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DIET COMPOSITION OF ASIATIC JACKAL (*Canis* aureus IN MARGALLAH HILLS NATIONAL PARK, ISLAMABAD, PAKISTAN

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ABSTRACT

We investigated diet composition of Asiatic jackal (*Canis aureus*) in Margallah Hills National Park, Islamabad. A total of 90 scat samples of the species were collected from three different selected sites. Prey species were identified by comparison of medullary and scale patterns on the hair remains with reference slides of the wild and domestic prey species in the same area. Analysis revealed, on average, 27 different food items including animal matter (46.47 % by volume), plant matter (25.08 %), soil (22.42%) and anthropogenic material (5.35%). Animal matter included both wild (rodents, and mongooses) and domestic prey (poultry birds). The jackal also scavenged wild boar and livestock. Grasses, wheat, tomato, berries, grams, melon, water melon and orange were among the plant matter consumed by the jackal. Seasonal samples showed variation in the consumption of animal and plant matter but animal matter was dominant in all seasons. Prey species richness (S) was found maximum (17) during summer and least (11) during autumn. Diet diversity (H') was highest in summer (2.35) and least during autumn (2.12), while the evenness (E) was higher during winter (0.9) and least during summer (0.82).

Key words: Asiatic Jackal, Diet, Scats, Margallah Hills National Park, Islamabad, Prey species, Diversity index.

INTRODUCTION

Three species of jackals occur worldwide viz. black-backed jackal (*Canis mesomelas*), side striped jackal (*Canis adustus*) and Asiatic jackal (*Canis aureus*). In Pakistan, only *Canis aureus* is reported.

The Asiatic jackal (*Canis aureus*) can occupy all types of terrestrial habitats including extreme deserts and dense forests (Macdonald, 1984; Roberts, 1997), however, it prefers steppes, scrubland, open areas and marshes up to 1,000 m in elevation (Anitei, 2008). In Pakistan, it occurs throughout the plains of Sind, Punjab, Balochistan and Khyber Pakhtoonkhwa (KPK) provinces. Although it does not penetrate into higher elevations, but it does occur in most of the broader Himalayan valleys such as Murree hills up to 2150 m or 7000 ft (Roberts, 1997).

Asiatic jackal is an opportunistic feeder and also not a persistent hunter. It generally likes easy human-produced food and subsists almost entirely on garbage and human wastes (Macdonald, 1979). It hunts singly as well as in packs, but packs are more successful in hunting. A single jackal typically hunts smaller prey species like rodents, hares and birds, and uses its sense of hearing to locate rodents in the grass and then pounce on them by leaping in the air. It can even dig out gerbils (*Tatera indica)* from their burrows and can also hunt young, old and sick ungulates that are 4-5 times larger than its own size and body weight. Besides feeding on vertebrates, Asiatic jackal can also feed on invertebrates (like mollusks and insects) and plants matter (like fruits and grasses) as well. Jackals are generally omnivorous and their diet width varies according to the seasons and habit (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 comprises of rodents and reptiles. They also supplement their diet with fruits and insects when available (Roberts, 1997).

The "Margalla Hills National Park (MHNP)" as a protected area represents an important habitat for the Asiatic Jackal. The area is diverse in its flora and fauna, comprising of 618 different species of trees, shrubs, grasses and herbs of medicinal and economic value along with 250 species of exotic birds, song birds and birds of prey representing 24 families, 38 mammal species belonging to 8 orders, at least 13 taxa of reptiles and numerous insects (Roberts, 1997). These plant and animal species can serve as important diet components of the Asiatic Jackal in the area, the current study, therefore, investigated diet composition and seasonal variation in its diet in MHNP.

MATERIALS AND METHODS

Study Area: The current study was conducted at three selected study sites at the foothills of Margalla Hills National Park, located in the Potohar Plateau, in the north of the country (Fig. 1). It features an atypical version of a humid subtropical climate, with hot summers

accompanied by monsoon season, and followed by mild and wet winters. It lies in the monsoon belt and experiences two rainy seasons each year; summer monsoon that occurs from July through September, with heavy rainfalls and evening thunderstorms and winter rain that lasts from January till March (Encyclopaedia Britannica, 2010).

Study sites: Three different potential study sites were selected in the National Park (Fig. 1) mainly focusing the activity areas of the Asiatic jackal in the surroundings of human habituations. The selected sites included **(**a) surrounding areas of "Saidpur village (33º 44'.272 N, 073º 03'.819 E)", (b) surroundings of "Sindh House" (33º 44'.273 N, 073º 05'.382) Islamabad and (c) open fields of "National Agricultural Research Centre (NARC) (33º 44'.995 N, 073º 07'.673 E) Shehzad Town Islamabad (Table 1; Fig. 1)

Study Design: Selected sites were visited and surveyed fortnightly from August 2010 to July 2011, for collection of scat samples of the Asiatic Jackal to investigate its diet composition (Table 1). For scats collection, potential activity areas of the Asiatic jackal were located in each site which were then searched during the day and evening times for scat samples.

A total of 24 field visits were made to the selected study sites and 90 scat samples of *Canis aureus* were collected; including 34 samples from Saidpur village (site-I), 27 from the surroundings of Sindh house (site-II), and 29 samples from the open cultivated fields of NARC (site-III) Islamabad.

The criteria given by Jackson and Hunter (1995) were followed for collection of scat samples, the scats of the Asiatic Jackal were distinguished from those of other carnivores such as domestic dog, fox, civet and cats in the same area by their size, shape, scat dimensions (diameter), structure (segmented, non-segmented), characteristics contents (hairs, bones, plant material etc.) and spoors around the scats. Additional criteria included nature of scat deposit site, and presence of tracks or sign of activity of the species under study. The collected scats were stored in deep freezer at 0°C temperature to avoid any fungal growth till analysis.

Collection of Reference Materials: Hair samples of potential mammalian prey species (domestic, wild) of Asiatic jackal found in study area were collected as reference material for making hair identification key. Hair samples of domestic animals that were taken as reference materials included goat *(Capra hircus)*, sheep *(Ovis aries)*, cow *(Bos taurus)*, buffalo *(Bubalis bubalis)* and dog *(Canis familiaris)*; whereas those of wild animals included red fox *(Vulpes vulpes)*,Wild hare *(Lepus americanus)*, Himalayan Palm Civet *(Paguma larvata)*, Wild boar *(Sus scrofa)*, Rhesus monkey *(Macaca mullata)*, large Indian mongoose *(Herpestes edwardsii)*, house rat *(Rattus rattus)*, house mouse *(Mus musculus)*, Lesser Bandicoot rat *(Bandicota bengalensis)*, Indian gerbil *(Tatera indica)*, and soft-tailed mole rat *(Nesokia indica)*. In addition, reference hair were also collected from "Marghzar Zoo" Islamabad, and those of rodent species from "Pakistan Museum of Natural History", Islamabad. Thus a photographic reference key of potential prey species was developed for identification of the recovered material from analysis of scat samples of the Asiatic jackal.

Scat Analysis: The scats were placed in warm and dry place in the sun to avoid damage to their contents with fungus and to dry them for further procedure. After the scats got dried completely, their physical parameters like length, width and weight were recorded. During analysis, scats were soaked in warm water for at least 24 hours and washed repeatedly and thoroughly under flowing tap water to remove un-necessary dust particles and mucus. They were then sieved through a fine-mesh sieve and their contents were carefully segregated and observed (first by naked eye and then by 10X hand lens) to identify hair, bones, feathers and plant material recovered from them. The separated contents were placed on a paper in the sun for 2 to 3 days for drying and recovered food items were segregated into identifiable groups on the basis of their identification as "plant based", and "animal based", materials. They were weighed separately on an electronic weighing balance (SHIMADZU, AY 220).

Whole mount preparation: Light microscopic slides of the hairs of the prey species recovered from the scats were prepared. Hairs were first dipped in carbon tetrachloride for 15-20 minutes for preparing whole mount. Then hair was placed on a clean glass slide and evenly spread and mounted in DPX mountant. Jumbled up hairs were separated from each other to place a single hair on the slide, similarly, long hairs were cut into two or more small pieces.

The identification of prey species was based on medullary pattern of the hair as described by Moore *et al*., (1974) and also on the basis of cuticle cast pattern. Slides of hairs recovered from scats were matched with those of reference hair slides. Similarly, bones, feathers and plant materials recovered from scats were also sorted and identified.The medullary patterns of the hairs were observed under the microscope, first under lower (10x) and then under higher magnification (40x and 100x) respectively.

Scale replication: Cuticular scale patterns of mammalian hair were studied following Lavoie (1971), by preparing 3 percent solution of glycerin jelly in a beaker by mixing 3 ml of glycerin with 94 ml of warm water and then 3 g of gelatin was added. Then beaker was heated in a pan of hot water to prevent the medium from jelling. The medium was gel when cool and fluid when warm. Two to

three drops of medium were placed on glass slide and clean hair was placed in a vertical position to the long axis of the slide with one end of hair projecting out of the edge of the slide so that it could easily be plucked with a single attempt. Then the slide was set for sometime till the medium became fairly solid. With the help of forceps, hair was removed with a fast jerk to prevent it from sticking to the medium from slide and the cast of hair became apparent under the microscope which was exact duplicate of the scales of the hair.

Microphotography: Microphotographs of reference hairs of the representative medulla and scale patterns were taken along the length of hair by XSZ 107BN microscope. A 10.2 mm×10.2 mm, DCE-2 electronic eyepiece was attached with XSZ 107BN microscope for taking photographs.

Seasonal variation in the diet: For investigation of seasonal variation in the diet composition of the Asiatic jackal, scat samples collected from different sites were pooled season-wise and compared. The prey species diversity index (H'), prey richness (S) and prey evenness (E) indices were calculated from the data of seasonal variation in the diet composition of Asiatic jackal.

Prey Species Richness (S) was calculated by taking into account the total number of plant and animal prey species consumed by Asiatic jackal in a specific season. Diversity Index (H') was calculated by using the following formula:

$$\mathbf{H'} = -\sum [pi \times \ln pi]$$ (Where pi represents the prey index)

Whereas, the Evenness Index (E) was calculated by using the formula:

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

Where, S represents the prey species richness and H' represents diversity index.

RESULTS

Physical characteristics of scats: The mean scat mass, length and width were 8.89g, 5.63cm and 1.34cm at site-I (N=34),8.76g, 5.37cm and 1.25cm at site-II (N=27), and 8.19g, 5.18cm and 1.3cm at site-III (N=29), respectively (Table 1).

Diet composition: Analysis of scat samples of the Asiatic jackal revealed 27 different types of food items belonging to both animal and plant remains in general, however, animal matter appeared in slightly higher percentage (Table 2) than the plant matter while some proportion of soil and anthropogenic materials were also recorded.

Results of analysis of scat samples from site-I (N=34) revealed four main categories of materials viz. animal matter, plant matter, soil and anthropogenic materials (Table 4). Most frequently recovered remains from study site-I were bones (79% by frequency), while approximately 70% scat samples revealed hairs. The animal remains from scats constituted 45.35% by volume, including both wild and domestic animals. The wild prey species consumed by jackal from this site included rodents and mongoose while domestic prey were goat and sheep and poultry birds were also represented in the diet (2.12%). Asiatic jackal also scavenged on wild boar (1.66% by volume). The second abundant material recovered from scats collected from this site was plant remains (21.89% by volume), in the form of leaves of grasses and wheat (approximately 64% by volume), while seeds (26%) of various plants included tomatoes, berries, melon, water melon, oranges and grams. The soil and anthropogenic matter recovered included 27.3% and 5.1%, respectively (Table 2).

From study site-II (surrounding areas of Sind House Islamabad), results (N=27) showed less animal matter (36.1% by volume) consumed as compared to that in site-I, whereas more plant matter was (33.34%) consumed than that at site-I, soil (24.35%) and anthropogenic material (5.89%) recovered from scats were not much different from site-I . About 96% scats (% F) contained bones while about 48% samples had hairs. In study site-II, Asiatic jackal also scavenged on cow (*Bos Taurus*; 7.4% F), and wild boar (*Sus scrofa*; 4.81% F), apart from feeding on other wild (rodents, and mongoose) and domestic prey species (goat, sheep, poultry birds) (Table 2).

From site-III (NARC fields), N=29 scat samples analyzed revealed maximum (57.53% by volume) animal matter consumed across all the three study sites tested whereas plant matter (21.22%), soil (15.98%) and anthropogenic materials (5.16%) were least consumed among all sites. Among animal matter, bones represented 86% (by frequency) while hairs recovered constituted approximately 37% by volume. Different species of rodents were the main wild prey (18.2% collectively by volume) of Asiatic Jackal in this site. The domestic prey species included goat (1.65% V) and poultry birds (13.74%). Among plant matter were small leaves and stems of grasses and wheat and seeds of different wild and domestic fruits such as tomato seeds (1.19%), bajra seeds (0.26%), melon (0.73%), water melon (0.35%), and also some unidentified plant material (UPM; 7.08%). The soil recovered from scats constituted 15.98% by volume and anthropogenic items 5.16% (Table 2).

Average percent volume composition of (N=90) scat samples from all three sites of MHNP showed animal matter, on average, 46.47%, plant matter 25.08%, soil 22.42% while average anthropogenic material recovered from all collected
samples was 5.35% by volume (Fig.2).

Table 1. Details of three selected study sites in Margallah Hills National Park Islamabad and physical characteristics of scat samples of Asiatic jackal collected during the current study period.

Study site	Geographic coordinates	Sample size (N= 90)	Average Weight (g)	Average Length (cm)	Average Width (cm)
I Said Pur Village	33º 44.272N 073º 03.819E elevation 625m	34	8.89 ±0.50	5.63±0.13	1.34±0.03
II Sindh House	33º 44.273N 073º 05.382E elevation 605m	27	8.76±0.52	5.37±0.16	1.25±0.05
III NARC-Fields	33º 44.995N 073º 07.673E Elevation 513m	29	8.19±0.50	5.18±0.16	1.3±0.05

Table 2 Percent frequency of occurrence (%F) and percent volume occurrence (%V) of food items in the scat samples of Asiatic jackal collected from three selected sites of Margallah Hills National Park, Islamabad.

S.No	Food Remains	Study Site-I (n=34) %F	%V	Study Site-II (n=27) %F	%V	Study Site-III (n=29) %F	%V
Animal matter							
1	Bones Hair	79.41(27)	18.79	96.29(26)	22.49	86.20(25)	17.97
2	*Bos Taurus* (Cow)	0	0	7.40(2)	0.95	0	0
3	*Herpestes edwardsi*	17.64(6)	5.92	3.70(1)	0.37	0	0
4	*Capra hircus* (Goat)	14.70(5)	4.93	7.40(2)	1.25	3.44(1)	1.65
5	*Ovis aries* (Sheep)	11.76(4)	5.79	0	0	0	0
6	*Tatera indica* (Indian gerbil)	2.94(1)	0.49	3.70(1)	1.18	20.68(6)	13.83
7	*Sus Scrofa* (Wild boar)	5.88(2)	1.66	14.81(4)	3.69	6.89(2)	3.01
8	*Rattus rattus (House rat)*	5.88(2)	1.53	0	0	3.44(1)	0.43
9	*Bandicota bengalensis*	0	0	3.70(1)	0.63	3.44(1)	1.12
10	*Mus musculus* (House mouse)	2.94(1)	0.96	0	0	3.44(1)	2.82
11	*Canis familiaris* (Dog)	0	0	3.70(1)	0.9	0	0
12	**Birds**	8.82(3)	2.12	3.70(1)	0.55	31.03(9)	13.74
13	**UAM**	8.82(3)	3.16	25.92(7)	4.1	27.58(8)	2.96
	Total		**45.35**		**36.11**		**57.53**
Plant Matter							
14	Grass	32.35(11)	3.25	37.03(10)	4.09	41.37(12)	5.91
15	Small leaf, stems	23.52(8)	4.91	33.33(9)	3.48	17.24(5)	1.96
16	*Triticum aestivum* (Wheat)	8.82(3)	3.77	7.40(2)	3	6.89(2)	2.74
Seeds							
17	*Lycopersicum esculentum*	14.7(5)	1.14	11.11(3)	1.41	10.34(3)	1.19
Seeds							
18	*Zizyphus spp* (Bair)	2.94(1)	0	1.99	0	0	0
19	*Pennisetum glaucum (Bajra)*	0	0	0	0	0	0
20	*Cucumis melo (melon)*	0	0	0	0	6.89(2)	0.73
21	*Citrulus lanatus (W.melon)*	0	0	0	0	3.44(1)	0.35
22	*Citrus sinensis* (Orange)	2.94(1)	0.42	0	0	0	0
23	*Cuminum cyaminum* (Zeera)	2.94(1)	0.58	0	0	0	0
24	*Cicer arietinum* (Chana)	2.94(1)	0.09	0	0	0	0
25	UPM	17.64(6)	5.74	55.55(15)	21.36	27.58(8)	7.08
	Total	**21.89**		**33.34**			**21.22**
Others							
26	Soil	55.88(19)	27.3	59.25(16)	24.35	55.17(16)	15.98
27	Anthropogenic items	32.35(11)	5.1	51.85(14)	5.89	41.37(12)	5.16
	Total	**32.4**		**30.24**			**21.14**

UAM= unidentified animal matter; UPM= unidentified plant matter

Seasonal Variation in diet composition: The consumption of major food items by Asiatic jackal varied during different seasons of the year, including fall or autumn (August, September and October 2010), winter (November, December 2010, January 2011), spring (February, March, April 2011) and summer (May, June, July 2011). The scat samples of the species collected during different seasons from different sites were pooled and then analyzed for seasonal variation in the diet (Table 3; Fig.3).

Table 3 Seasonal variation in mean percent volume occurrence (%V) of prey species in the diet of Asiatic jackal in Margallah Hills National Park Islamabad.

		Percent volume occurrence (%V)			
S. No	**Food Remains**	**Autumn (n=12)**	**Winter (n=18)**	**Spring (n=21)**	**Summer (n=39)**
Animal Matter					
1	**Bones**	17.92	22.12	23.94	16.90
	Hairs				
2	*Bos taurus* (Cow)	2.15	0	0	0
3	*Herpestes edwardsi* (Large mongoose)	4.04	0	3.64	2.21
4	*Capra hircus* (Goat)	4	0	2.61	3.76
5	*Ovis aries* (Sheep)	0	0	3.13	3.36
6	*Tatera indica* (Indian gerbil)	0	2.70	5.78	7.17
7	*Sus scrofa* (Wild boar)	0	8.81	1.58	1.33
8	*Rattus rattus* (House rat)	0	0	0	1.66
9	*Bandicota bengalensis* (Bandicoot rat)	0	0	0	1.27
10	*Mus musculus (*House mouse)	0	0	0	2.93
11	*Canis familiaris* (Dog)	0	1.35	0	0
12	**Birds**	7.06	15.40	1.28	2.47
13	**UAM**	4.88	3.10	3.17	3.16
	Total	**40.05**	**53.48**	**45.13**	**46.22**
Plant Matter					
14	Grass	3.30	4.51	3.58	5.02
15	Small leaf, stems	12.78	3.75	3.45	0.64
16	*Triticum aestivum*	0	7.77	7.10	0
Seeds					
17	*Lycopersicum esculentum* (Tomato)	0	2.27	2.34	0.55
18	*Zizyphus spp* (Bair)	5.66	0	0	0
19	*Pennisetum glaucum* (Bajra)	0.61	1.19	0	0.19
20	*Cucumis melo* (Melon)	0	0.86	0.27	0
21	*Citrulus lanatus* (W.melon)	0	0	0	0.26
22	*Citrus sinensis* (Orange)	1.19	0	0	0
23	*Cuminum cyaminum* (Zeera)	0	0	0.95	0
24	*Cicer arietinum*(Chana)	0	0	0	0.07
25	UPM	15.59	11.62	12.12	8.65
	Total	**39.13**	**31.97**	**29.81**	**15.38**
Others					
26	Soil	11.99	9.76	18.45	34.39
27	Anthropogenic items	8.73	4.70	6.58	3.96

The consumption of animal matter was predominant as compared to plant matter in the diet of the Asiatic jackal in the study area during all the four seasons, ranging from 40.06% to 53.48%, with maximum consumption occurring during winter season (Fig.3). Fall diet comprised of almost an equal percentage of animal matter (40.06 %) and plant matter (39.15%) while anthropogenic material in the diet contributing 8.74%. However, during winter, spring and summer seasons, more animal matter was consumed (53.48%, 45.09% and 45.23%, respectively) than that of plant matter (31.97%, 29.81% and 16.88%, respectively), with anthropogenic materials contributing 4.71%, 6.58% and 4.03%, respectively (Table 3; Fig.3).

Prey species richness, diversity and Evenness Indices: Results of seasonal variation in diet composition of Asiatic Jackal from three selected sites were utilized to

investigate prey species richness (S), diversity Index (H') of the prey species and Evenness Index (E) in the study area. Prey species Richness (S) for Asiatic Jackal was found maximum (17) in summer season while it was least (11) in autumn. The diversity Index (H') showed that diet of Asiatic jackal was more diverse during summer season (2.35) as compared to that in winter (2.26) and spring (2.28) seasons, and it was least diverse during autumn season (2.12). The Evenness Index (E) showed higher values during winter season (0.9) as compared to spring (0.86) and autumn (0.88) while it was least during summer season (0.82) (Fig. 4).

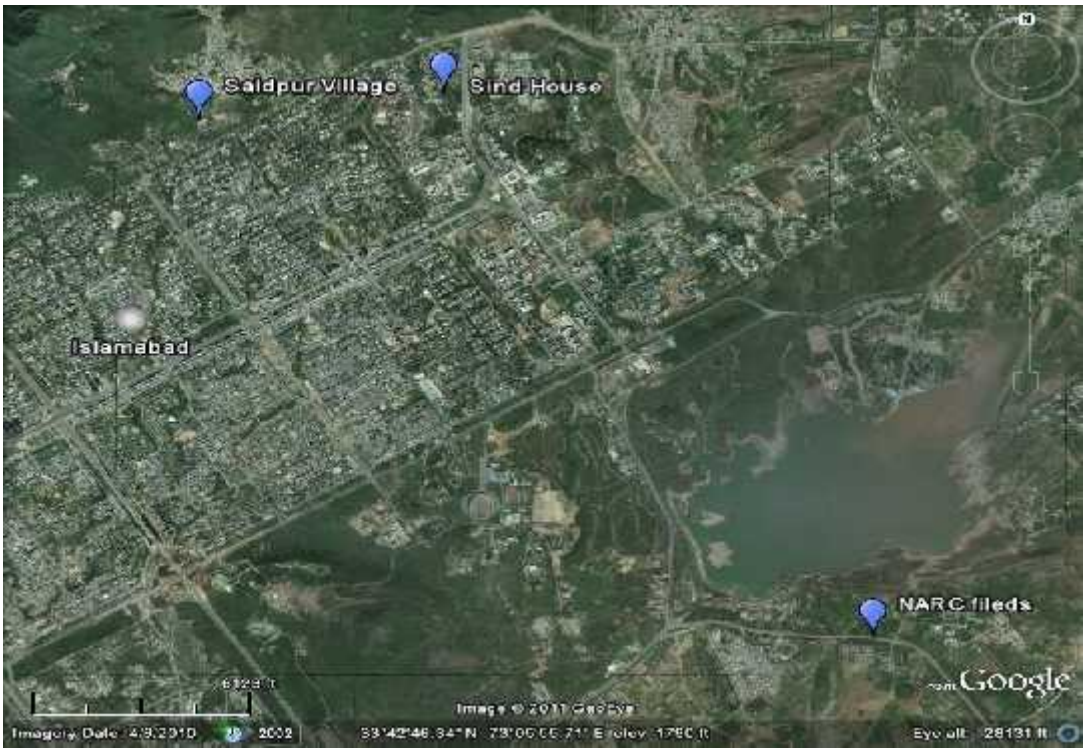

Fig 1. A satellite image of the study area showing location of three selected study sites in Margallh Hills National Park Islamabad, for data collection during the current study period (taken and modified from Google Earth).

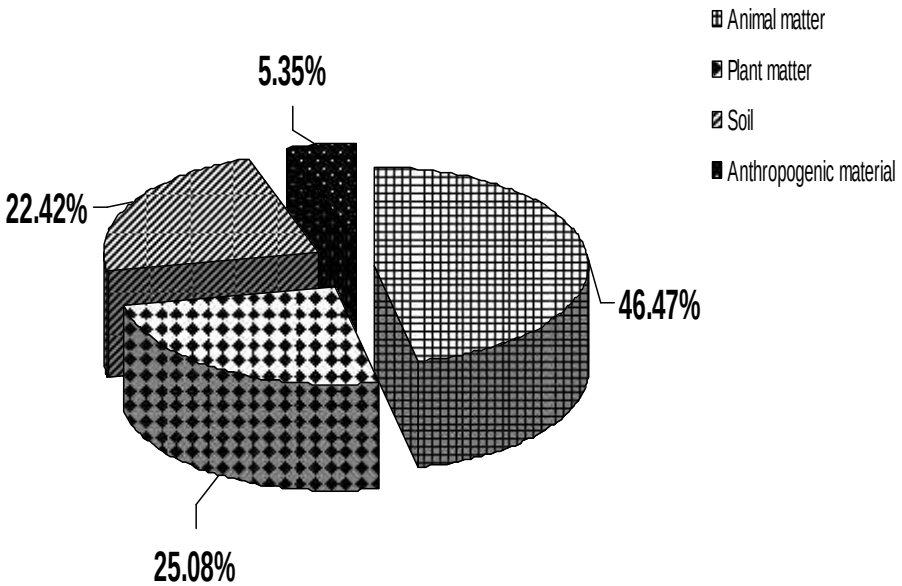

Fig. 2. Average percent volume occurrence (%V) of different food items recovered from analysis of scats (N=90) of Asiatic jackal from the study area during 2010-2011.

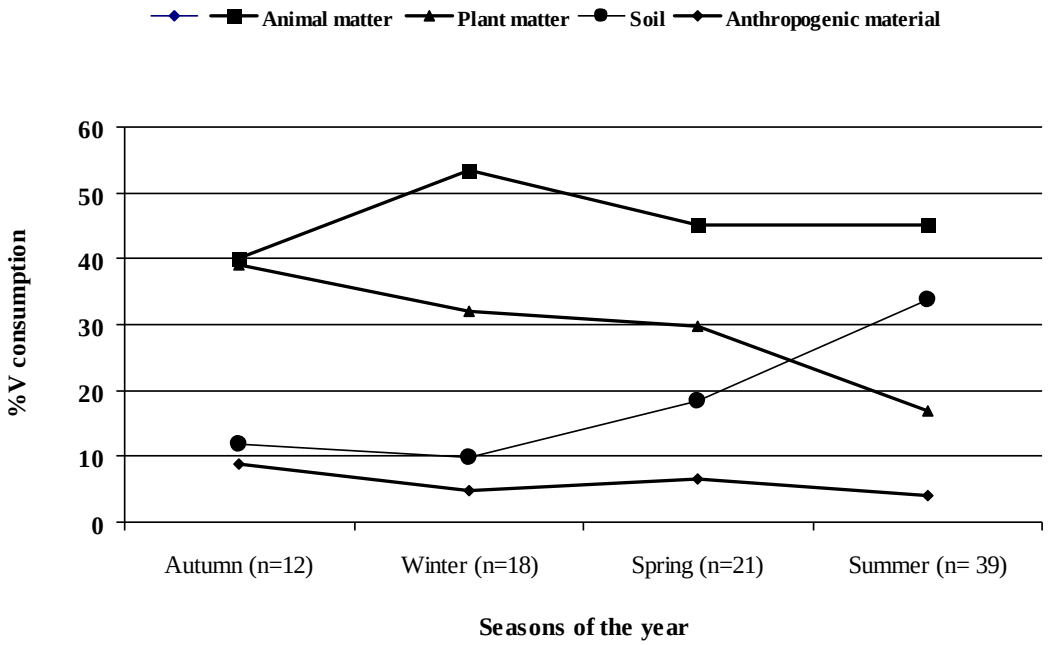

Fig. 3 Seasonal variation in the percent volume (%V) consumption of four main groups of food items comprising the diet of Asiatic Jackal in Margallah Hills National Park Islamabad during the current study period.

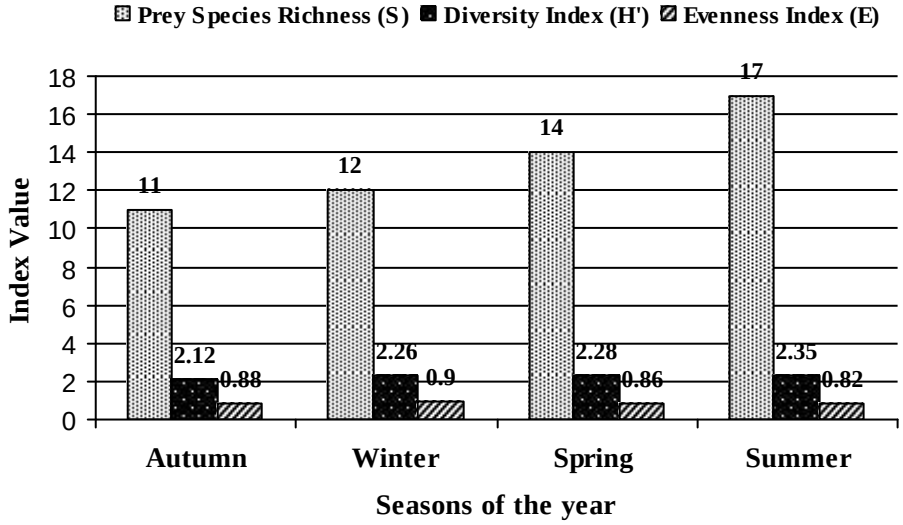

Fig. 4. Prey species Richness (S), Diversity Index (H') and Evenness Index (E) of prey species of Asiatic jackal (*Canis aureus*) during different seasons of the year in Margallah Hills National Park Islamabad during current study period.

DISCUSSION

Wild fauna of Pakistan has been under tremendous pressure due to extensive hunting practices and resultantly many species are at the verge of endangerment or extinction. The decline in prey species obviously affects the abundance of their predators as it has been notices in case of feeding habits of the Asiatic jackal (*Canis aureus*). Due to decline in wild prey, the Asiatic jackal started to predate on domestic livestock and poultry birds which has ultimately led to a conflict between Asiatic jackal and the local people. In this context, reliable scientific information on the diet composition of Asiatic jackal is required to assess the magnitude of human-wildlife conflict related to livestock predation and for the conservation of this important carnivore species in the country. However, with exception of very few studies, no published scientific information exists in Pakistan on food habits of the Asiatic jackal. Therefore, the current study investigated

diversity of prey species comprising the diet of Asiatic jackal in Margallah Hills National Park, Islamabad to contribute towards effective management of this animal species.

For the current study, scat samples were collected randomly from three study sites and identified on the basis of their physical characteristics (shape and diameter) very carefully. Previous studies on identification of scats of snow leopard based on molecular techniques such as Mckelvey *et al.* (2006); McCarthy *et al*. (2008) and Lovari *et al*. (2009) have shown that identification of scats in the field might not be 100% accurate and chances of overlap and resemblance with scats of other sympatric carnivores like red fox and wild cats remain unavoidable during collection and this, in turn, may also have some impact on the results obtained. Similarly, hair mounting technique is widely acceptable for many carnivore species for the identification of the mammalian prey species because molecular genetic studies are quite costly and not feasible in all cases (Oli, 1993).

The diet of jackal depends on habitat, season, and availability of food resources and also the vulnerability of the prey species (Kaunda and Skinner, 2003). The results of the current study have also shown this dependency and revealed a wide range of diversity in the food items of Asiatic jackal including medium to large sized ungulates, rodents, small carnivores, insects, seeds, fruits and other plant materials. Radovic and Kovacic (2007) had shown that at Peliesac Peninsula, mammalian species dominate among the prey species in the food of jackals (50.3 % of examined scats). In the current study, bones (79% F) and hairs (70%F) have been recovered from the scats more frequently, indicating that vertebrates are dominant among the animal food of the Asiatic Jackal. The animal matter represented in the scats by approximately 46% (by volume), including both wild and domestic animal species. The wild prey of Asiatic Jackal included rodents and large mongoose (*Herpestes edwardsii*), while goat, sheep and poultry birds represented the domestic prey species. The Asiatic jackal also scavenged on wild boar (1.66% V). Bones of poultry birds, rodents and other mammals have contributed 19.62% and so have medium-sized mammals (goat, sheep, and dog) as well as small mammals (rodents and mongoose) indicating that mammalian prey species are dominant in the diet of Asiatic Jackal in the study area.

Lanszki and Heltai (2002) had reported that small mammals, mainly rodents, dominate the diet of Golden jackal. Similarly, Khan (1982), reported that diet of Asiatic jackal (*Canis aureus*) in central Punjab (Pakistan), mainly comprised of rodents (bandicoot rat, house mouse, Indian gerbils and the soft furred field rat) and birds while cold blooded vertebrates appeared relatively low in the diet. The results of the current study have also shown occurrence of rodents remains in the scats of Asiatic jackal, representing Indian gerbil (4.99%), house rat (0.72%), bandicoot rat (0.55%) and house mouse (1.27%). It looks that bulk of the diet of Asiatic Jackal comprises of rodents and reptiles secured through hunting and they freely supplement their diet with fruits and insects when available (Roberts, 1997). However, some other studies represent contrary findings to the results of the current study such as those by Lanszki *et al.,* (2006); Mukherjee *et al.,* (2004); and Giannatos *et al*., (2009). This could probably be due to the presence of some more food items in their study area which were more easily available to the Jackal.

Large quantities of vegetable matter also occur in the diet of Jackal and during fruiting season in India, the animal species also feeds intensively on fruits of Ber (*Zizyphus)*, Karvand (*Carissa carvanda)*, Jamun (*Syzigium cuminii)*, and pods of Vilayati Kikar (*Prosopis juliflora)* and Amaltas (*Cassia fistula)* (IUCN, 2004). In the current study, plant matter and fruits were recovered from the scat samples of Asiatic Jackal; grasses constituted about 4.76% (%V), in contrary to the investigations of Sanker (1988) at Bharatpur, North Rajasthan India where grasses contributed 20.1%. All the fruits and seeds that were eaten by Asiatic jackal in the current study are nutritionally very important since these possess some important vitamins and are rich in energy that is why Asiatic jackals supplement their diet with fruits and seeds.

The presence of bird remains in the scats of Asiatic jackal is dependent on the availability and accessibility of their carcasses because it is not easy for a jackal to capture a bird, although they try to do so but mostly fail (Kaunda and Skinner, 2003). A comparison of different published studies shows that bird percentages consumed by Asiatic jackal vary considerably from very high in protected areas in India (Mukherjee *et al.,* 2004) to a protected wetland in Greece (Lanszki *et al.,* 2006). Results of the current study have also revealed that birds represented 5.39% in the diet of Asiatic jackal in Islamabad area.

The golden jackal reportedly scavenges in Israel and Bangladesh, eating mostly garbage and carrion while in India and Bangladesh, the major food sources for jackal were domestic animals and human refuse such as leftover of meals, plastic, pieces of fabric and so on (Poche *et al*., 1987; Jhala and Moehlman, 2004; Giannatos *et al.,* 2009). In the current study, leftover of meals, plastic, and pieces of fabric have also been recovered from scat samples and represented under the category of anthropogenic material constituting 5.35% of the total diet of Asiatic Jackal by volume (%V) and the current results are in agreement with above cited studies. Regarding the feeding habits of jackal, the relative importance of scavenging and predation varies both in accordance with time and place. In an area where the

density of larger predators is higher in a particular time period, then the jackal acts as a scavenger while in an area where larger predators are very low in numbers or completely absent, then jackal acts as an active predator (Estes, 1967; Lamprecht, 1978; Kaunda and skinner, 2003).

Statistical analysis of scat samples of Asiatic Jackal revealed no significant difference. Scat samples collected from different sites and during seasons were pooled for seasonal variation in the diet composition. Results showed that predominantly occurring food item was mammalian prey. For example, only in autumn season, the animal matter was consumed in slightly less proportion as opposed to the rest of three seasons (winter, spring and summer). Similarly, soil was recovered considerably higher in proportion from scat samples of summer season as compared to the other three seasons. The anthropogenic items were higher in autumn season and lowest in winter season. Kaunda and Skinner (2003) showed that most common food item during autumn season was mammals (25.8 %). In present study, the food items slightly varied during different seasons. In autumn, among animal matter, birds were consumed in higher proportion while among plant matter, small leaves and stems were consumed. Similarly in winter season, the birds' consumption was again higher and among plant matter the most common plant consumed was wheat. The probable reason for higher proportion of animal matter in the diet during winter could be the less availability of grasses, fruits and other plant based materials. In both spring and summer seasons, the dominant food item was animal matter. The soil consumed appeared higher in summer season while anthropogenic items were greater in autumn season. Therefore, in current study, more consumption of animal matter than plant matter in autumn and winter season have coincidence with the investigations of Kaunda and Skinner (2003), who showed that most common food item during autumn and winter season in the diet of jackals was mammalian remains (25.8% during autumn and 41.8% during winter). Likewise, during spring and summer season again the animal matter was higher than plant matter. The previous studies by Kaunda and Skinner (2003) support the findings of the current study that most common food items of Asiatic jackal during spring and summer are mammals.

The previous published literature in different parts of the world shows that different species of jackals are playing important role in the dispersal of seeds. Fruits are an easy source of carbohydrates and energy for jackals when they are abundant. Fruits grow in patches and are sessile food resource, while searching for animal prey jackals may encounter with fallen fruits. With little expenditure of energy and time jackals may obtain considerable amount of berries from the same place. Moreover, Jackals prefer to eat fleshy fruits in the areas where little water is available including water melon to get water and to save time and energy (Kaunda and Skinner 2003). During current study, the seeds of different plants recovered from the scats have included tomato, melon, water melon orange and grams and so on.

In the present study, indices of the prey species occurring in the study area were calculated. The prey species richness, diversity and their evenness showed seasonal variation in the diet composition of Asiatic jackal. Species were richer in summer season (17) and lower in autumn season (11) as compared to winter and spring. Similarly there was more diversity of species in summer season (2.35) as compared to autumn and winter where it was low while it was again higher in spring season (2.28). As far as the evenness of species in a specific season is concerned, highest evenness was seen in winter season whereas the evenness was lowest in summer as compared to autumn and spring season.

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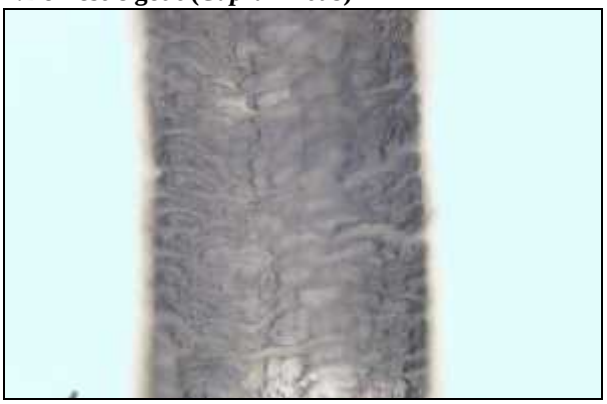
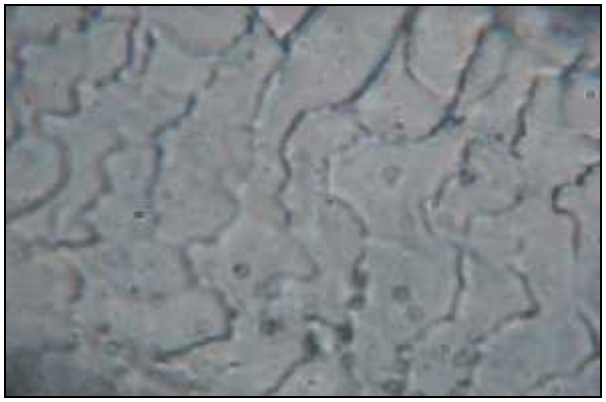
Annex-I: Photographs of some of the Reference hair slides of different animals

1.Domestic goat (*Capra hircus*)



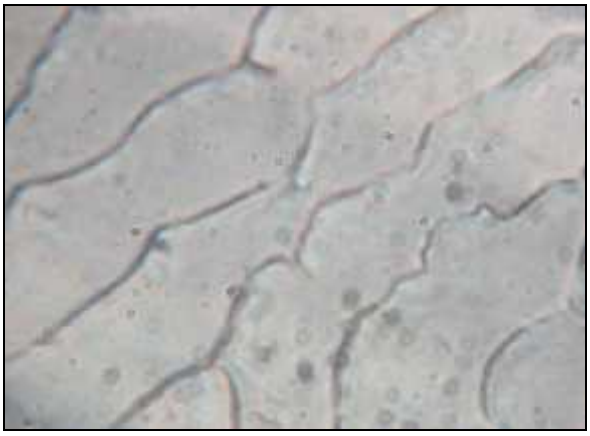
Whole mount (100 X)



Scale Replication of hair at mid shaft region (100 X)

2. Domestic sheep (*Ovis aries*)

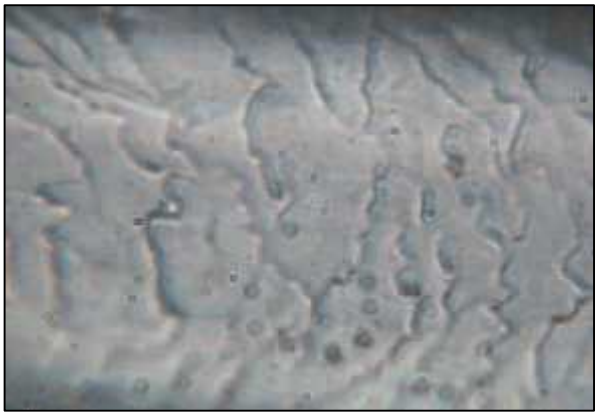
Whole mount of sample hair at mid shaft region (100 X)



Scale replication of reference hair at mid shaft region (40 X).

3. Domestic cow (*Bos taurus*)

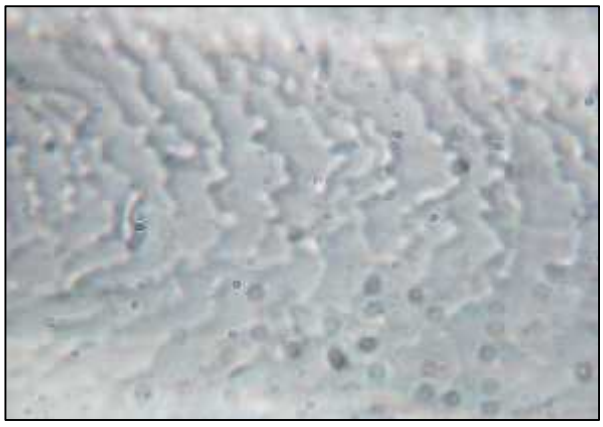
Whole mount of reference hair at mid- shaft region. (100 X)



Scale replication of reference hair at mid shaft region (100 X)

4. Large Indian mongoose (*Herpestes edwardsii*)

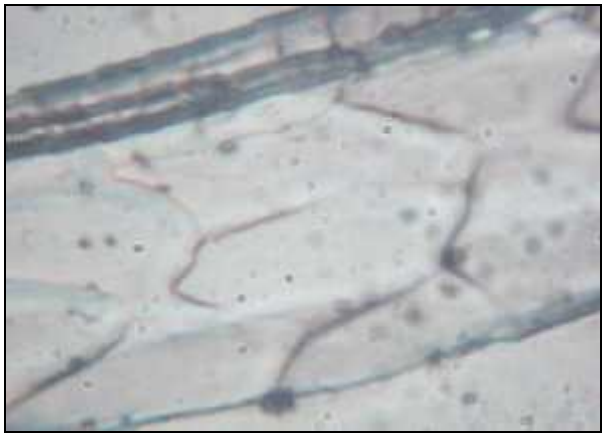
Whole mount of reference hair at mid shaft region(100 X)



Scale replication of reference hair at mid shaft region (40 X).

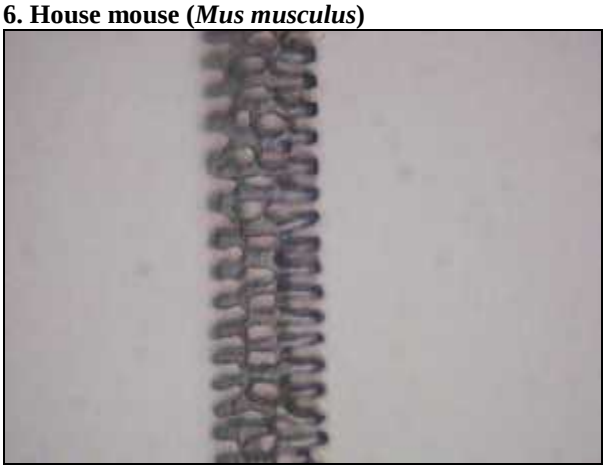
5. Indian gerbil (*Tatera indica)*

Whole mount of reference hair at mid shaft region (40 X)

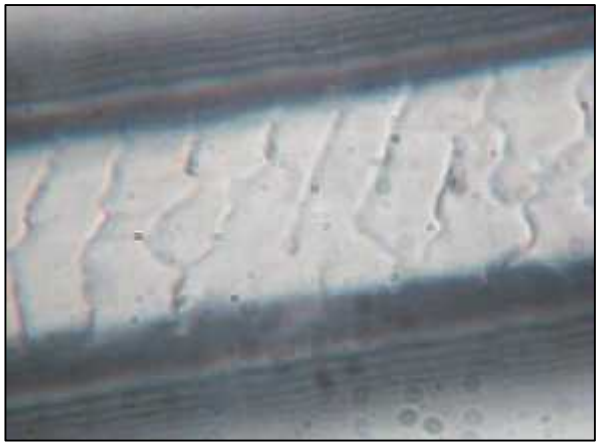


Scale replication of reference hair at mid shaft region (100 X)

6. House mouse (*Mus musculus*)

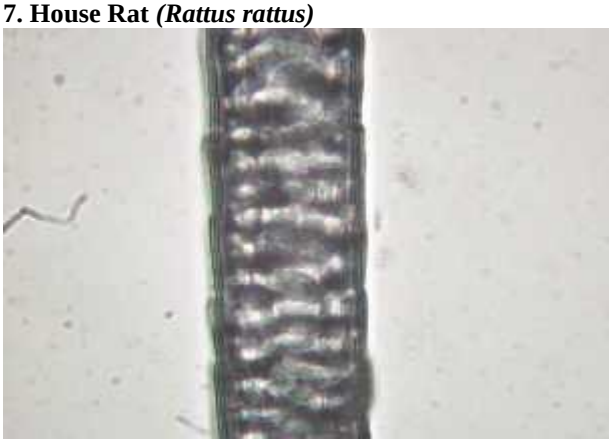


Whole mount of sample hair at mid shaft region (40 X)

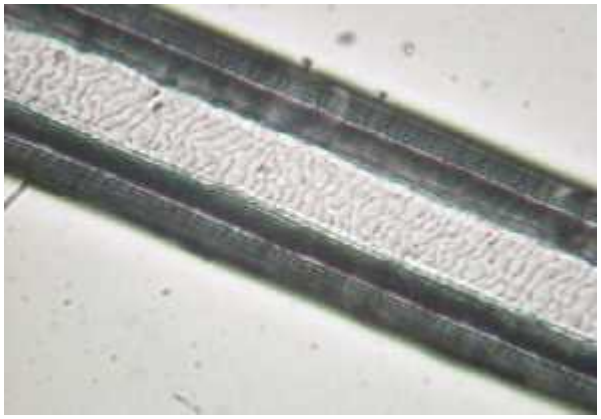


Scale replication of reference hair at mid shaft region (100 X)

7. House Rat *(Rattus rattus)*



Whole mount of sample hair at mid shaft region (40 X).



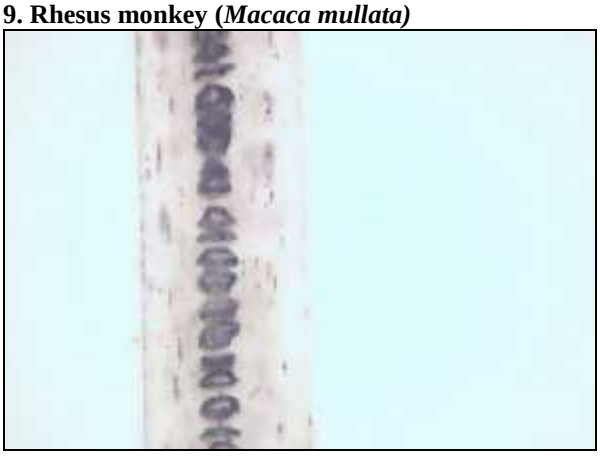
Scale replication of reference hair at mid shaft region (40 X)

8.Wild hare (*Lepus nigricolus*)

Whole mount of reference hair at mid shaft region (40 X)

Scale replication of reference hair at mid shaft region (100 X)

9. Rhesus monkey (*Macaca mullata)*

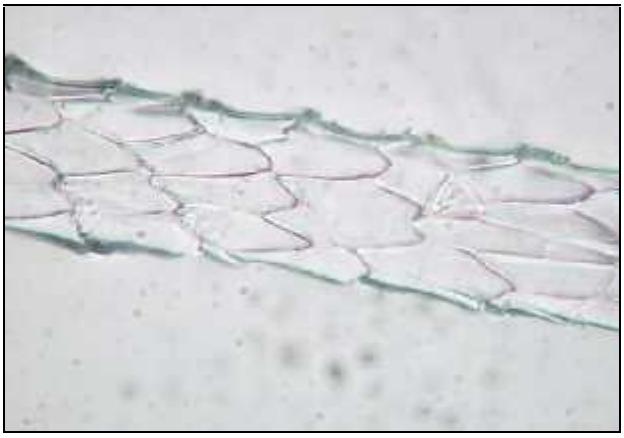


Whole mount of reference hair at mid- region (100 X)

Scale replication of reference hair at mid shaft shaft region (40 X)

10. Red fox (*Vulpus vulpus*)

Whole mount of reference hair at mid- shaft region(40 X).



Scale replication of reference hair at mid shaft region (100 X)