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Food Habits of Tiger (*Panthera tigris*) in Dabka Watershed Area of Uttarakhand, India

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ABSTRACT
Food availability and utilization are among the most critical factors influencing the distribution of free-ranging animals. Little is known about the feeding habit of the tiger (*Panther tigris*) outside the tiger reserves. We collected data on food habits of tigers in Dabka Watershed Area (DWA) of Kumaon Himalaya, Uttarakhand, India. Scats analysis was used to determine the food habit of the tiger. A total of 55 scats were collected and analyzed. The overall diet diversity of tigers in DWA (Shannon-Wiener Index H') was 2.923. Scat contents were analyzed in terms of both the relative frequency of occurrence and the relative prey biomass consumed. A minimum of 13 different prey species were identified, of which chital constituted 30.91% of the diet followed by sambar (21.82%). The wild prey constituted 77.36% of the diet, whereas domestic prey constituted 23.64% of the diet. Prey selectivity analysis indicated that selective predation by tigers was directed towards prey species with large body mass. This highlights the importance of adjacent forests around protected areas that helps large carnivores to disperse spatially and temporally during resource crunch, competition, and dispersal.

Key words: Food habit, Reserve forest, Tiger, Watershed, Prey, Biomass

INTRODUCTION

Large carnivores such as the big cats have remained in focus for conservation research and action (Brodie 2009) due to their charisma and functional role in maintaining ecosystem integrity and services (Ripple et al. 2014). One of the main causes of global biodiversity decline is habitat loss due to agricultural expansion (Foley et al. 2005). This constitutes a severe threat for large carnivores as they occur at a low number, have slow population growth rates, and require sufficient prey and large areas (Carbone et al. 2011), all of which make them particularly vulnerable to extinction (Boron et al. 2016). Their prey requirements also make them prone to conflict with humans and retaliatory killing, further increasing their vulnerability (Inskip and Zimmermann 2009).

In India, tigers (*Panthera tigris*) inhabit a wide variety of habitats ranging from the high mountains, mangrove swamps, tall grasslands to dry and moist deciduous forests, evergreen and shola forest systems and need undisturbed tracts of habitat with ample prey to maintain long-term viable populations (Jhala et al. 2019). The tiger is an umbrella species for most eco-regions in the Indian sub-continent; thus, knowledge of its food habits is crucial for long-term conservation and management. Being an umbrella species, its effective conservation enhances survival prospects for other forms of biodiversity (Karanth 2003). Because of the cryptic nature of tiger and occupation of large ranges, it is inherently difficult to assess its population status, hindering conservation efforts, particularly across unprotected areas and the protected-unprotected interface.

Quantifying diets has long been and continues to be one of the first steps in studying a species' basic ecology (Sih and Christensen 2001) as well as when trying to understand the ecology and natural history of carnivores (Miquelle et al. 1996). As in case of all other organisms, the tiger's diet is a fundamental aspect of its ecological niche (Mukherjee and Sarkar 2013). Faeces of wild animals are the most evident and most easily recognizable signs of their presence (Liebenberg 2000). Major carnivores are at an advantage in this regard because they usually feed on such animals, which are easily recognizable in their droppings which consist of partly digested material and undigested parts of such animals and occasionally plants (Mukherjee and Sarkar 2013). The fecal components may include bones, teeth, claws, scales, feathers, plant tissues, mucus, epithelial cells, and many living and dead bacteria (Mukherjee and Sarkar 2013). Food availability and utilization are among the most critical factors influencing the distribution of free-ranging animals. Formulating any management strategy for the given species in the question necessarily requires information on the species' food habits (Martin 1955). The knowledge of the diet spectrum and feeding habits provides requisite information to understand the complex relationship between predator and prey. It means understanding of feeding ecology of these predators is essential for formulating better management strategies for managing and conserving big cats within their distributional ranges.

STUDY AREA

Dabka Watershed Area (henceforth DWA) has an area of approximately 69 km^2. It is situated between 29^0 30' 19" N and 29^0 24' 09" N latitudes 79^0 17' 53" E and 79^0 25' 38" E longitude, in the region of the Lesser Himalayas in the state of Uttarakhand (Fig. 1). The climate of the area is temperate to cold with the temperate vegetation. This area falls within 700-2600 meters of altitudinal ranges. The mean annual temperature varies at different altitudinal ranges (600-900, 18.9 to 21.1^{o}C), (900-1800, 13.9 to 18.9^{o}C), (1800-2500, 10.3 to 13.9^{o}C) (Sultana 2002). Though a reserve forest, the study area includes 33 villages within the revenue villages category. DWA is a reserve forest divided into the Vinayak and Naina woodlands. Most of the study area lies within the Kumaon division's Vinayak forest range with dominant *Quercus leucotricophora* and a few patches of *Pinus roxburgii*, *Taxus baccata* and *Cedrus deodara* (Ahmed and Khan 2021).

METHODOLOGY

Tiger scats were collected whenever encountered during the study period from September 2007 to June 2009 during the summer and winter seasons. These scats were identified on the basis of associated signs and tracks, their size, and appearance (Mukherjee and Sarkar 2013). The other large predator in the study area was the leopard (*Panthera pardus*). The tiger and leopard scats were differentiated based on the degree of lesser coiling and a larger gap between two constrictions in a piece of tiger scat (Biswas and Sankar 2002, Ahmed 2007, Ahmed and Khan 2008,

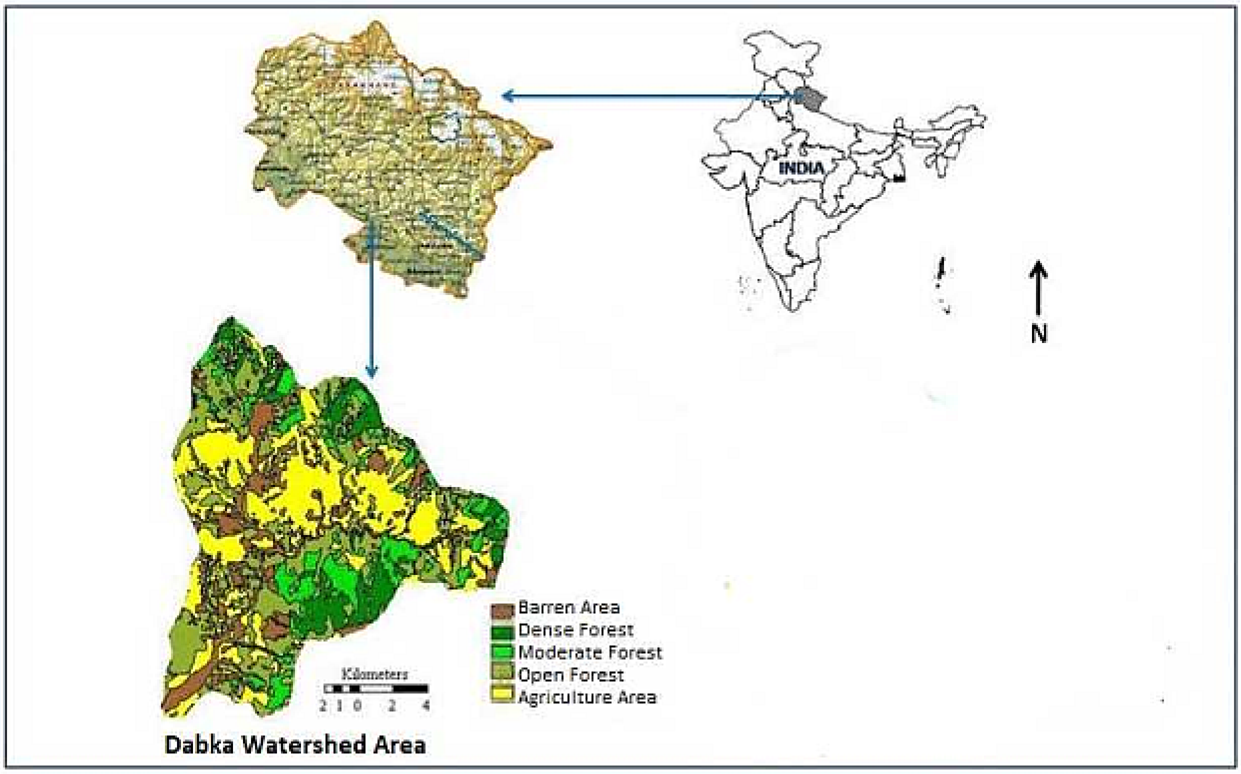

Figure 1. Map showing the location of Dabka Watershed Area

Ahmed 2010). Scats were sun-dried and then washed using sieves, and collectible hairs, bones, and feathers were filtered out (Ahmed 2007, Ahmed and Khan 2008). Tiger scats were found in the Kotabagh area of DWA below 1000 m. Scats that could not be identified were excluded from the analysis. We primarily identified prey species based on the hair content in the scats. We also found bone fragments, ungulate hooves, quills, claws, and teeth in the scats, which allowed for reliable species identification during physical examination. Scat samples were processed following methods described by Mukherjee et al. (1994), Karanth and Sunquist (1995), Ahmed and Khan (2008), Ahmed (2009), Mukherjee and Sarkar (2013). The identification of prey species was based on the cuticular and medullary pattern of hair as described by Moore et al. (1974) and also the reference slides available at the Department of Wildlife Sciences, Aligarh Muslim University, Aligarh. Quantification of the diet was based on both frequency of occurrence (proportion of total scats in which each item was found) and percent of occurrence (number of times a specific item was found as a percentage of all items found) (Mukherjee and Sarkar 2013). A total of 50 hair from a scat were picked up randomly and the prey species detected by scanning a hair for each additional hair. Then the cumulative proportions of prey species detected from all the hair scanned from a scat were recorded. The cumulative proportions of total prey items in a scat were plotted against the number of hair scanned. This analysis aimed to ascertain the minimum number of hair that need to be scanned per scat for detection of all prey species in the scats of tiger.

DATA ANALYSIS

The frequencies of prey species remains that can be identified in scats do not usually give a representative picture of the consumed proportion of different prey species when the prey types vary in size to a considerable extent (Ahmed and Khan 2008, Mukherjee and Sarkar 2013). Smaller prey species having more hair per unit of body weight produce more scats per unit of prey weight consumed, leading to an overestimation of smaller prey species in the carnivore diet (Floyd et al. 1978, Ackerman et al. 1984). Thus we applied the correction factor that was developed by Ackerman et al. (1984) to calculate the relative prey biomass consumed and the number of prey individuals consumed by leopards. The regression of biomass consumed per scat produced against prey weight resulting in the linear relationship $y = 1.980 + 0.0355x$ has been used in the present study, where y = kg of prey consumed per field collectible scat and x = average weight of an individual of a particular prey type.

Selectivity for principal prey species was tested using χ^2 goodness-of-fit test (Zar 1999) based on the null hypothesis of random or non-selective prey killing by predators. The program SCATMAN (developed by Link and Karanth (1994) was utilized to calculate the expected proportion of prey species in scats. The average live weights of wild prey species were taken from Karanth and Sunquist (1995), Khan et al. (1996), Henschel et al. (2005), and those of domestic livestock from Schaller's (1967). The density of prey species was also estimated to assess prey selectivity in the tiger diet.

RESULTS

The number of hair needed to be scanned per scat to detect centpercent of the mammalian prey species in a particular scat of tiger with 95% certainty was between 11-17 hair, whereas 95% of the mammalian prey species were detected by analyzing 10-12 hairs per scat (Fig. 2). Maximum scats were found with only one prey species (70.37%, n= 38), whereas very few scats were found containing two (18.52%, n=

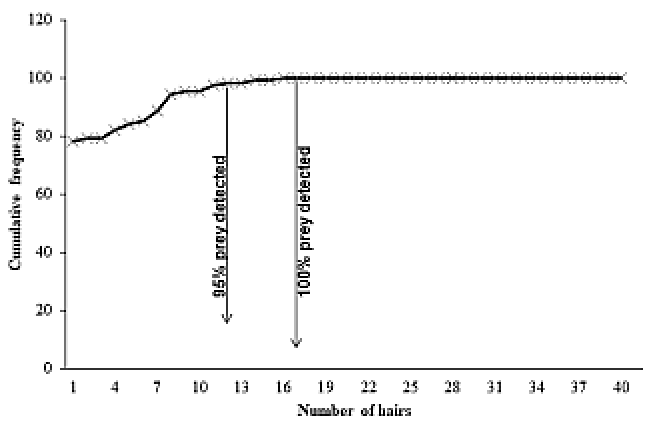

Figure 2. Standardization of minimum number of hair required per scat to know the food habit of tiger in DWA

10), three (7.41%, n= 4) and four prey species (3.70%, n= 2).

Diet Diversity

The overall diet diversity of tigers in DWA (Shannon-Wiener Index H') was 2.923. A total of 13 prey items were found in the dietary spectrum of the tiger. Spotted deer (*Axis axis*) constituted 30.91% of the diet, followed by sambar (*Rusa unicolor*) (21.82%), cattle (*Bos taurus*) (13.64%), and buffalo (*Bubalus bubalis*) (10%). The remaining prey items contributed less than 5% to its diet. Overall, the wild prey constituted 77.36% of the diet, whereas domestic prey constituted 23.64% of the diet (Fig. 3).

In terms of relative biomass consumed, spotted deer and sambar were the two main dietary prey items of the tiger in the study area, making up 19% and 29.45% of total biomass consumed, respectively. The domestic prey, cattle, and buffalo constituted 19% and 20% of the total biomass consumed, respectively. Overall, domestic livestock constituted 39% of the biomass of the tiger diet (Table 1).

A comparison of the observed and expected frequency of occurrence of prey species in tiger scats indicated a significant difference in utilization of prey species by tigers and rejected the hypothesis of non-selective predation by tigers ($\chi^2 = 73.35$, df = 12, P = 0.01). It was found that sambar, wild pig (*Sus scrofa*) and muntjak (*Muntiacus muntjac*) were utilized more than their availability. Spotted deer were utilized in proportion to their availability and langur (*Semnopithecus schistaceus),* and rhesus macaque (*Macaca mulatta*) were utilized less than their availability (Fig. 4).

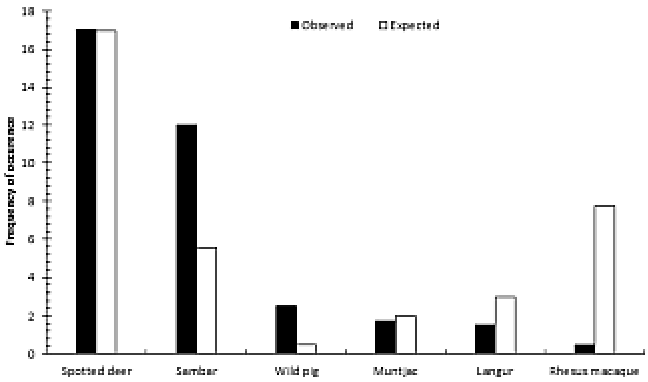

Figure 4. Comparison of observed and expected proportions of prey consumed in scats of tiger in DWA.

DISCUSSION

Large prey species (sambar, spotted deer, wild pig, cattle, and buffalo) were found to be favored by tigers in comparison to smaller prey species in the study area. Predators may select prey species containing the most profitable prey as measured by the ratio of

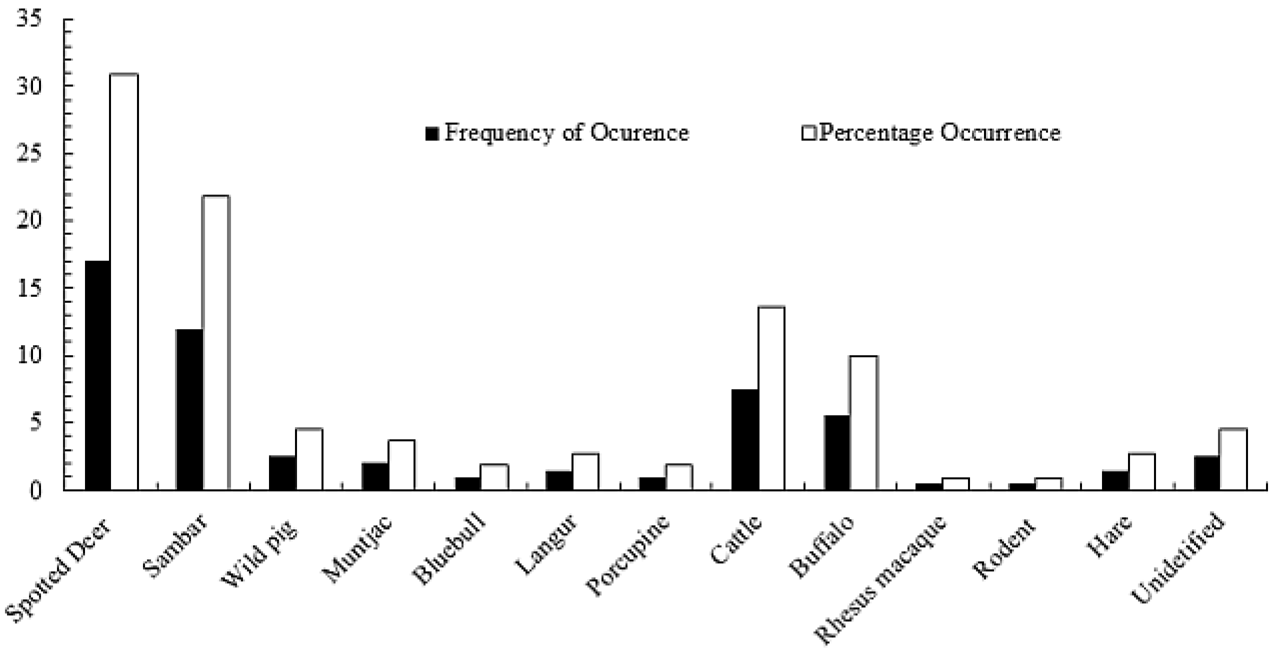

Figure 3. Frequency and percentage occurrence of food items in 55 tiger scats in DWA

Table 1. Prey species composition in tiger scats (n=55), their relative biomass contribution in tiger diet and production of scats for each prey species with estimated biomass and number of individuals of each prey item consumed in DWA

Species	Body Wt. (kg)	Collectable scat/kill	Prey Biomass Consumed (kg)	Biomass/100 Scats (kg)	% Biomass eaten (kg)	No of individuals eaten/100 scats	Ratio of number of individual eaten
Spotted Deer (*Axis axis*)	45	3.555	60.44	109.88	19.04	2.44	1.00
Sambar (*Rusa unicolor*)	166	7.79	93.48	169.96	29.45	1.02	0.42
Indian Wild pig (*Sus scrofa*)	32	3.1	7.75	14.09	2.44	0.44	0.18
Muntjac (*Muntiacus muntjac*)	20	2.68	5.36	9.75	1.69	0.49	0.20
Bluebull (*Boselaphus tragocamelus*)	184	8.42	8.42	15.31	2.65	0.08	0.03
Himalayan langur (*Semnopithecus schistaceus*)	8	2.26	3.39	6.16	1.07	0.77	0.32
Porcupine (*Hystrix indica*)	14	2.47	2.47	4.49	0.78	0.32	0.13
Cattle (*Bos species*)	180	8.28	62.10	112.91	19.56	0.63	0.26
Domestic Buffalo (*Bubalus bubalis*)	273	11.54	63.44	115.35	19.99	0.42	0.17
Rhesus macaque (*Macaca mullata*)	4	2.12	1.06	1.93	0.33	0.48	0.20
Rodent species	0.113	1.98	0.99	1.80	0.31	15.96	6.54
Hare species	3	2.09	3.13	5.69	0.99	1.90	0.78
Unidentified	5	2.16	5.39	9.80	1.70	1.96	0.80

energy gain to handling time (Scheel 1993, Karanth and Sunquist 1995). The comparison of the frequency of occurrence of different prey species in scats of tiger in other areas of the Indian sub-continent has revealed that if predation on spotted deer is high, then the contribution of sambar is relatively low or vice-versa (Schaller 1967, Johnsingh 1983, Karanth and Sunquist 1995, Biswas and Sankar 2002, Sankar and Johnsingh 2002, Ahmed 2007, Andheria et al. 2007).

Compared to other areas, the predation rate on livestock species (cattle and buffalo) was relatively high as other studies where the predation rate on livestock is reported low were conducted in protected areas, where the forest department restricts livestock entry. The present study was conducted in a reserve forest, where local people are permitted to graze livestock. The high availability of livestock species may be the reason for a high predation rate on livestock species by tigers compared to other areas. Moreover, the study areas have villages in their vicinity and eventually have sizeable livestock, which roams mostly unguarded within the study site and becomes easy prey to large predators.

Prey selectivity analysis indicated that selective predation by tigers was directed towards prey species with large body mass in DWA. Karanth and Sunquist (1995) reported similar selective predation of tigers towards large-bodied prey in Nagarhole, Karnataka. Regarding the number of individuals eaten, spotted deer contributed maximally to the tiger's diet in the study area and was utilized in proportion to its availability. The present results are consistent with Biswas and Sankar (2002), who reported prey utilization proportion to its availability. This is in contrast with Johnsingh (1983 in Bandipur), Karanth and Sunquist (1995) in Nagarahole, Southern, India, and Stoen and Wegge (1996) in Nepal , who reported the underuse of spotted deer as compared to its availability. Sambar and wild pig were consumed more than their availability in the study area. A similar pattern of high predation of sambar and wild pig by tiger was also reported from Pench (Biswas and Sankar

2002), indicating habitat overlap between the tiger and wild pig. Selective predation on muntjak by a tiger in the study area might be considered a rare event since this species is too small to be profitable prey for tigers. It occurs in very low density, prefers hilly terrain and quick to disappear in the bushes and is thus difficult for tigers to prey on it. Langur was under utilized by tigers because of its arboreal nature. Bluebull (*Boselaphus tragocamelus*) preferred flat areas and was uncommonly found in the study area so this could be the reason for its tiny portion in the tiger's diet in Dabka Watershed Area.

CONCLUSION

Conserving large-bodied wild felids outside the protected areas faces considerable conservation challenges (Kshettry et al. 2018). Although numerous studies on the food habits of the tiger have been conducted in tiger reserves of India (Karanth and Sunquist 1995, Biswas and Sankar 2002, Sankar and Johnsingh 2002, Bagchi et al. 2003, Ahmed 2007, 2009, Andheria et al. 2007, Avinandan et al. 2008, Ramesh et al. 2009, Mukherjee and Sarkar 2013, Navaneethan et al. 2019, Basak et al. 2020), the present study highlihgts the dietary pattern of a tiger outside tiger reserve adjacent to Corbett Tiger Reserve. This study also highlights the importance of adjoining forests around protected areas that help them disperse spatially and temporally during resource crunch, competition, and dispersal. Although numerous studies on food habits of tiger have been conducted in different Tiger Reserves of India, this study increases their significance as it adds to a growing body of literature on tiger food habits outside the tiger reserves.

Authors' contributions: All authors contributed equally

Conflict of interest: Authors declare no conflict of interest

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