEMENT

We are thankfull to the University Grants Commission for funding the Barasingha Ecology Project for which the current data were collected and the Uttar Pradesh Forest Department for permission to work. We also thank our field assistants Radhay Sham, Lela Dhar and Vijay Kumar for their assistance in field work when this study was conducted.

Authors' contributions: Both the authors contributed equally

Conflict of interest: The authors declare no conflict of interest

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Received:12th October 2021
Accepted:30th August 2022