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Distribution, Diet Menu and Human Conflict of Grey Wolf *Canis lupus* in Mahoodand Valley, Swat District, Pakistan

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ABSTRACT

Grey wolf *Canis lupus*, categorized as "Endangered" in Pakistan, is one of the largest species of Canid family; it occurs in various parts of the country including upper Swat area. Reportedly, species population is declining in its range, however, data on its ecological aspects are scanty in the country. In the current study, we investigated distribution and diet of grey wolf and the level of its human conflict in Mahoodand valley of Swat District. Results revealed the occurrence of grey wolf at an elevational range between 2332 m to 2926 m above mean sea level (amsl); a total of 7 dens, 30 pug marks and 33 scats of the species were recorded. A careful estimate gave a population density of 0.45 individuals/km^2 in the study area. Scat analysis for diet composition showed 5 domestic and 8 wild prey species in its diet menu, with major share (53 %) from livestock and relatively less (46%) from wild prey. The grey wolf has emerged as one of the major predator in the study area consuming mainly donkey, horse, cow, sheep and goats, resulting in a negative perception among the locals. Most of the depredation occurs at night time while maximum livestock are depredated during winter season.

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TM designed and supervised the study and wrote the manuscript. MRK conducted field visits and collected data. HF, FA, SA and AH helped in lab work and data analysis.

Key words
Grey wolf, Distribution, Diet, Prey, Mahoodand valley

INTRODUCTION

In biotaxonomic classification, the grey wolf *Canis lupus* (Linnaeus, 1758), appears as a carnivorous mammal (Mammalia, Carnivora) that belongs to the family of dogs, the canids. The modern wolves live in temperate and cold climates, having successfully occupied vast habitats, from the tundra to the forests and mountains in the steppes and occur throughout the northern hemisphere (North Asia, Europe and North America), with the exception of tropical forests and deserts, which demonstrates a marked ability to adapt to climatic and environmental conditions. In general, the wolf is considered the only ancestor of the modern dog (*Canis lupus familiaris* Linnaeus, 1758) and wolves and dogs can cross and are able to produce fertile offspring.

Being a tremendous roamer, the Indian grey wolf inhabits nearly all habitats, however, it is largely restricted to fragile tracks of barren, hilly regions and vast deserts (Roberts, 1997). Likewise, it occupies wide plains, low rainfall grasslands, scrublands, and pasture lands (Shahi, 1982). Territories of the grey wolf range from 150 to 300 square kilometers which is a function of availability of prey and sites of denning in their territory (Jhala, 2003; Habib and Kumar, 2007). Natural caves are occupied in mountain areas (Roberts, 1997).

In arid and semi-arid areas, grey wolf depredates on large hoofed mammals, subsisting on small sized livestock as well, usually sheep, goats and indeed on other small prey species as well like wild hare (*Lepus* species) and rodents (Singh and Kumara, 2006). Furthermore, birds, insects and fruits of some plants are also consumed by wolves. Camel calves and donkey are also recorded to be depredated by the Indian grey wolf (Jhala, 1993). Domestic dogs are also frequently killed by wolves and this fact is also shown by wolf on the outreach of mountain villages.

In response to depredation on livestock, efforts are made to control grey wolf population by poisoning, shooting and smoking out their denning sites, resultantly their populations are reportedly declining in Pakistan (Roberts, 1997). Human-wolf conflict becomes more severe for wolf because of its extensive home ranges and the top position in food chains (Woodroffe and Ginsberg, 1998), resultantly many wolf populations are threatened by habitat destruction, disease and persecution (Treves and Karanth, 2003; Ashenafi *et al.,* 2005). This conflict between predators (carnivores) and human is a significant problem throughout the world (Saberwal *et al.,* 1994; Distefano, 2005). Conflicts of such a kind are observed

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most regularly as a result of competition for limited or shared available resources (Conforti and de Azevedo, 2003) and are peculiarly debated when the concerned resources have economic value and the legally protected predators are involved (Graham *et al.,* 2005) or occur in protected areas (Lodhi, 2007).

Out of 32 wolf sub-species, two are reported from Pakistan viz., Tibetan wolf (*Canis lupus chanco*) and Indian grey wolf (*Canis lupus pallipes*). The Indian grey wolf occupies wide plains, low rainfall grasslands, scrublands and pastureland; was distributed in various protected areas of the country including Kirthar National Park, Chhumbi Surla Wildlife Sanctuary, Hazarganj Chiltan National Park, Hingol National Park, Cholistan and Lal-Suhanra National Park (IUCN, 2003). Whereas the Tibetan Wolf, inhabits wasteland rocky valleys of Baltistan, Gilgit, Hunza, Chitral, Upper Swat and Khunjerab National Park (IUCN, 2003). Lydekker (1907) distinguished two wolf species in Pakistan, Tibetan wolf inhabiting some of the Himalayas portions and the Indian Wolf occupying Kashmir valley`s southern parts. As indicated by the recent molecular phylogenetic studies the lineages of wolf might undergo significant taxonomic revision in the Indian subcontinent (Sharma *et al.,* 2004; Aggarwal *et al.,* 2007). In spite of being "Endangered" in Pakistan, very few studies have focused on dietary niche breadth and human conflict of wolves (one such study by Ali *et al.,* 2016) in Pakistan. In the current study, we investigated occurrence of grey wolf in Mahoodand valley area of Swat district, in northern Pakistan, with emphasis on its diet composition and human conflict in the study area.

MATERIALS AND METHODS

Study area

The current study was conducted in "Mahoodand valley" of Swat District, Kalam, situated at a distance of about 99 km from Mingora city in the northern elevated reaches of valley Swat along the River Swat in the Pakistan`s province of Khyber Pakhtunkhwa (Fig. 1). Kalam has lush vegetation, dense forests, scenic lakes, waterfalls, meadows and pasturelands.

With a mild and generally warm and temperate climate, Kalam features a humid sub-tropical climate. Average temperature is 13.4 °C, while the annual precipitation averages 639 mm. November is the driest month with 15 mm of precipitation, while April, the wettest month, has an average precipitation of 93 mm. July is the hottest month of the year with an average temperature of 24.1 °C. The coldest month January has an average temperature of 1.5 °C (Climate Data of Kalam, 2016). The climatic data are not available separately for Mahoodand, hence, Kalam data have been quoted here.

Mahodand Lake, is an important area for different wildlife species, including the grey wolf, since all wildlife species visit it for drinking water. The lake is located in the upper "Ushu Valley" at a distance of about 40 km from Kalam. The lake is accessible by a four-wheel drive vehicle and is often utilized for fishing and boating. The Mahoodand Lake lies at the foothills of Hindukush Mountains at an elevation of 2927 m, surrounded by the meadows, mountains and dense forests. Similarly, the banks of Mahoodand Lake are covered by pines and pastures that serve as a camping site during the summer. The Mahoodand Lake is fed by melting glaciers and springs of the Hindu Kush Mountain and gives rise to Ushu Khwar, the major left tributary of the Swat River. During the winter, the Mahodand lake freezes and is covered by heavy snow (Climate Data of Kalam, 2016).

Major habitats of the grey wolf in Mahoodand valley were identified, after getting information from native people and from the staff of Wildlife department Khyber PakhtunKhwa province. Sampling sites were selected, on the basis of literature mentions and information from local people, for data collection on grey wolf and monthly field surveys were undertaken from July, 2017 to June, 2018, to record direct and indirect signs of the grey wolf and collect its scats from the study area. Scat were analyzed to determine food habits.

Distribution

Monthly surveys were conducted and signs of the grey wolf presence including pug marks, den counts, scats, hair samples, dead specimens and prey species consumed were recorded following Abbas *et al.* (2013). Geographical coordinates of the positive sites were recorded using Global Positioning System (GPS). In addition, a questionnaire survey was carried out to collect information from local people about the occurrence of grey wolf and its depredation on livestock.

Diet composition

The diet composition of grey wolf was investigated by analyzing scat samples following Burns *et al.* (1998). The samples were collected wherever/whenever encountered in the study area during field surveys. The scats were identified in the field morphologically and distinguished from those of other predator species, depending on their diameter (Norton *et al.,* 1986; Rabinowitz, 1989), tapering ends and many knots (Edgaonkar and Chellam, 2002). Geographical coordinates of scat locations were also recorded using Global Positioning System (GPS) device (eTrex Vista). The scats were analyzed in the laboratory after measuring their physical characteristics like weight,

length and diameter. During analysis, scats were soaked, sieved and segregated into identifiable groups like bones, feathers, hair and any plant parts. Undigested prey remains like hair, were subjected to the identification of mammalian depredated species as described by Mukherjee *et al.* (1994); the hairs were used randomly from each scat for the preparation of light microscopic slides (whole mount and scale replication) for identification of mammalian prey species consumed by the grey wolf.

A combination of hair characteristics like color, length, medullary and cuticular pattern of the mammalian prey hair recovered from each scat were observed under light microscope and compared with the reference hair slides available in the laboratory to identify the mammalian prey species of grey wolf in the study area. Similarly, bird prey species of wolf were identified from feathers recovered from scats. The plant materials recovered included seeds which were also identified. The diet composition and prey species of the grey wolf were segregated into domestic prey and the wild prey, the data on wolf diet were also analyzed in the context of seasonal consumption and variation in its prey species like summer and winter. The biomass consumption of prey species by grey wolf was estimated following Ackerman *et al*. (1984):

$$y = 1.98 + 0.005X$$

Where, y = weight of prey consumed per scat and x = average live weight of prey species.

RESULTS

Distribution of grey wolf- field signs

Seventeen potential sampling sites were surveyed for recording distribution of grey wolf in the study area (Table I), out of which seven (7) sites were found positive where Grey wolf signs could be recorded (Fig. 1).

We recorded 92 different signs of the grey wolf including 7 dens, 32 pug marks, 6 snow tracks, 10 prey remains and 57 scats in the study area (Fig. 2). Out of 57 scats collected, 37 were identified to be those of wolf. A considerable number of scats of the species were mostly found on the road sides, while many others were found along the walks and trails (Fig. 3), the species Pug marks were recorded in snow and mud along the banks of river, snow tracks and riparian zones (Fig. 2B). All the signs of grey wolf were recorded at an elevation ranging from 2,332 m to 2,926 m above mean sea level (amsl). The occurrence of wolf signs showed that the species was widely distributed in the study area. Out of 17 sites surveyed, 10 sites were found negative for wolf occurrence, where no signs of the species were recorded. The bones and skulls of prey species were also recorded at five (positive) sites (Table I).

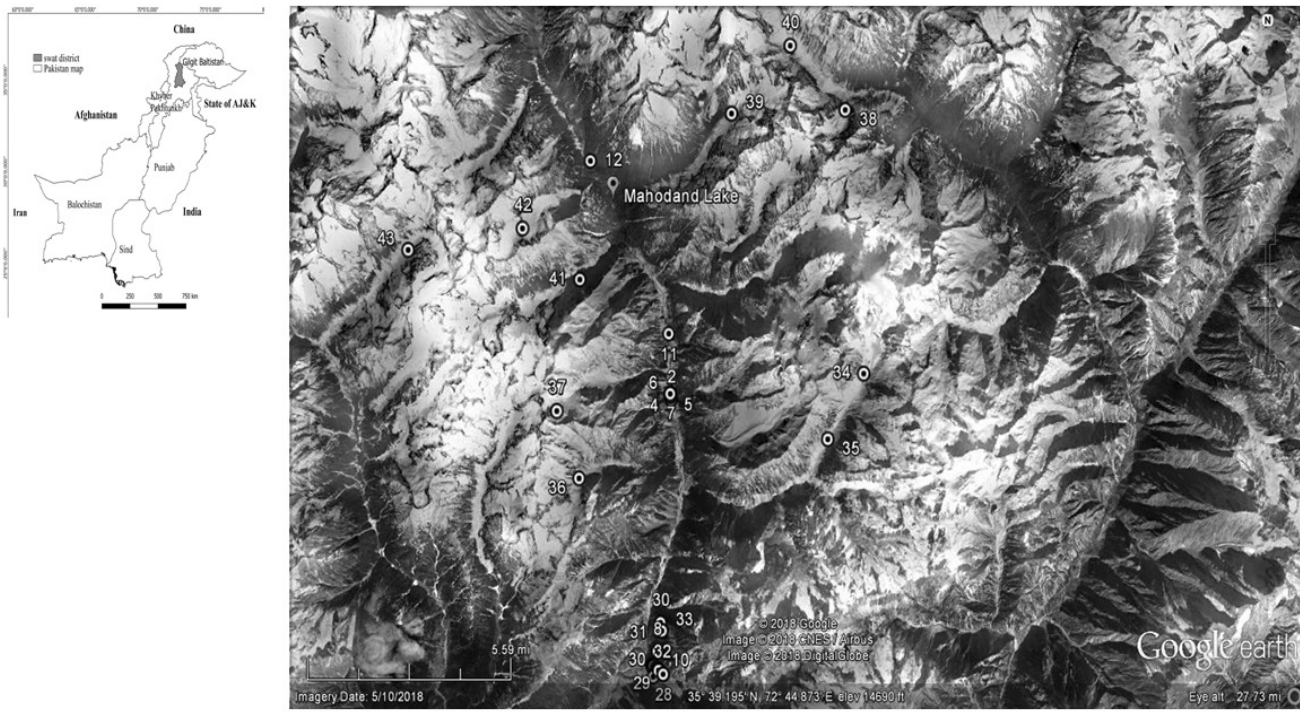

Fig. 1. Map of study area (Mahoodand Valley, Swat) showing locations where scat samples of grey wolf were collected (modified from Google earth).

Table I.- Details of indirect signs of the Indian grey wolf (*Canis lupus*) recorded in the Mahoodand Valley, Swat, Pakistan for determining its distribution from August 2017 to July 2018.

Site No.	Site name	Geographical coordinates and elevation above mean sea level	Types of grey wolf signs recorded				
			Dens	Scats	Pug marks	Snow tracks	Prey remains skins/bones
1	Mahoodand Lake Road (Baseen Maal Glacier)	35°38'26.32"N, 072°40'51.10"E (8433 ft.)	✓	✓	✓	✓	✓
2	Shameel Dara	35°41'29.11"N 72°32'55.61"E (12806 ft.)	×	×	×	×	×
3	Matiltan Goss Bandha	35°32.878"N, 072°40.448"E (8790 ft.)	✓	✓	✓	×	✓
4	Zoonchal Dara	35°41'54.91"N 72°36'30.47"E (13607 ft.)	×	×	×	×	×
5	FatturShai	35°39.743"N, 072°40.812"E (8727 ft.)	×	✓	×	×	×
6	Chameen Dara	35°40'53.05"N 72°38'7.42"E (10764ft.)	×	×	×	×	×
7	Saif-Ullah Jheel	35°43.426"N, 072°38.408"E (9547 ft.)	×	✓	×	×	×
8	Mazghal Dara	35°45'48.29"N 72°44'39.59"E (11939ft.)	×	×	×	×	×
9	Dabbir	35°32.447"N, 072°40.429"E (7922 ft.)	×	✓	✓	✓	✓
10	Qandeel Shai Dara	35°44'20.88"N 72°42'51.40"E (12936ft.)	×	×	×	×	×
11	Glacier	35°33.500"N, 072°40.552"E (9226 ft.)	✓	✓	✓	✓	✓
12	Qala Sheer Dara	35°44'26.91"N 72°46'21.33"E (11846 ft.)	×	×	×	×	×
13	Chorrat	35°33.347"N 072°40.606"E (9201 ft.)	✓	✓	✓	×	✓
14	Saan Bandha	35°38'7.16"N 72°37'35.05"E (13948 ft.)	×	×	×	×	×
15	Dosech Banda	35°36'41.28"N 72°38'9.85"E (11888 ft.)	×	×	×	×	×
16	Shattar Banda	35°37'29.71"N 72°45'48.69"E (11343 ft.)	×	×	×	×	×
17	Cheelgal Banda	35°38'53.20"N 72°46'54.17"E (12726 ft.)	×	×	×	×	×
		Total	04	07	05	03	05

Sign density

Among 92 different signs of the grey wolf found in an area of approximately 22 km^2 surveyed (Fig. 2 and 3), highest numbers of wolf signs were recorded at sampling site-9 “Dabbir” where 37 signs were found with a density of 6.16 signs/km^2, followed by at “Mahoodand Lake Road (Baseen Maal Glacier)” site-1 with 29 signs with a density of 5.8 signs/km^2, whereas the least number of signs were recorded at Fattursha i (site-5) and Saifullah (site-7) with only one sign each, having a sign density of only 0.5 sign/

km². Ten sites were found negative regarding occurrence of the grey wolf (Table II). Taking into account the total area surveyed (22km²) and the number of wolf dens and snow tracts recorded, a total population of approximately 10 grey wolves was estimated for the study area with a density of 0.45 wolves/km², with the maximum number of three wolves/dens occurring at Matiltan site (Table II).

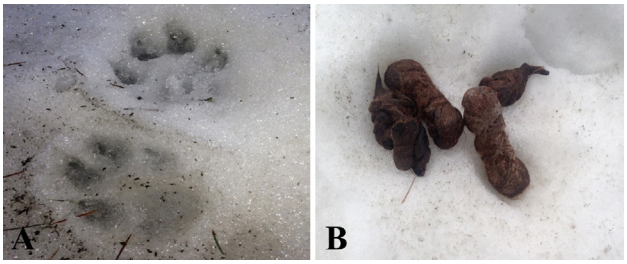

Fig. 2. Field signs of grey wolf (*Canis lupus*) recorded at different sampling sites in the study area. A) Pug marks on snow tracks, B) Scats of grey wolf.

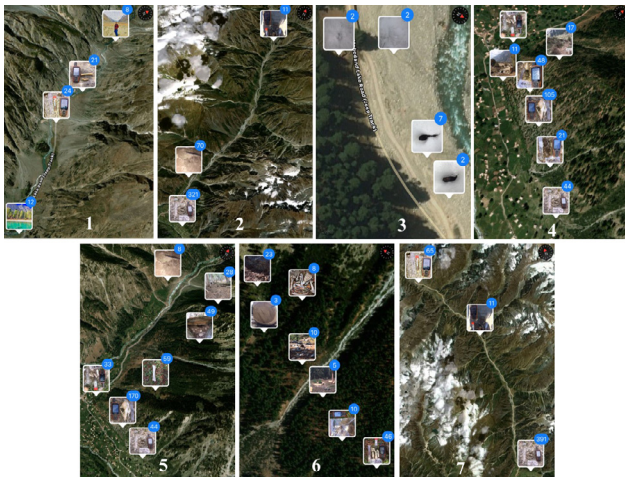

Fig. 3. Maps (1 -7) of the trails that were walked for scat collection; from Matilatan to Mahoodand and Saifullah Jheel in Swat, showing sampling sites with maximum number of samples (I-Phone Mobile Maps 2017-2018).

Table II.- Details of field signs and density estimates of grey wolf (*Canis lupus*) recorded in Mahoodand valley, Swat, Pakistan from August 2017 to July 2018

S. No	Site name	Scats (n)	Pug marks (n)	Snow tracks (n)	Dens (n)	Prey remains (skin/bones) (n)	Total signs (n)	Distance traveled (km)	Sign s/km²	Estimated no of wolves (N)
1	Mahoodand Lake Road (Baseen Mall)	7	15	3	2	2	29	5	5.8	2
2	Shameel Dara	-	-	-	-	-	-	-	-	-
3	Matiltan	3	2	0	3	3	11	3	3.66	3
4	Zoonchal Dara	-	-	-	-	-	-	-	-	-
5	FatturShai	1	0	0	0	0	1	2	0.5	0
6	Chameen Dara	-	-	-	-	-	-	-	-	-
7	Saif-Ullah Jheel	1	0	0	0	0	1	2	0.5	0
8	Mazghal Dara	-	-	-	-	-	-	-	-	-
9	Dabbir	22	11	2	0	2	37	6	6.166	2
10	Qandeel ShaiDara	-	-	-	-	-	-	-	-	-
11	Glacier	1	2	1	0	1	5	1	0.5	1
12	Qala Sheer Dara	-	-	-	-	-	-	-	-	-
13	Chorrat	2	2	0	2	2	8	3	2.66	2
14	Saan Bandha	0	0	0	0	0	0	0	0	0
15	Dosech Banda	0	0	0	0	0	0	0	0	0
16	Shattar Banda	0	0	0	0	0	0	0	0	0
17	Cheelgal Banda	0	0	0	0	0	0	0	0	0
	Total	37	32	6	7	10	92	22	24.29	10

*Probable individuals of grey wolf estimated (based on dens plus snow tracks), **10** individuals
*Total area surveyed = 22 km² area; Estimated density of grey wolf (D): N/A = 10/22 = 0.45 individuals/km²

Table III.-. Morphological Characteristics of scats of grey wolf (*Canis lupus*) collected from the selected sampling sites in Matiltan Mahoodand valley, Swat, Pakistan from August 2017 to July 2018. Total wolf scat samples were N= 37.

Sampling site	No of Scats (N)	Weight (g)	Length (cm)	Breadth (cm)
Mahoodand Lake Road (Baseen Mall Glacier)	7	28.44	30.45	3.19
Matiltan Goss Bandha	3	30.38	15.99	3.49
FatturShai	1	43.40	34.26	2.51
Saif-Ullah Jheel	1	19.01	14.24	2.85
Dabbir	22	38.35	24.97	3.25
Glacier	1	62.40	38.40	3.20
Chorrat	2	19.00	30.23	4.045
Mean ± SE		34.43 ± 5.79	26.93 ± 3.43	3.22 ± 0.182

Physical characteristics of wolf scats

As per the dietary pattern of individual wolf and its prey species, the scats were of different sizes and shapes (Fig. 2). Morphologically, the mid-points of scats were broad while their end points were narrow and tapering. Mean weight, length and breadth of scats were 34.43 ± 5.79 g, 26.93 ± 3.43 cm, and 3.22 ± 0.182 cm respectively (Table III; Fig. 2).

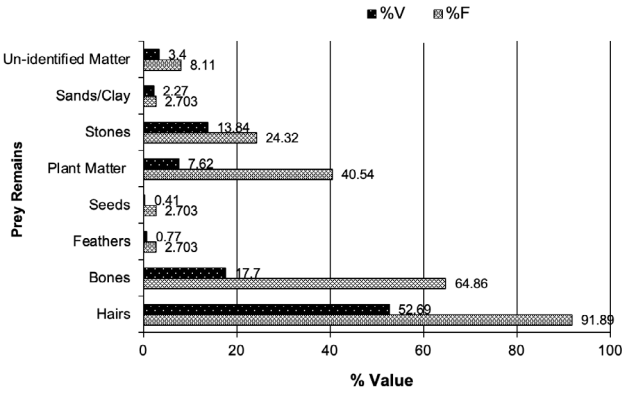

Fig. 4. Percent frequency (%F) and percent volume (%V) occurrence of recovered food items from analysis of scat samples of grey wolf (*Canis lupus*) from Mahoodand valley Swat. N = 37.

Undigested prey components

Analysis of scat samples revealed undigested components of prey species including hairs, bones, feathers, seeds and other plant matters, stones and sands/ clay (Fig. 4). By frequency, hairs were recovered from approximately 92% scat samples, followed by bones (65 %) whereas feathers, seeds, sand/clay constituted the least with only 2.70% each. By percent volume (%V) consumption, hair also dominated (52.69 %), followed by bones (17.70 %) while seeds (0.41%) and other plant matter (7. 62%) contributed the least (Fig. 4).

Prey species consumed by grey wolf

Thirteen prey species (5 domestic and 8 wild) were recorded in the diet of grey wolf from its scat analysis (Table IV). Among domestic prey species, donkey (*Equus africanus asinus*) was most frequently consumed by wolf (100 % F), followed by sheep *Ovis aries;* 24.32%) and domestic cow (*Bos taurus*, 13.51 %), whereas horse (*Equus caballus*; 5.40%) and goat (*Capra aegagrus hircus*; 1.08%) contributed the least.

Table IV.- Percent frequency (%F) of occurrence of domestic and wild prey species in the scats of grey wolf (*Canis lupus*) from Matiltan Mahoodand valley, Swat, Pakistan. N=37.

Sr. NO.	Prey species	%F (N=37)
Domestic prey species		
1	Goat (*Capra aegagrus hircus*)	2.70
2	Sheep (*Ovis aries*)	24.32
3	Cow (*Bos taurus*)	13.51
4	Horse (*Equus caballus*)	5.40
5	Donkey (*Equus africanus asinus*)	100.0
Wild prey species		
6	Markhor (*Capra falconeri*)	29.73
7	Rhesus monkey (*Macaca mullata*)	5.40
8	Woolly -flying squirrel (*Eupetaurus cinereus*)	2.70
9	Golden marmot (*Marmota caudate*)	2.70
10	Asian -palm civet (*Paguma larvata*)	29.73
11	Indian bush rat (*Golunda ellioti*)	29.73
12	House mouse (*Mus musculus*)	13.51
13	Indian gerbil (*Tatera indica*)	5.40

Among the wild prey species, grey wolf consumed frequently (29.73% each) Markhor (*Capra falconeri*), Asian palm civet (*Paguma larvata*) and Indian bush rat (*Golunda ellioti*) followed by House mouse (*Mus musculus,* 13.51%). Rhesus monkey (*Macaca mullata*) and Indian gerbil (*Tatera indica*) were also consumed by wolf (5.4% each), while the flying squirrel (*Eupetaurus cinereus*) and golden marmot (*Marmota caudata)* contributed the least (2.70% each) in total diet of grey wolf (Table IV).

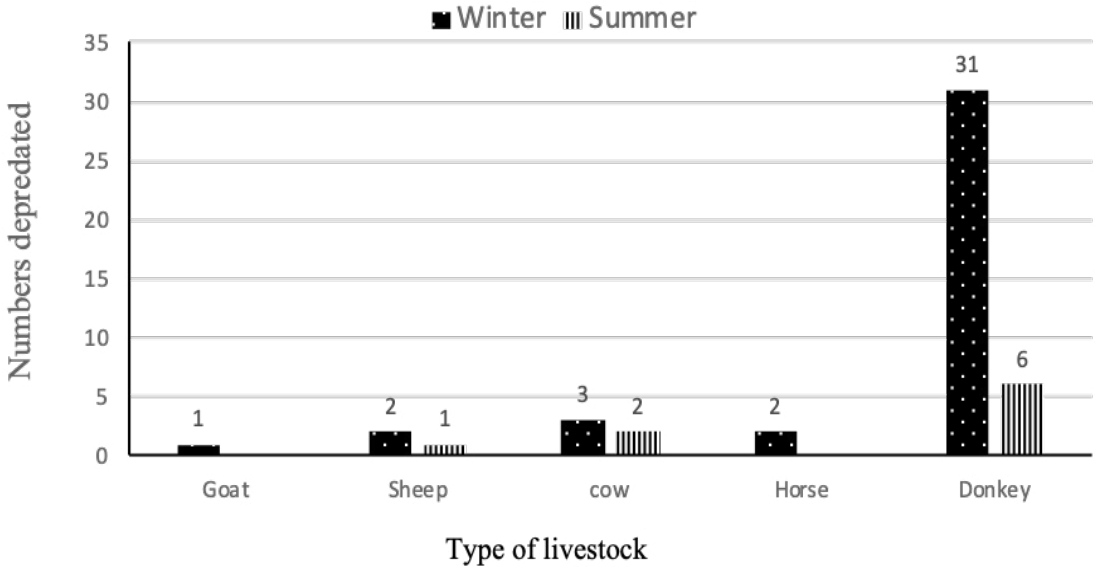

Fig. 5. Seasonal pattern of livestock depredation by grey wolf (*Canis lupus*) in Swat area, Pakistan from August 2017 to July 2018.

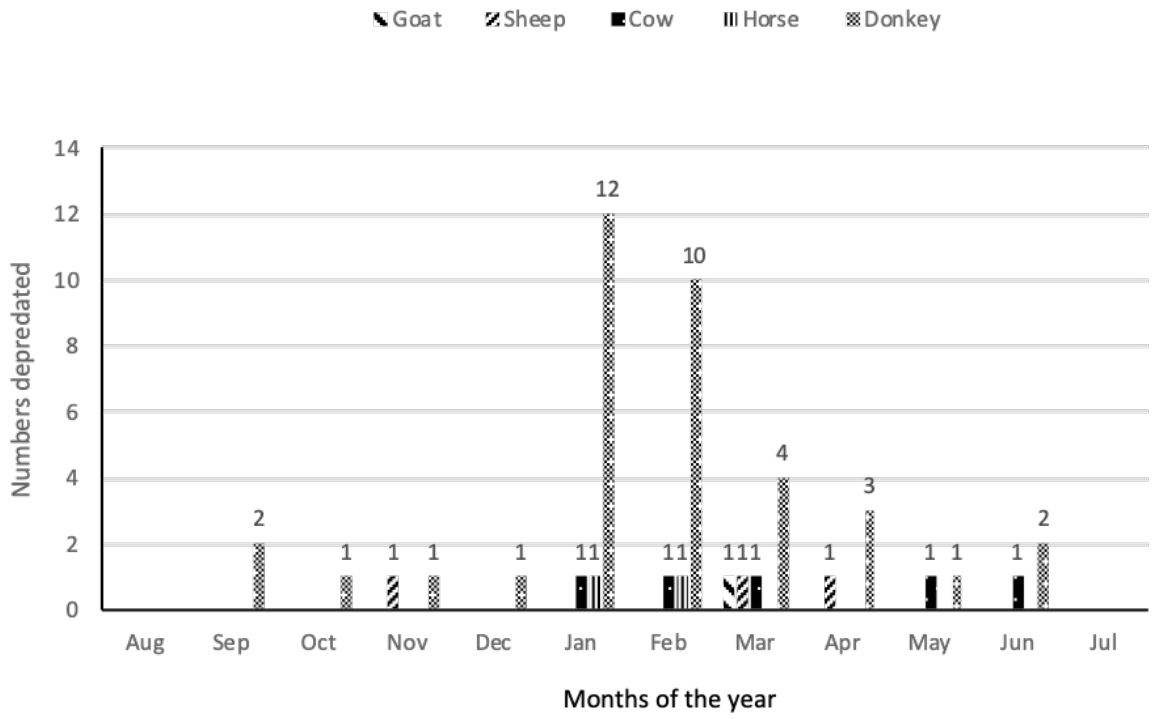

Fig. 6. Monthly pattern (August 2017 to July 2018) of Livestock depredation by grey wolf (*Canis lupus*) in Mahoodand valley, Swat, Pakistan.

Table V.- Biomass consumption of grey wolf (*Canis lupus*) during winter (November 2017 to April 2018) and summer (August –October 2017 and May-July 2018) seasons in Mahoodand valley, Swat, Pakistan.

Prey species	Winter season					Summer season			
	Assumed weight (kg)	Biomass per scat	Number of scats	Biomass consumed (kg)	Biomass consumption %	Biomass per scat	Number of scats	Biomass consumed (kg)	Biomass consumption %
Domestic prey									
Goat	45	13.5	1	1.49	2.1	-	-	-	-
Sheep	45	41.3	2	0.98	1.4	19.01	1	1.1	2.97
Cow	615	32.46	3	13.5	19	19	2	29	76.76
Horse	450	24.55	2	16.38	23	-	-	-	-
Donkey	80	35.95	31	31	43.6	31.75	6	6.78	17.94
Sub total	1235	147.76	39	63.35	89.1	47.36	9	36.88	97.67
Wild prey									
Indian gerbil	0.21	28.85	2	0.0066	0.01	-	-	-	-
House mouse	0.019	13.22	5	0.0032	0.0045	19.01	1	0.00045	0.0012
Rhesus monkey	7.7	10.9	2	0.66	0.93	-	-	-	-
Flying squirrel	0.14	13.5	1	0.005	0.01	-	-	-	-
Markhor	41	29.19	10	6.3	8.87	26.05	1	0.7	1.85
Palm civet	4.3	40.3	9	0.45	0.63	26.065	2	0.2	0.53
Indian bush rat	0.019	34.66	10	0.0025	0.0035	27.5	1	0.00031	0.00082
Marmot	3.7	6.2	1	0.27	0.38	-	-	-	-
Sub total	57.08	85.1	40	7.6973	10.838	85.1	5	0.90076	2.38202
Grand total	1292.08	232.86	79	71.0473	99.938	132.46	14	37.78078	100.052

Formula used: $y = 0.439 + 0.008x$, x, assumed live weight of prey species; y, estimated biomass consumed per scat.

The consumption of different prey species differed during winter and summer seasons (Table V). Among domestic prey, goat and horse were consumed only during winter seasons while among wild prey, Indian gerbil, Rhesus monkey, flying squirrel and Marmot were consumed during winter season only. Domestic sheep and Asian palm civet were consumed more heavily during winter than in summer season. Thus it looks that winter diet of grey wolf is more diversified than its summer diet.

Biomass consumption

In winter season, grey wolf consumed approximately 71.05 kg biomass, dominated heavily by domestic prey (63.35 kg; 89.1%) (Table V). Domestic donkey was the major prey (43.6%), followed by horse (23%) and cow (19%). The goat (2.1%) and the sheep (1.4%) contributed the least. On the other hand, contribution of wild prey in wolf diet was 10.83% during winter season, although eight different prey species were consumed, Markhor contributing the most (8.87 %). In summer season, grey wolf consumed approximately a total of 37.78 kg biomass, including 97.6 % (36.88 kg) domestic prey and only 2.38 % (0.90 kg) wild prey (Table 5). Domestic cow contributed heavily (76.76 %), followed by donkey and much lesser contribution from sheep (2.97 %). Among domestic prey, goat and horse were not consumed. Among wild prey, Markhor, Asian palm civet, Indian bush rat and house mouse were consumed while rhesus monkey, flying squirrel, marmot and Indian gerbil were absent from the summer diet of grey wolf (Table V).

Human-grey wolf conflict

The grey wolf was found as one of the major predators attacking livestock of local inhabitants of the study area. During August 2017 to July 2018, the wolf depredated upon 37 donkeys, 1 goat, 3 sheep and 5 cows (Fig. 5). Most of the attacks by wolf on livestock were reported at night time, whereas maximum numbers of livestock (n = 33) were depredated during the months of January 2017 to March 2018 which is winter season in the study area (Fig. 6).

DISCUSSION

Although grey wolf is reported from different parts of the country including plains and high elevation hilly areas, but the data on its ecology are poorly documented so far. Virtually, there are no population data and density estimates of the species reported from Pakistan. It is categorized as "Endangered" in the country (Sheikh and Molur, 2005) while it is rated as "Least Concern" globally (Boitani *et al*., 2018). It is one of the most controversial predators that symbolize the wilderness, devastation, destruction and negative changes (Shelton, 2004). For the wolf species Human-wolf conflict becomes more severe because of its large home ranges while in terminology of food chains it is on the top position (Woodroffe and Ginsberg, 1998). Many wolf populations however are threatened as a result of disease, persecution and habitat destruction (Ashenafi *et al.,* 2005). We investigated the occurrence and diet composition of grey wolf in Mahoodand valley of Swat District, in northern Pakistan. The grey wolf, being a carnivore, consumes animal prey, however, studies from different parts of the world have reported that its diet may comprise of wild as well as domestic prey. In the current study, we recorded grey wolf at seven out of 17 different sampling sites surveyed during August 2017 and July 2018. Its dens were found in natural wild areas, but the species did roam around human habitation for livestock depredation. Its dens were recorded at three sampling sites while its scats were found at seven different sites in the study area. This fact indicates frequent roaming of grey wolf at trails and around human settlements. According to Linnell *et al*. (1998) and Kunkel *et al.* (2005), by conducting indirect surveys such as sign surveys, distribution range of elusive or rare species such as large carnivores can be determined. Collection and mapping of indirect signs viz., scats, pug marks, prey remains etc. is relatively easy. Spatial point-pattern can be defined from these presence data, similar to the data being inferred from monitoring animals directly such as telemetry. Roberts (1997) reported that grey wolf may occur in nearly all types of natural terrains but it greatly avoids natural forest areas in addition to densely populated or well cultivated regions and is largely restricted to the remoter tracts of extensive desert or barren hilly regions. In mountains areas, grey wolf occupies natural caves or excavates burrows under boulders. It ascends into mountains regions of Pakistan from Balochistan up to Chitral, Gilgit and Baltistan in the north. In the current study we also recorded three dens of grey wolf in wild natural areas, far away from human settlements due to its secretive and elusive nature. Prater (2005) is of the view that the Indian wolf may live in forest but in India they are more common in bare and open regions. In barren uplands of Kashmir, Ladakh and Tibet, the species like wild ungulates and domestic livestock migrates to valleys during winter and to higher reaches even up to snow line in summer. In these parts, holes, caves and cavities in rocks provide them shelter/refuge in winter and thickets or reeds and scrub during summer.

Data on population or density estimates of grey wolf are scanty. Some efforts have recently been made. For example, Abbas *et al.* (2013) reported about 350 - 400 grey wolf distributed over 35,000 km^2 area (0.01 to 0.1142 per km^2) in Gilgit-Baltistan, in 2006. Bocci *et al.* (2017) investigated sympatric snow leopard and Tibetan wolf in Karakoram mountain range for their dietary composition. In the current study, we recorded 92 different signs of grey wolf including its dens (07), scats (37), pug marks (32) and snow tracks (n=06), and prey remains (10) in the study area. Using these data, we have estimated a population density of 0.45 wolves per km^2 in the study area. Considering the topography of the area, and undisturbed habitat, this area seems to support a fair density of wolf. We also predict very carefully, on the basis of dens and scats and to some extent the numbers of pug marks of the wolf. a population of about 10 wolves in approximately 22 km^2 area surveyed. We could not find any scientific data estimates to compare the population size and density of grey wolf in the country with those from the study area, except that were reported by Abbas *et al.* (2013) who reported a very low density estimates of wolf (1.0 ±1.4/100 km^2) for Gilgit-Baltistan. However, our density estimates of grey wolf are quite higher in the Swat area compared to those reported in earlier study from Gilgit-Baltistan.

In the current study, we found eight wild and five domestic prey species in the diet of grey wolf, with domestic donkey being the most frequently consumed, represented in all scats analysed, followed by domestic sheep. Among wild prey, Markhor and Asian palm civet were the major prey, while some rodent species also formed important component of wolf diet in the study area. Rhesus monkey was also among the wild prey but it was consumed less frequently. Published literature shows that wolf diet seems to be opportunistic and myriad (Salvador and Abad 1987; Cuesta *et al.,* 1991), the major prey consumed are the wild herbivores (Ballard *et al.,* 1987; Kohira and Rexstad, 1997; Jędrzejewski *et al.,* 2000). Relying on the local accessibility, wolves primarily feed on medium sized wild hoofed mammals (Sidorovich *et al.,* 2003; Nowak *et al.,* 2005). Similarly, some other studies report that anthropogenic food sources such as junk or rubbish and domesticated animals are also consumed in areas where wolves live in close proximity to humans (Theuerkauf, 2003; Chavez and Gese, 2005; Gazzola *et al.,* 2005; Nowak *et al.,* 2005). The greatest loss to mankind is

that depredation on domesticated animals or livestock, and Wolves have been reported to kill almost 400 to 600 sheep annually on the Scandinavian Peninsula (Swedish Wildlife Damage Centre, 2004). Gazzola *et al.* (2005) and Ansorge *et al.* (2006) argue that if the wild prey is available in adequate numbers, wolves prefer wild ungulates over domestic ungulates. If we compare the results of our current study, one wild herbivore (Markhor) and Asian Palm Civet are consumed by grey wolf in the study area. However, in general, beyond any doubt, the contribution of domestic prey is dominant over wild prey consumption, as is evident by biomass consumption of domestic prey which contributed as 89.1% in winter season over 10% wild prey in the study area. Similarly, in summer, domestic prey consumed comprised of biomass at 97.6% over 2.4% wild prey. The share of domestic sheep is not enough in the wolf diet in the current study. This fact indicates that even consumption of eight different wild prey species alone (which contribute to 10% biomass of wolf diet in winter and 2.4% in summer), without depredation on livestock, cannot sustain grey wolf in the study area. Naturally, the wolf has to attack livestock of the local people. It is also evident from the current study results that although wild prey is available to the grey wolf, but not sufficient (only 10% biomass in winter and 2.4% in summer diet of wolf)to sustain the carnivore species alone. Wolves' diet could be composed of a significant quantity of anthropogenic food origin, in areas where habitat is shared by wolves and man, and wolves might feed on domestic animals and scavenge on accessible carcasses at baiting areas or litter or junk dumping sites (Salvador and Abad, 1987; Lesniewicz and Perzanowski, 1989; Meriggi *et al.,* 1996).

The rapidly growing human population and accordingly the ever increasing resource utilization and habitat destruction have generated the issues of human wildlife conflicts in the wild. Due to larger home range size that coincides with human settlements and their nutritional needs that attract these animals to human settlements larger carnivores are subjected to conflicts and persecuted. Wolf depredation occurs in every type of habitat including edges of densely populated areas. Population growth, range expansion of wolves has resulted in increasing wolf-livestock conflicts. Bibikov (1982) and Okarma (1995) observed that the consumption of man-related food sources by the opportunistic wolf is the result of scarcity of wild ungulates, abundant anthropogenic food sources, disruption of pack social structure size due to intensive hunting, and husbandry practices.

Some interesting information has been generated regarding human-wolf conflict in the study area. Although, there are other predators also present in the study area including snow leopard, red fox, black bear, Jungle cat and weasels, but the grey wolf, in the current study, has been found to be one of the major predator attacking livestock of local people. The grey wolf during one year period (2017 – 2018), depredated on 37 donkeys, one goat, three sheep and five cows. Resultantly, perception of local people was found negative for grey wolf, and they tried to kill it. Most of the livestock depredation occurred outside the penned areas, where domestic animals grazed in the wild meadows and forest areas during day and night. Such an easy prey attracts predators seeking food in the near vicinity. The domestic animals attacked were left in the open and no one was guarding them; neither dogs nor humans. The grey wolf attacks on livestock are more frequent during winter season compared to summer season. Most of depredation occurs during the months of January, February and March. Roberts (1997) reported that the grey wolf was persecuted by using firearms, poisoning and smoking of dens in response to livestock depredation which caused the decline of grey wolf population in the country. Jhala (2003) further added that some other factors responsible for wolf decline included destruction of its habitat because of expanding human population, intensified agricultural practices, grazing competition, deforestation and scarcity of its wild prey species.

Earlier on, Jhala (2003) reported that ever increasing human population, urbanization, agriculture practices expansion, grazing pressure, forest clearing and poor wild prey availability are all the causes of habitat destruction of grey wolf. Predation is a natural phenomenon evolved with the animals. It becomes a problem when the predator population rises and shares the habitat with a particular prey species and humans; when the wild prey animals are scarce the domesticated animals are an easy and readily available alternative prey for predators to consume (Shelton, 2004). Johnson *et al.* (2005) also reported occasional attacks on human beings.

Co-existence of grey wolf in the human-dominated landscape requires specific conservation measures to be taken for grey wolf including awareness education among local populations about wolf conservation, infrastructural development like pens, and proper guarding of livestock during grazing and at home, and also protecting the habitat of grey wolf in the study area.

CONCLUSIONS

The grey wolf occurs at an elevational range between 2332 m to 2926 m above mean sea level in Mahoodand valley, Swat District, Pakistan. A careful estimate revealed a population density of 0.45 individuals/km^2. Scat analysis showed 5 domestic and 8 wild prey species in its diet menu, with greater contribution (53 %) from livestock and

relatively less (46%) from wild prey. It is one of the major predators in the study area consuming mainly donkeys, horses, cows, sheep and goats. Most of the depredation occurs at night time while maximum livestock are depredated during winter season.

Statement of conflict of interest

The authors declare no conflict of interest.

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