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Cover: Whale Shark *Rhincodon typus* and Reef - made with poster colours. © P. Kritika.

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COMMUNICATION

Food habits of the Red Fox *Vulpes vulpes* (Mammalia: Carnivora: Canidae) in Dachigam National Park of the Kashmir Himalaya, India

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Abstract: Food habits of the Red Fox *Vulpes vulpes* were studied in Dachigam National Park of the Kashmir Himalaya from December 2017 to November 2018 by scat analysis. A total of 246 scats were collected across seasons from different habitat types of the park. The diet of the Red Fox was characterized by a wider prey spectrum with small rodents, plants, and Himalayan Grey Langur *Semnopithecus ajax* as the major food items. The dietary behaviour showed slight seasonal variation with more invertebrates and plant material (fruits, berries, & grasses) during spring and summer. The food niche of the canid was wider in the warm season than in the cold season. Diet analysis revealed substantial use of anthropogenic food sources (human refuse and livestock carrion) by the Red Fox. The frequency of occurrence of human refuse and livestock carrion in the scats of the canid species varied seasonally. The results show that the Red Fox is an opportunistic feeder, and capable of adapting to a variety of dietary items.

Keywords: Anthropogenic items, dietary behaviour, livestock carrion, scats, seasonal diet, wild prey.

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Author contributions: Kulsum Ahmad Bhat, Aamir Majeed, Naziya Khurshid and Muniza Manzoor conducted field surveys and collected scat samples from hilly terrain of Dachigam National Park. Bilal A. Bhat and Bashir A. Ganai are mentors and helped the first author in analysis and writing of the manuscript.

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INTRODUCTION

The Red Fox is cosmopolitan in distribution (Hegglin et al. 2001; Mcdonald & Reynolds 2008) with opportunistic feeding behaviour (Vlachos et al. 2010; Lanszki et al. 2018; Alexandre et al. 2020; Jahren et al. 2020). The species is the most widespread wild canid in India and is distributed across the Himalayan and Trans-Himalayan ranges in the north and the desert region in the north-west (Ghoshal et al. 2015; Reshamwala et al. 2018). The species has managed to survive over almost all of its former range irrespective of habitat destruction and anthropogenic pressure (Jahren et al. 2020). The enormous range of the Red Fox is evidence of its adaptability and opportunistic behavior (Delibes-Mateos et al. 2008). The diet of Red Fox is highly diverse, both in space and time, which allows the species to survive in diverse habitats (Cavallini & Volpi 1995; Cagnacci et al. 2003).

The elusive and nocturnal habits of the animal make direct observations difficult in the field. Therefore, the use of scats is common and extensive method to investigate its food habits (Descalzo et al. 2020). This investigation is based upon examining a collection of scat samples for a thorough dietary analysis of the canid species in the Dachigam National Park (DNP) of Kashmir Himalaya. Being a key meso-carnivore in most parts of the world with its known ecological role (Sánchez 2018), it may be of crucial importance to the ecology of Kashmir Himalaya as well. Meso-carnivores like Red Fox occupy a central position in the food web and any change in their ecology may affect higher and lower trophic levels (Sánchez 2018). A thorough investigation of its seasonal food habits is, therefore, necessary for understanding the pattern of distribution of this canid species in and around DNP. The available information on the diet and prey preferences of Red Foxes in the northwestern Himalayan region is scanty (Reshamwala et al. 2018). With this background, the present study was undertaken in the DNP to augment the existing literature in this region. The study will help further in understanding the role of human subsidies in driving this canid species outside the National Park.

MATERIALS AND METHODS

Study area

The intensive study area, Dachigam National Park (DNP), a key protected area of Kashmir Himalaya lies in the northwestern Himalayan landscape (Image 1). The mountain ranges surrounding Dachigam are a part of the great Zanskar Range, which forms the north-west branch of the central Himalayan axis. The geographical location is roughly between 34.083–34.183 ^{0}N and 74.883–75.150 ^{0}E (Rodgers et al. 2000). The landscape is dominated by high mountains, rugged cliffs, and high-altitude pastures with an elevation of 1,676–4,267 m. The climate of the area is sub-Mediterranean to temperate with varying degrees of precipitation and dryness. The maximum average temperature recorded in summer is 27ºC and in winter a minimum of 2ºC. The annual average rainfall recorded is about 660 mm with snow as the main source of precipitation. The vegetation structure of Dachigam is typically Himalayan moist temperate with sub-alpine and alpine forest types (Champion & Seth 1968). The faunal elements of the national park include Hangul Deer *Cervus hanglu hanglu*, Himalayan Grey Langur *Semnopithecus ajax*, Golden Jackal *Canis aureus*, Common Leopard *Panthera pardus*, & Asiatic Black Bear *Ursus thibetanus* are major mammals whereas Black Bulbul *Hypsipetes leucocephalus*, Yellow-billed Magpie *Urocissa flavirostris,* & Blue Whistling Thrush *Myophonus caeruleus* are the birds usually found in DNP.

Collection of samples

A total of 246 scats of Red Fox were collected along systematic transects and opportunistically whenever found in and around the fringe areas of the study site and analysed. The scat samples were collected monthly from December 2017 to November 2018 along 12 transects, covering different habitat types and altitudinal zones. The total transect effort was 319 km for all seasons (Figure 1). The scats of Red Fox were identified on the basis of certain features such as shape, size, odour, and quantity typical to that of the relative species, following a standard protocol (Vanak & Mukherjee 2008). The sites were also searched for fox dens, rock crevices, and burrows in order to increase scat samples. The location, date, associated marking signs, and GPS location were recorded for each scat using a handheld global positioning system. The scats were collected in paper bags with a unique identification number, transported to the laboratory for further analysis and stored at -20ºC until processing (Ciucci et al. 1996).

Laboratory analysis

The scats were decontaminated in an oven at 80ºC to eradicate any parasitic infection frequently found in canid scats (Eddine et al. 2017) and then rinsed with tap water through a sieve of BSS 120 having a pore size of 125 µm so that the digested material could

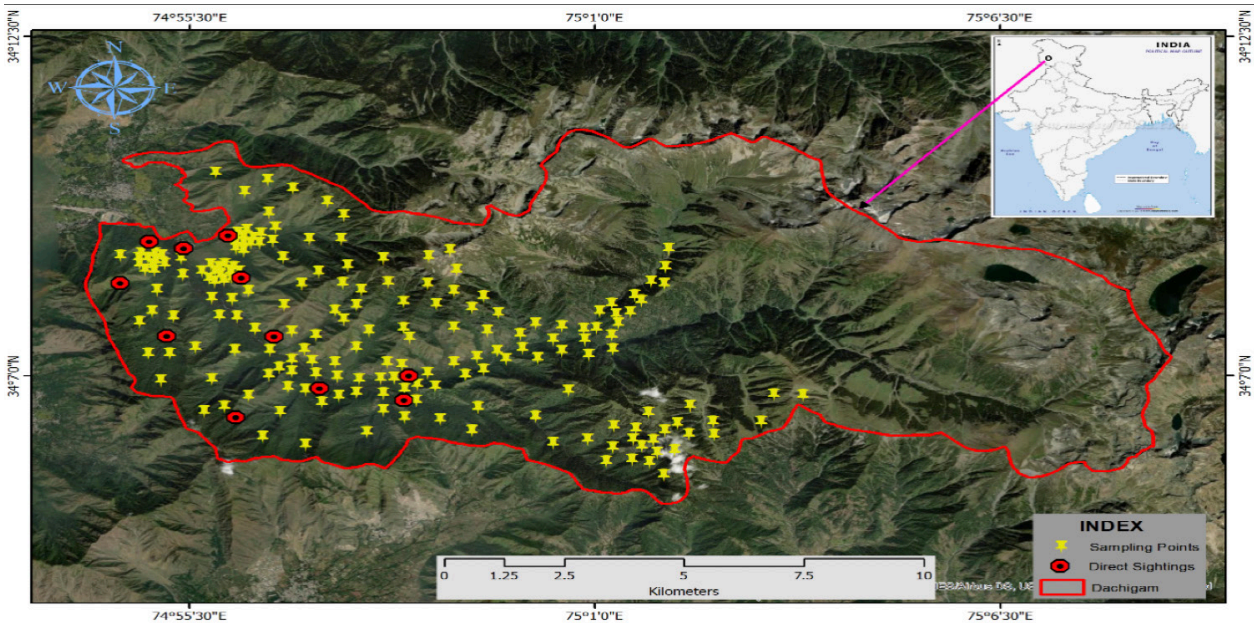

Image 1. Locations of scat samples and direct sightings of Red Fox in Dachigam National Park.

pass through the sieve. The remains were separated macroscopically for identification of prey items such as the claws, teeth, bones, seeds, insects, hairs, feathers, grasses & other plant materials, and human subsidies like pieces of cloth, paper, and plastic. The hairs were then dried in an oven at 47ºC for 48 hours and then soaked overnight in absolute alcohol to remove any wax depositions and moisture. Sampled hairs were mounted on slides and observed under a microscope. Hairs were microscopically examined to the lowest taxonomic level possible by comparison with reference hair collections. The medullary pattern of the hair was compared with the reference slides as well as the reference guide (Mukherjee et al. 1994; Bahuguna et al. 2010). Flight feathers of some birds recovered from the scats were identified on the basis of their color, shape and structure (Fraigneau 2017). Moreover, feathers from some scats in the fringe areas of DNP were compared with the remains of domestic fowl left over by Red Fox near scats.

Statistical analysis

Diet was expressed in terms of frequency of occurrence (scats with food item (i) / number of scats) multiplied by 100 (Mahmood & Nadeem 2011) and relative frequency of each food item (number of times a specific item was found) as a percentage of all items identified (Ackerman et al. 1984; Amroun et al. 2006). Seasonal differences in the prey species in the diet were verified using chi-square ($\chi 2$) test where differences at $p < 0.05$ reflected significance.

RESULTS

The overall diet composition of the Red Fox included 18 items across all seasons. The food items were broadly classified into rodents, wild carrion, livestock carrion, birds, plants, invertebrates (insects), and human subsidies. Rodents were the major food item with a relative percent occurrence of 26.81 followed by vegetation (25.64), wild carrion (17.01), insects (13.84), birds (7.43), livestock carrion (5.72), and human subsidies (3.45). Hair analysis revealed that among Wild Carrion, Himalayan Grey Langur contributed most to the diet (15.57%), followed by Hangul Deer with 1.44%. Among the livestock species, sheep *Ovis aries* contributed most to the diet (2.88%), followed by Domestic Fowl *Gallus gallus domesticus* & Goat *Capra aegagrus hircus* with a relative percent occurrence of 1.14 & 0.85, respectively. Cow *Bos taurus* & Horse (*Equus ferus*) were represented least with a relative percent occurrence of 0.57 & 0.28, respectively. Of the total hair samples, 2.9% remained unidentified. Invertebrates (insects) contributed significantly (13.84%) to the diet. Vegetation was represented by grasses (12.39%) and wild seeds (10.67%). The birds constituted 7.43% of the diet. Human subsidies constituted the lowest proportion in the diet with a relative occurrence of 3.45% (Table 1, Figure 2). The fox occurrence showed a positive association with the availability of human subsidies along the adjoining areas, with increased sightings around human settlements and orchards. Thus, human

Table 1. Diet composition of the Red Fox in Dachigam National Park (Fi = frequency of occurrence, n = number of appearances of food items, and N = number of scats).

Food items	Winter N = 74		Spring N = 62		Summer N = 51		Autumn N = 59		Total N = 246		χ^2 Value	P Value
	n	Fi	n	Fi	n	Fi	n	Fi	n	Fi		
Rodents	21	28.3	32	51.61	22	43.13	18	30.50	93	37.80	4.763	›0.05
Wild carrion	13	17.56	19	30.64	16	31.37	11	18.64	59	23.98	2.491	›0.05
Livestock carrion	11	14.86	3	4.83	3	5.88	3	5.08	20	8.13	9.600	‹0.05
Birds	5	6.75	9	14.51	6	11.76	6	10.16	26	10.56	3.261	›0.05
Plants	27	36.48	29	46.77	17	33.33	16	27.11	89	36.17	6.056	›0.05
Invertebrates (Insects)	9	12.16	20	32.25	12	23. 52	7	11.86	48	19.51	8.167	‹0.05
Human subsidies	8	10.81	0	0	2	3.92	2	3.89	12	4.87	6.000	‹0.05

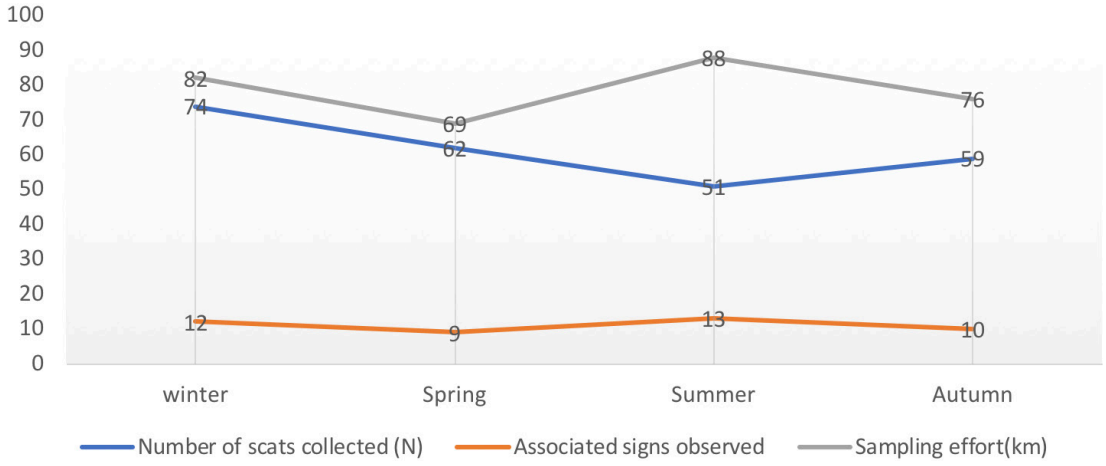

Figure 1. Details of sampling efforts (December 2017–November 2018).

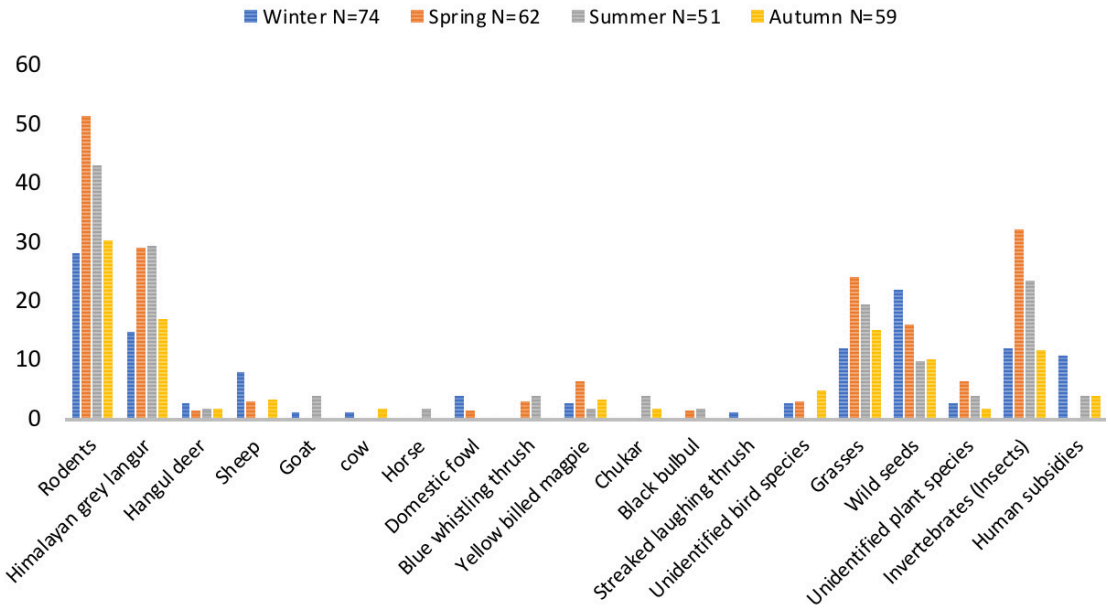

Figure 2. Percent occurrence of food items in the diet of Red Fox in Dachigam National Park.

Image 2. Red Fox in different habitat types of Dachigam National Park.

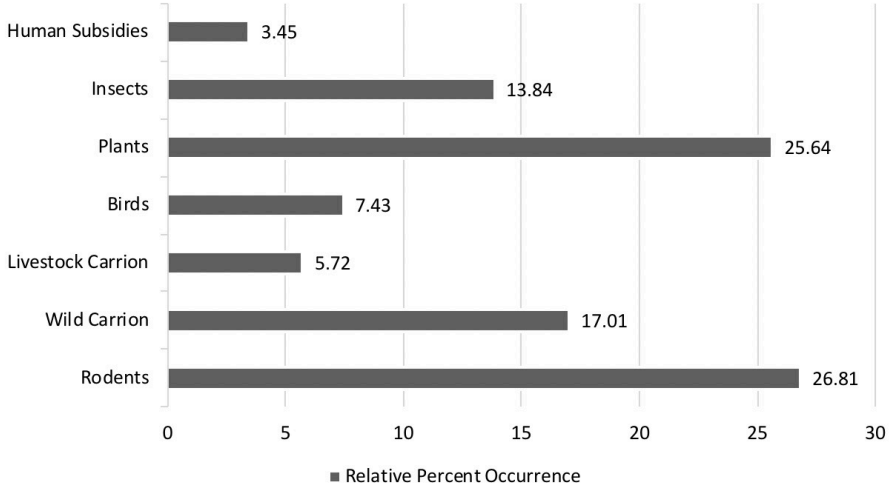

Figure 3. Relative percent occurrence of food items in the diet of Red Fox.

subsidies attracted Red Foxes and constituted an important part of their diet, especially during harsh winter. Chi square analysis has revealed that there is a significant difference ($p < 0.05$) in the consumption of livestock carrion, invertebrates and human subsidies. The rest of the prey types (rodents, wild carrion, birds, and plants) did not differ significantly across seasons ($p > 0.05$).

DISCUSSION

The diet of the Red Fox in the Dachigam National Park was dominated by rodents, wild carrion, plants and invertebrates (Figure 3). The rodents were a major source in the diet without following any habitat or temporal pattern. This is in conformity with Reshamwala et al. (2018). A variety of food items in the diet of Red Fox in the DNP showed that its feeding behavior is of generalist and opportunistic type, which is consistent with several previous workers (Macdonald 1980; Cavallini & Lovari 1991; Dell'Arte et al. 2007; Hartová-Nentvichova et al. 2010). During the warm season a broader trophic niche was witnessed owing to diverse food availability compared to a narrower niche during colder months when the food resources were scarce. This seasonal variation in the diet was obtained and this may be due to seasonal habitat utilization patterns as confirmed by Jędrzejewski & Jędrzejewska (1992), Baltrūnaitė (2006), Sidorovich et al. (2006), and Díaz-Ruiz et al. (2013). It has been noted that among wild carrion, Himalayan Grey Langur always formed a substantial percentage of the Red Fox's diet. The reason being that the langur is preyed upon consistently by leopards across all habitats

Image 3. Steps of scat analysis, separation of prey items and preparation of slides.

and seasons owing to their abundance in the park (Shah et al. 2009). The Hangul Deer represented a small percentage in the diet of Red Fox indicating that the deer is infrequent in distribution (Khurshid et al. 2021). The low occurrence of Hangul in the diet of Red Fox may be due to scavenging. The Red Fox utilized insects (mostly beetles) and was often reported in spring and summer owing to their availability. This is in concurrence with Ricci et al. (1998), Ciampalini & Lovari (1985), and Calisti et al. (1990).

Significant consumption of vegetation in different seasons was revealed with grasses, wild seeds, and fruits (mostly *Malus domestica, Prunus avium, Pyrus* spp.) forming an important component of the Red Fox diet. Fruits such as apple, plum, cherry, berries, and pear are reported worldwide as part of the Red Fox diet (Basuony et al. 2005; Hartová-Nentvichova et al. 2010; Matías et al. 2010). Red Foxes play an important role in the dispersal and germination of seeds (Juan et al. 2006), it might be aiding in the dispersal and germination of seeds in our study site as well. Birds were preyed uniformly across seasons and habitats probably due to low hunting energy costs. The consumption of avian prey decreased during autumn and winter. This may be due to the reason that during spring and summer juveniles are learning to fly and thus are more vulnerable to predation risk (Cavallini & Volpi 1995).

The winter diet of Red Fox revealed that human subsidies formed an essential part and its utilization increased along the fringe areas in the form of garbage and improper disposal of livestock carcasses. Our study revealed that 6.71% of the diet of Red Fox consisted of livestock carrion which included sheep, goat, horse, and domestic fowl. This finding is similar to previous studies (Doncaster et al. 1990; Saunders et al. 1993; Contesse et al. 2004; Mateos et al. 2007; Killengreen et al. 2011). Most of these studies suggest that the reason behind this might be the easier availability of human subsidies than natural prey items.

Red Foxes generally eat and hunt in a wide range of habitats and also show a seasonal shift in their food preferences. They sustain themselves on available food but become scavengers when food is limited (Basuony et al. 2005). This was attributed to the seasonal availability of different dietary items. Our findings suggest that foraging of the Red Fox with reference to human subsidies needs further investigation in the north western landscape for strengthening the understanding of the critical facets of this carnivore.

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