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Diet composition and niche overlap of two sympatric carnivores: Asiatic jackal *Canis aureus* and Kashmir hill fox *Vulpes vulpes griffithii*, inhabiting Pir Lasura National Park, northeastern Himalayan region, Pakistan

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Studies on dietary habits and niche overlap of sympatric carnivore species can be vital for their conservation. They can reveal the potential level of inter-specific competition and prey species overlap, thus highlighting species specific conservation requirements. We investigated diet composition of two such sympatric carnivore species Asiatic jackal *Canis aureus* and the Kashmir hill fox *Vulpes vulpes grifithii* in and around Pir Lasura National Park, in northeastern Himalayan region of Pakistan by using fecal analysis after confirming the carnivore species by genetic analyses. The scats of the two carnivores were collected during four different seasons of the year and analyzed in the laboratory. Results revealed sixteen prey species in the diet of Asiatic jackal and 21 species in the diet of the Kashmir hill fox. For Asiatic jackal, wild prey contributed approximately 18%, whereas 60% of the diet comprised of domestic prey. For Kashmir hill fox, the wild prey consumption was approximately 18%, while consumption of domestic prey was 51% and plants contributed 28%. Niche breadth of the Asiatic jackal was broader (0.78) compared to Kashmir hill fox (0.31). Niche overlap between these two sympatric carnivores was found to be a rather high 0.81.

Keywords: diet composition, dietary niche breadth, niche overlap

Knowledge of a predator's diet is vital to understand its ecology and to predict its effect on the dynamics of prey populations (Oli 1993). Scat analysis has been used extensively by various researchers in various parts of the world for investigating the diet composition of carnivores, especially the elusive species. However, the correct identification of scats in the field, based on morphology of the scats, is vital otherwise wrong information may be communicated to readers (Akrim et al. 2018). Therefore, more recently, field identified scats of carnivores are being subjected to molecular identification techniques for confirmation of the carnivore species. Components of carnivore feces can include feathers, bones, hairs, teeth, claws, scales, arthropod chitin, plant matter, mucus cells and bacteria (Bang and Dahlström 1975, Bujne 2000). However, the quantity and size of carnivore scats can be different based upon age of individuals (Akrim et al. 2018), prey species consumed and absorption capacity (Bang and Dahlström 1975).

Carnivore species that are widely distributed globally include golden or Asiatic jackal *Canis aureus* and the red fox *Vulpes vulpes*. The Asiatic jackal has a widespread distribution in north and north-east Africa, also occurs in the Arabian Peninsula and has expanded its range into Europe, where the species has patchy distribution. It is regularly found as a vagrant in Austria, Slovakia, Slovenia and north-eastern Italy (Krystufek et al. 1997). It is well distributed in central Asia and the entire Indian subcontinent (Jhala and Moehlman 2008). Red fox *Vulpes vulpes* is most widespread terrestrial carnivore species (covering nearly 70 million km^2) globally (Harris and Baker 2001, IUCN 2016). It is distributed across the whole northern hemisphere from the Arctic circle to southern North America Europe, North Africa, Asiatic

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steppes, Pakistan, Indian and Japan (Jenkins and Craig 1992, Gloor et al. 2001, Wandeler et al. 2003, Crooks et al. 2010, Soulsbury et al. 2010).

Although, the Asiatic jackal is not found at higher elevations in the Himalayas (above 3500 m), it has however been recorded at lower elevations in Himalayan valleys such as Murree hills up to 2150 m (Roberts 1997). The red fox, on the other hand occurs up to 4500 m asl (IUCN 2016).

The Asiatic jackal is an opportunistic feeder and it usually scavenges on garbage, human waste and animal carcasses. Jackals can hunt singly and in packs which are more successful in hunting. When single, it hunts smaller prey such as rodents, hares and birds by locating prey by hearing. It can dig out Indian gerbils *Tatera indica* from burrows and can hunt young, old, or sick ungulates 4–5 times larger than its own size and body weight. Besides vertebrates, the Asiatic jackal has been reported to feed on invertebrates and plant matter. Jackals are omnivorous and the range of their diet varies among different seasons and habitat (Wyman 1967, Moehlman 1983). They are generalist feeders and large quantities of vegetable matter and fruits are included in their diet, however, bulk of their food is comprised of rodents and reptiles. They also supplement their diet with fruits and insects when available (Roberts 1997).

The red fox is an omnivore; it has broad diet which includes; invertebrates, small mammals, birds, fishes, fruits and carrion (Flower 1932, Macdonald 1979, Osborn and Helmy 1980). Diet composition of the red fox depends on various factors including habitat type, prey availability (Kolb and Hewson 1979, Leckie et al. 1998, Sidorovich et al. 2006) and seasonal variation in food availability (Goszczyński 1986, Jędrzejewski and Jędrzejewska 1992, Baltrunaite 2001, 2002). Data on dietary composition of the red fox and Asiatic jackal is well documented in other countries, however very few studies on diet of Asiatic jackal have been conducted in Pakistan and no research study has focused on the red fox.

The Asiatic jackal and the red fox are both reported from Pakistan and in many parts of the country are sympatric in distribution (Roberts 1997). However, at higher elevation areas, the sub-species Kashmir hill fox *Vulpes vulpes grifithii* occurs. Since both species are carnivores and share distribution ranges in the country, their feeding niches may overlap, potentially resulting in interspecific competition for food. Although a few individual studies have focused on investigating the diet of the Asiatic jackal in the country such as Nadeem et al. (2012) and Mahmood et al. (2013), the red fox has been neglected totally in this regard, with virtually no studies reported from Pakistan that have investigated its diet and prey species. The study of diet composition and niche overlap of the two carnivores can reveal the potential level of competition for their prey and the species-specific habitat requirements of the two carnivores wherever the two are sympatric in their distribution. The Pir Lasura National Park (PLNP), is an important protected area and has both the Asiatic jackal and the Kashmir hill fox. Here, we investigate the diet composition and the niche overlap between these two sympatric meso-carnivores in the human-dominated landscape in and around Pir Lasura National Park, north Himalayan region, Pakistan.

Material and methods

Study area

This study was conducted in and around Pir Lasura National Park (PLNP; 33°25′92″N to 33°29.31″N and 74°05′64″E to 74°03′02″E), District Kotli, north-eastern Himalayan region, Pakistan. The park is an important protected area in the country regarding some key sympatric carnivores. It encompasses 1580 ha area with elevation ranging between 1000 and 2000 m above sea level (a.s.l.). Since the current study also focused surrounding areas of the Park, the overall size of the whole study area was 17 183 ha. The valleys of the park consist of subtropical pine vegetation, with the tops/mountains having sub-tropical dry evergreen forest. Average annual rainfall in the study area is 1500 mm. The study area experiences four different seasons during the calendar year including summer (May–July), autumn (August–October), winter (November–January) and spring (February–April). Major wildlife species in the park include common leopard *Panthera pardus*, rhesus monkey *Macaca mulatta*, Asiatic jackal *Canis aureus*, Kashmir hill fox *Vulpes vulpes grifithii*, small Indian mongoose *Herpestes javanicus*, Indian grey mongoose *Herpestes edwardsii*, barking deer *Muntiacus muntjak*, Indian pangolin *Manis crassicaudata* and kaleej pheasant *Lophura leucomelanos* (Akrim et al. 2017, 2018).

Local people keep a variety of animals including domestic cows, buffalos, goats, dogs, horses, poultry and rabbits. A majority of people are associated with professions of doing agriculture, government jobs, labor and shop-keeping with average household income per month ranging from US$ 100 to 200. Farmers, shopkeepers and labor or usually keep livestock for milk and meat production and they depend on livestock for subsistence.

Morphological identification of carnivore scats

The diet composition of Asiatic jackal and Kashmir hill fox was investigated by analysis of scat samples. We conducted surveys to collect scats of both carnivores during summer, autumn, winter and spring seasons during 2014–2017 using area searches on 30 trails in the study area. Three people participated in survey but to eliminate one source of variation, only a single person (the author) was responsible for morphological identification of the scats in the field. When any scat was encountered, field identification was made based on its morphology including diameter, length, shape, color, odor, physical appearance such as characteristic contents (hairs, bones and plant material) (Seton 1925, Jackson and Hunter 1995). Additional criteria included nature of scat deposit site and presence of tracks or signs of activity of the species under study. The diameter at widest point, length, disjoint segments and weight of each scats sample was measured and samples were preserved in 95% ethanol for molecular identification and further analysis.

Molecular identification of carnivore scats

The morphologically-identified scats of the two carnivore species were subjected to molecular identification for further confirmation. For this purpose, we extracted fecal DNA in

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the Non-invasive and Environmental DNA Lab (NIEL), Conservation Genomics group (CGG) at the University of Montana, Missoula, USA which is dedicated to DNA extractions. We used QIAamp DNA Stool Mini Kits (Qiagen, Inc., Valencia, CA) for extraction of DNA from scats. We used negative controls to keep track of cross contamination during extraction (Beja-Pereira et al. 2009). The total volume of DNA extracts from each scat sample was 100 µl.

The PCR for all scats samples were carried out in a total volume of 50 µl. The recipe of our master mix (MM) per sample was 20.375 µl H_2O, 5 µl buffer (7 µl $MgCl_2$, 0.375 µl BSA, 2 µl dNTP, 2.5 µl 12S/V5 primer F, 2.5 µl 12S/V5 primer R, 0.25 µl Taq polymerase and 10 µl DNA as extract template for each scat sample. The PCR condition was denaturation at 95°C for 5 min then 40 cycles of PCR starting at 95°C for 1 min then annealing at 55°C for 1 min and elongation at 72 °C for 1:30 min. A final elongation at 72°C for 5 min at the end and 4°C until the product was removed from PCR. All PCRs were conducted on Eppendorf vapo. protect Master cycler pro and all reactions included a negative and positive control. All sequences were then run on a 3130 genetic analyzer and sequences were read using Finch TV software. The sequences were then subjected to NCBI Blast for species identification. All failed samples were discarded and not included in the final analysis.

Scat analysis

The collected scat samples were assigned to each of the carnivore species based on molecular identification for investigating diet composition of the two carnivores. During analysis, scat samples were sun dried first and then morphological characteristics of scats such as length, breadth and weight were recorded. For disintegration, scat samples were soaked in warm water and then washed under tap water in a sieve to remove dust and mucus and segregated different prey items such as hairs, bones, insects, bird feathers and plant parts (Mahmood et al. 2013). These prey parts were dried and divided into different groups such as plant-based diet and animal-based diet.

Whole mount preparation

We used hairs recovered from the scats for identification of mammalian prey species of the two carnivores. For this purpose, light microscopic slides of the hairs of prey species were prepared. Hairs were washed in carbon tetrachloride 15–20 min), long hairs were cut into small pieces and jumbled up hairs were separated. For whole mount preparation, we used transparent nail polish.

Prey species of carnivores were identified using medullary pattern and cuticular cast pattern of the hairs recovered from scat samples as described by Moore et al. (1997). Prepared light microscopic slides were then compared with reference hair slides for identification.

Similarly, other parts recovered from scat samples such as bones, feathers of birds, invertebrates such as insects and plant matter including seeds were also identified. The hairs of prey species were identified using a light microscope with objectives of 10×, 40× and 100× magnification.

Scale replication

Cuticular scale patterns of mammalian hair were identified by using a slightly modified procedure after Lavoie (1971). Two to three drops of transparent nail polish were spread evenly on a glass slide. A small hair was placed in vertical position along axis of slide so as one end of hair projected out of slide. After the nail polish was dry the end of hair projecting out was plucked with a single motion using forceps to get a cast of the hair's surface in the nail polish. The hair cast was studied under a microscope against a reference collection for identification.

Identification of plant matter

Plant matter recovered form scats of two carnivore species was mainly comprised of seeds and fruit parts. Recovered seeds and fruit remains were compared with reference material collected from the field to identify them. Seeds were also sown and germinated in pots for plant species identification.

Dietary niche breadth

We measured dietary niche breadth of two sympatric carnivore species using niche breadth (L) and standardized Levins index (0–1) (L_{st}) (Levins 1968, Colwell and Futuyma 1971) as follows:

$$L = \left(\sum_{i=1}^{n} p_i^2 \right)^{-1} \quad \text{and} \quad L_{st} = \frac{L-1}{n-1}$$

where p_i is the relative percentage of food item i and n is the number of food items.

L_{st} is the standardized niche breadth and its value ranges from 0 to 1. A higher L_{st} indicates a broader diet niche.

Niche overlap

We used the frequency of occurrence of each prey item to compute the dietary overlap between jackal and fox occurring in the study area using Pianka's index, the value of which ranges from zero (no overlap) to one (complete overlap) (Pianka 1973). We chose this index to allow comparison of the degree of overlap to similar studies of carnivores conducted elsewhere in the world (Fedriani et al. 2000, Ray and Sunquist 2001, Jacomo et al. 2004). The Pianka's index was calculated using formula:

$$O_{jk} = \frac{\sum_{i}^{n} p_{ij} p_{ik}}{\sqrt{\sum_{i}^{n} p_{ij}^2 \sum_{i}^{n} p_{ik}^2}}$$

where p_{ij} (or p_{ik}) is the relative percentage of food item i in diet j (or k).

The prey species diversity index (H′), prey richness (S) and prey evenness (E) indices were calculated for each of the two-carnivore species during different seasons. Prey species richness (S) was the total number of prey species consumed by each predator during each season.

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Diversity index (H′) was calculated by using the following formula:

$$H' = -\sum \left[pi \times \ln pi \right]$$

where pi is prey index.

The evenness index (E) was calculated by using the formula:

$$E = \frac{H'}{\ln \text{ of } S}$$

where, S represents the prey species richness and H′ represents the diversity index.

All data were analyzed using SPSS (ver. 23) software and Excel statistics.

We compared total frequency of dietary items consumed by each carnivore species for statistical differences. To compare seasonal variation in diet composition of each carnivore species we used a generalized linear model (GLM). Similarly, we compared seasonal variation in consumption of wild prey species, domestic prey species and plant matter. We repeated GLM for variation in consumption of each dietary item consumed by each carnivore species. Frequencies of dietary components of four seasons were our response (dependent) variables while carnivore species were explanatory (independent) variables. The distribution of our data was normal $p > 0.05$. Our scale response was linear which specifies normal as the distribution and identity as the link function. All analysis was conducted in SPSS ver. 23.

Results

Diet composition

Asiatic jackal

Analysis of n = 64 scat samples of the Asiatic jackal collected during four different seasons (summer, autumn, winter and spring) of the year revealed sixteen prey species including mammals, birds, insects and plants (Table 1). Among these species, 10 were wild, 5 domestic and 1 plant species. Frequency of occurrence of wild prey in the diet of jackal was 18% but that of domestic prey was approximately 60%. Among wild prey, rhesus monkey was most consumed (5.43%), followed by Norway rat (3.26%). Among domestic prey, consumption of poultry was high (27.17%), followed by domestic goat (20.65%). The plant matter represented 3.26% of the jackal's diet (Table 1). Bones and hairs of the prey remains dominated the scats of Asiatic jackal by percent volume occurrence followed by bird feathers. A general linear model fitted explained 82.6% of the variation in prey item consumption of Asiatic jackal. The consumption of dietary items varied significantly $F = 15.02$, $df = 17$, $p < 0.0001$.

The analysis of seasonal variation in diet composition revealed a higher consumption of wild prey during the autumn season (21.88%) but low during spring (12.5%). Similarly, consumption of domestic prey was high during the winter season (66.67%) and low during autumn and spring (56.25% each) (Table 1). GLM showed no statistically significant difference in seasonal diet consumption of Asiatic jackal during the study period $F = 0.946$, $df = 3$, $p = 0.423$. Similarly, consumption of wild prey species did not differ significantly during four seasons $F = 1.082$, $df = 3$, $p = 0.371$. Consumption of domestic prey species did not differ during different seasons $F = 0.346$, $df = 3$, $p = 0.792$.

Kashmir hill fox

Analysis of n = 92 scat samples of Kashmir hill fox revealed 21 prey species including mammals, birds, plants and insects in the diet. Among prey species, 10 were wild, 5 were domestic and there were 6 plant species. Frequency of wild prey was approximately 18%, domestic prey 51% and plants 28% (Table 2). Among wild prey species, wild boar was most consumed (2.99%) followed by house mouse (2.4%). Among domestic prey, the consumption of poultry was high (29.34%), followed by domestic goat (14%)

Table 1. Percent frequency (%F) of occurrence of prey items in diet of Asiatic jackal in the study area.

Prey species	Summer (n = 17)	Autumn (n = 23)	Winter (n = 14)	Spring (n = 10)	% Total freq.
Wild prey					
Rhesus monkey *Macaca mulatta*	4.35	9.38	0	6.25	5.43
Wild boar *Sus scrofa*	4.35	3.13	0	0	2.17
Desert hare *Lepus nigricollis dayanus*	0	3.13	0	0	1.09
Indian gerbil *Tetra indica*	4.35	0	0	0	1.09
Roof or house rat *Rattus rattus*	0	3.13	0	0	1.09
House mouse *Mus musculus*	0	0	4.76	0	1.09
Norway rat *Rattus norvegicus*	0	0	9.52	6.25	3.26
Kalij pheasant *Lophura leucomelanos*	0	3.13	0	0	1.09
Spotted dove *Streptopelia chinensis*	4.35	0	0	0	1.09
Insects (Orthoptera) grasshopper	0	0	4.76	0	1.09
Total wild prey	17.39	21.88	19.05	12.5	18.48
Domestic prey					
Goat *Capra hircus*	21.74	21.88	23.81	12.5	20.65
Sheep *Ovis aries*	4.35	0	4.76	6.25	3.26
Cow *Bos taurus*	8.7	9.38	9.52	0	7.61
Buffalo *Bubalus bubalis*	4.35	0	0	0	1.09
Poultry *Gallus gallus domesticus*	21.74	25	28.57	37.5	27.17
Total domestic prey	60.87	56.25	66.67	56.25	59.78
Jaro grass *Thameda anathera*	4.35	6.25	0	0	3.26
Grits	4.35	3.13	4.76	6.25	4.35
Anthropogenic	13.04	12.5	9.52	25	14.13

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(Table 2). A general linear model explained 73.9% variation in consumption of different dietary items by Kashmir hill fox ($R^2 = 0.739$). The consumption of different dietary items also varied significantly in the diet of Kashmir hill fox ($F = 8.86$, $df = 22$, $p < 0.0001$).

Consumption of wild prey species was found to be high during spring season (25%) but low during summer season (9.43%), whereas consumption of domestic prey was high during winter (66.67%) but low during autumn (40.35%). Consumption of plant species was high during summer and autumn (35.85% and 35.09%, respectively) but lowest during winter (9.09%). Analysis of the seasonal variation in the diet composition of Kashmir hill fox by GLM showed no significant difference across different seasons ($F = 1.14$, $df = 3$, $p = 0.337$). Consumption of wild prey species also did not differ across all four seasons ($F = 1.025$, $df = 3$, $p = 0.395$), similarly consumption of domestic prey did not differ among all four seasons ($F = 0.201$, $df = 3$, $p = 0.894$).

Prey species diversity, richness and evenness

The prey species diversity index of the diet of the Asiatic jackal was found to be high during summer and winter seasons (2.22 each), but low during spring (1.51). Prey species richness was high during summer (12) but low during spring (7). Prey species evenness was high during winter (1) but low during spring 0.78 (Fig. 1). Whereas for the Kashmir hill fox, prey species diversity index in diet was high during autumn season (2.38) but low during spring (1.83) whereas, prey richness was high during autumn (16 species) and low during spring (9 species). Prey evenness was high during autumn (0.86) and low during summer and winter seasons (0.83) (Fig. 1).

Niche breadth and niche overlap

When we compared the two sympatric carnivore species in habiting the PLNP study area, the Asiatic jackal was found to have a much broader niche breath compared to the Kashmir hill fox (Fig. 2). Individually, the niche breadth of Asiatic jackal was found broad during summer (17.25; 0.96) but narrow during spring season (6.67; 0.33). Total niche breadth of the Asiatic jackal was found to be 14.2 (0.78). On the contrary, the niche breath of Kashmir hill fox was wider 9.07 (0.37) during the autumn but narrow during spring season 4.8 (0.17). The overall niche breadth of fox was 7.89 (0.31) (Fig. 2). Niche overlap between these two sympatric carnivores was found to be 0.81.

Discussion

Knowledge of a predator's diet is vital to understand its ecology and to predict its effect on the dynamics of prey populations (Oli 1993). No previous studies exist on diet composition of Asiatic jackal and Kashmir hill fox from Azad Jammu and Kashmir particularly and diet composition of the Kashmir hill fox have not been studied in Pakistan so far. During this study we recorded mammals, birds, insects and anthropogenic items from the diet of Asiatic jackal at Pir Lasura National Park. Consumption of domestic prey was higher than that of wild prey. Wild prey species included

Table 2. Percent frequency (%F) of occurrence of prey items in diet of Kashmir hill fox in the study area.

Prey species/items recovered	Summer (n = 27)	Autumn (n = 31)	Winter (n = 19)	Spring (n = 15)	% Total freq.
Wild prey					
Desert hare *Lepus nigricollis dayanus*	3.77	0	0	0	1.2
Wild boar *Sus scrofa*	0	5.26	3.03	4.17	2.99
Rhesus monkey *Macaca mulatta*	0	3.51	0	0	1.2
Turkistan rat *Rattus pyctoris*	0	1.75	3.03	0	1.2
Indian gerbil *Tetra indica*	0	0	6.06	0	1.2
House mouse *Mus musculus*	0	0	6.06	8.33	2.4
Roof or house rat *Rattus rattus*	0	0	0	4.17	0.6
Red-vented bulbul *Pycnonotus cafer*	0	1.75	6.06	0	1.8
Spotted dove *Streptopelia chinensis*	1.89	1.75	0	0	1.2
Insects Hymanoptera (ants bees)	3.77	5.26	0	8.33	4.2
Total wild prey	9.43	19.3	24.24	25	17.96
Domestic prey					
Goat *Capra hircus*	13.21	14.04	15.15	12.5	13.77
Sheep *Ovis aries*	3.77	7.018	9.09	0	5.39
Cow *Bos taurus*	3.77	0	0	4.17	1.8
Buffalo *Bubalus bubalis*	1.89	0	0	0	0.6
Poultry *Gallus gallus domesticus*	26.42	19.3	42.42	41.67	29.34
Total domestic prey	49.06	40.35	66.67	58.33	50.9
Plant species					
Wild Himalayan pear (Dhandali) *Pyrus pashia*	22.64	21.05	0	0	14.37
Jaru grass *Themeda anathera*	5.66	3.51	3.03	4.17	4.19
Kov *Olea ferruginea*	5.66	7.02	6.06	0	5.39
Wheat *Triticum aestivum*	0	1.75	0	0	0.6
Dhania *Coriandrum sativum*	0	1.75	0	0	0.6
Choti berry *Ziziphus oxyphylla*	1.89	0	0	12.5	2.4
Total plant species	35.85	35.09	9.09	16.67	27.54
Grits	3.77	1.75	0	0	1.8
Anthropogenic	1.89	3.51	0	0	1.8

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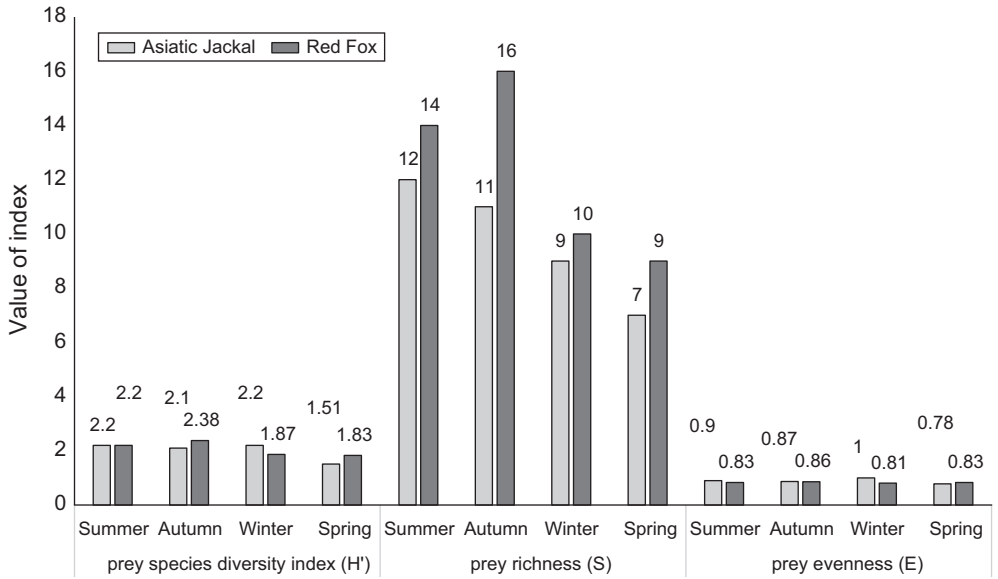


Figure 1. Prey species diversity index, prey species richness and evenness in diet of sympatric carnivore species in and around Pir Lasura National Park, Azad Jammu and Kashmir, Pakistan.

rhesus monkey (which was the main wild prey species) and four species of rodents. Among domestic prey species, poultry was the main prey followed by goat, whereas consumption of plant matter was low. Studies conducted elsewhere have reported rodents and plants as main components of jackal diets. However, we found that this was not the case in our study area, where the jackal seems to be more of a scavenger and predates on domestic poultry for a major part of its diet, followed by rodents and rhesus monkeys. Our results are in line with Roberts who reported that in Pakistan the jackal is perceived as a scavenger and carrion eater (Roberts 1997). Jackals feed on refuse in villages, however the majority of their diet is comprised of rodents, reptiles, fruits and insects when available (Roberts 1997). A study conducted in Bharatpur, Rajastan, India during 1984–1985 showed that diet of jackal comprised of rodents 26.5%, birds 24.1%, grass 20%, fruits 16.5%, insects 4.1%, snakes 4.1%, chital 2.4%, nilghai 1.2% and fish 1.2% (Sankar 1988). Stomach contents of four jackals in Rajasthan Indian revealed that diet of jackals mostly consisted of fruits of *Ziziphus*, with small proportion of beetles and scorpions. Another individual consumed desert jirds *Meriones hurrianae* and small mongoose (Prakash 1959). Analysis of 138 scats of Asiatic jackal in sal forests in India showed that 68 percent of their diet consisted of rodents followed by plants 27%, 11% reptiles, 8% fish and 9.4% birds (Schaller 1967). A study conducted in Sariska Tiger Reserve, India showed that the diet of the Asiatic jackal was comprised of plant matter 17.57%, rodents 15.77%, cattle 15.32%, chital 10.81%, fruits 9.01%, birds 7.21%, sambar 5.41%, hare 4.05%, nilgai 4.05%, goat 1.80% and reptiles 1.8% (Mondal 2012). Diet of jackals usually are comprised of small and medium-sized mammals

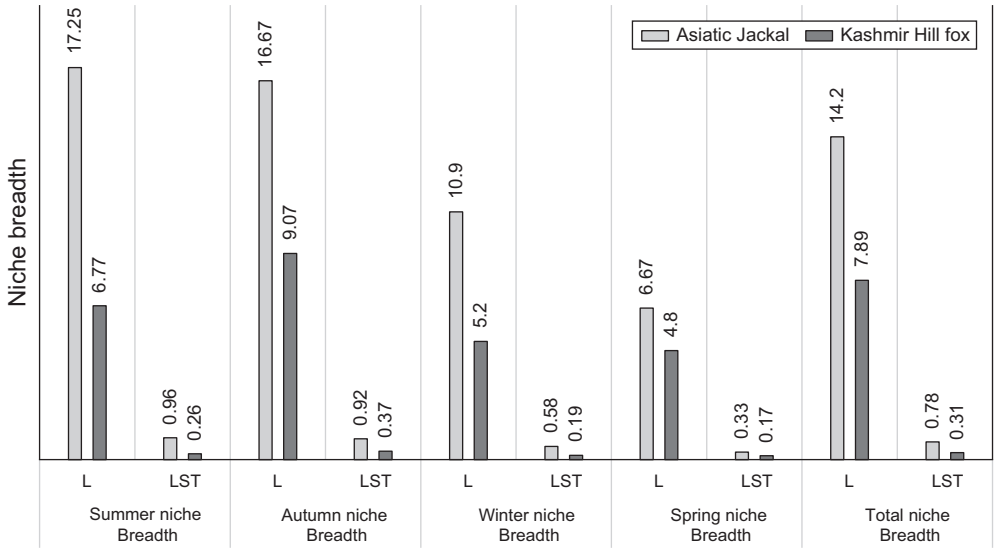


Figure 2. Niche breadth of sympatric carnivores occurring in and around Pir Lasura National Park, Azad Jammu and Kashmir, Pakistan. *L*, Niche breadth; L_{st}, standardized niche breadth (value 0–1).

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such as rodents, rabbits, birds, fishes, insects and vegetation (Aiyadurai and Jhala 2006). The diet of jackal in Keoladeo National Park, India was comprised of mainly plant matter 38.44%, nilgai 8.13%, rodents 10.31%, chital 9.69%, cattle 7.5%, anthropogenic 1.56% (Singh 2016). This high proportion of mammals in the diet of jackal suggest that they scavenge on dead animals and hunt calves as hunting larger mammals might be difficult (Singh 2016). Rodents are an important part of jackal diets (Mukherjee et al. 2004, Jaeger et al. 2007, Majumder et al. 2011, Singh 2016). Diet of Asiatic jackal in Pakistan showed that 46.47% of its diet is animal matter by volume including rodents, mongooses, wild boar, livestock, birds and domestic poultry and 25.08% plant included wheat, tomato, berries, grains, orange, melon and water melon (Mahmood et al. 2013). Most of these previous studies have recorded plants and rodents as major prey species in diet of Asiatic jackal, but this could be due to difference in methodology; ours is the first study in the region to use genetic methods to confirm the identity of the species which produced a given scat. Jackals living in high mountainous regions can take up mammals only as major part of their diet (Schaller 1970). In India Schaller (1970) reported that frequency of occurrence of rodents in the diet of jackal was 94%, however he also reported snakes and lizards 29% and insects 6.7%. Previous, studies which have been conducted in Pakistan has also reported large proportions of plant matter in the diet of jackal. However unlike previous studies, we confirmed scats by genetic analysis; it was interesting that scats identified as being from jackal had very little or no plant matter, and that other sympatric carnivores such as fox and civets consumed plant matter in large proportions. The difference between the results of our analysis and other studies in the region raises a question as to how much of this difference is might due to differences in diets in different places or times, or to what extent previous studies may have misidentified some unknown fraction of scats. We suggest that future studies of these predators confirming them by genetic analysis now that costs make this practical.

There is a paucity of information available on diet composition of fox in Pakistan and no published scientific literature is available. However, some information is available from a book by Roberts (1997) for comparison who states that foxes are adaptable hunters and can hunt hares, rodents, reptiles and small birds but when vertebrate prey is not available they can subsist on insects and fruits. According to Roberts, foxes feed on fruits of ber tree *Zizyphus mauritiana*. In the diet of fox, mice, rats, desert hare, Indian gerbils, have been reported by Roberts (1997). Studies in Indian Rajasthan showed that foxes feed on wild melon, termites (Prakash 1959). Foxes have reported to feed on scorpions, fruits of *Zizyphus nummularia*, spiders, cockroaches and also had some melon seeds in stomach. Roberts (1997) never encountered any sign of foxes feeding on domestic poultry although he has reported instances of domestic poultry being eaten by civets, cats, mongooses and martins.

During the present study, we recorded that diet of Kashmir hill fox diet was comprised of mammals, birds, invertebrates and plant matter. We also recorded anthropogenic material in the diet of fox. Consumption of poultry was higher than any other dietary component, followed by goat. We identified six species of plants in the diet of fox. The Kashmir hill fox also consumed sheep, cow and buffalo which likely indicate the fox's scavenging behavior. The consumption of different food items varied among during different seasons, in agreement with other studies (Basuony et al. 2005, Baker et al. 2006, Kidawa and Kowalczyk 2011). The red fox is essentially an omnivore having a diverse diet which includes invertebrates, small mammals, birds, plant matter and carrion (Flower 1932, Englund 1965, Amores 1975, Macdonald 1979, Osborn and Helmy 1980, Ciampaloni and Lovari 1985, Calisti et al. 1990, Basuony 1998). Fox has been reported by other studies to feed on plant material in southern Europe (Ciampaloni and Lovari 1985, Calisti et al. 1990) and it is known to feed on plant species or parts of plants having high sugar content (Basuony et al. 2005).

Niche overlap among Asiatic jackal and Kashmir hill fox was high (0.81) indicating a potential for competition in the study area. Lanszki et al. (2006) reported that trophic niche overlap among jackal and fox was 0.73 in Hungary. Of course, shared food resources are only indicative of competition as food could be super abundant. However, it can be argued that if some food items are shared but the two predators are not competing for it now, they might in future if this resource declines, or one (or both) of the predators increase.

We used scat analysis for documenting diet composition and niche overlap of both carnivore species which is most widely-used method for such purposes. Results of scat analysis only reveal undigested parts recovered from the scats hence we cannot obtain direct information about digested material using scat analysis. We did not try to calculate biomass consumed, because of substantial uncertainties which could affect these calculations (Chakrabarti et al. 2016, Lumetsberger et al. 2017). For example, hairs can identify the prey species, but it is impossible to know a) whether a young/subadult/male/female has been preyed upon and these different classes vary greatly in body mass) or b) whether a predator scavenged from a carcass which was killed by another predator.

Conclusion/recommendations

This study has provided baseline data on dietary habits and niche overlap of two sympatric carnivore species, the Asiatic jackal and Kashmir hill fox inhabiting Pir Lasura National Park, north-eastern Himalayan region of Pakistan. The dietary niche breadth of Asiatic jackal was wider than that of Kashmir hill fox, however, the dietary niche of the two carnivores overlapped 81% in the study area, suggesting a high level of potential competition between these two carnivore species. The diet of both carnivores showed that they predated on domestic poultry which leads to conflict, and thus raises concerns for conservation. This human–carnivore interaction, as well as a feeding study on captive animals should be performed in the future. Our results are important in the context of determining species-specific conservation requirements, not only in the study area, but also in other parts of the world where these two carnivores overlap.

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