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Plant Species Association, Burrow Characteristics and the Diet of the Indian Pangolin, *Manis crassicaudata*, in the Potohar Plateau, Pakistan

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Abstract.- The Indian pangolin (*Manis crassicaudata*) is one of the least studied species in the country. The current study investigated its habitat and diet composition in the district of Attock of Potohar Plateau. Data were collected from two selected sites viz. "Haddowali" and "Thatti Syedo Shah". For vegetation analysis, data about trees were recorded using "point centered quarter" method while shrubs and herbs were recorded by using "quadrate" method. Diet composition of animal was investigated by faecal analysis. Results showed that preference of the animal species is associated with *Capparis decidua* and *Salvadora oleoides* trees in its habitat for making its permanent burrows. The number of feeding and living burrows of the animal differed significantly ($p< 0.01$), as well as the height ($p< 0.05$) and width ($p <0.05$) of the openings of two types of burrows and the burrow depths ($p <0.05$). Analysis of faecal samples (n=50) revealed, body parts of ants (including heads 0.75% by volume, legs 7.32%, abdomens 20.6% and egg shells 0.21%), and plant matters (0.33 %), stones (0.1%), sand (22.75%) and clay (47.69 by %V). Identification of prey from recovered materials revealed two species of ants (*Camponotus confucii* and *Camponotus compressus*) and one species of termite (*Odontotermis obesus)* as main food items of the Indian pangolin in the study area.

Keywords: Indian pangolin, *Manis*, food habits, feeding burrows, living burrows.

INTRODUCTION

Four of the eight extant species of pangolins occur in Asia including Chinese or Formosan pangolin (*Manis pentadactyla*), Malayan or Sunda pangolin (*Manis javanica*), Palawan or Philippine pangolin (*Manis culionensis*) and Indian pangolin (*Manis crassicaudata*) (IUCN, 2008), while the remaining four are found in Africa which include black-bellied pangolin (*Manis tetradactyla),* giant ground pangolin (*Manis gigantea*), temminck's ground pangolin (*Manis temmincki*) and tree or African white-bellied pangolin (*Manis tricuspis*) (IUCN 2006).

In Asia, the Indian pangolin occurs in Bangladesh, India (South of Himalayas), Nepal, Myanmar, Western China, Sri Lanka and Pakistan. In Pakistan, the species is locally distributed and occurs at few places of the country including the Potohar Plateau in the Punjab province (Roberts, 1997). It is solitary, shy, slow mover, nocturnal mammal, commonly known as scaly anteater. Its limbs are powerful and are tipped with sharp, clawed digits used for digging into ant hills and termite mounds (Atkins, 2004). By physical appearance, it is marked by hardened, overlapping, large, plate like scales covering its skin. The scales are soft on newborn while they become hard as the animal matures and are made up of keratin (Briggs and Briggs, 2005).

The Indian pangolin (*Manis crassicaudata*) has the status of "Near Threatened" throughout its range in all the countries of occurrence (IUCN, 2008). However, this species is very vital in the food chain since it plays important role in terrestrial agro-ecosystem regarding insect pest controls, by being exclusively insectivorous in its food habit. It is estimated that one adult pangolin can consume approximately more than 70 million insects annually (d'Aulaire and d'Aulaire, 1983). Moreover, burrowing animals are worldwide ecologically important as their actions provide shelter or breeding habitat for many other animals and thus add up valuable contribution to increase species diversity (Hansell, 1993). In Pakistan, practitioners of traditional medicines (hakims) consider various body parts of the Indian pangolin very important and valuable source of medicines (Roberts, 1997).

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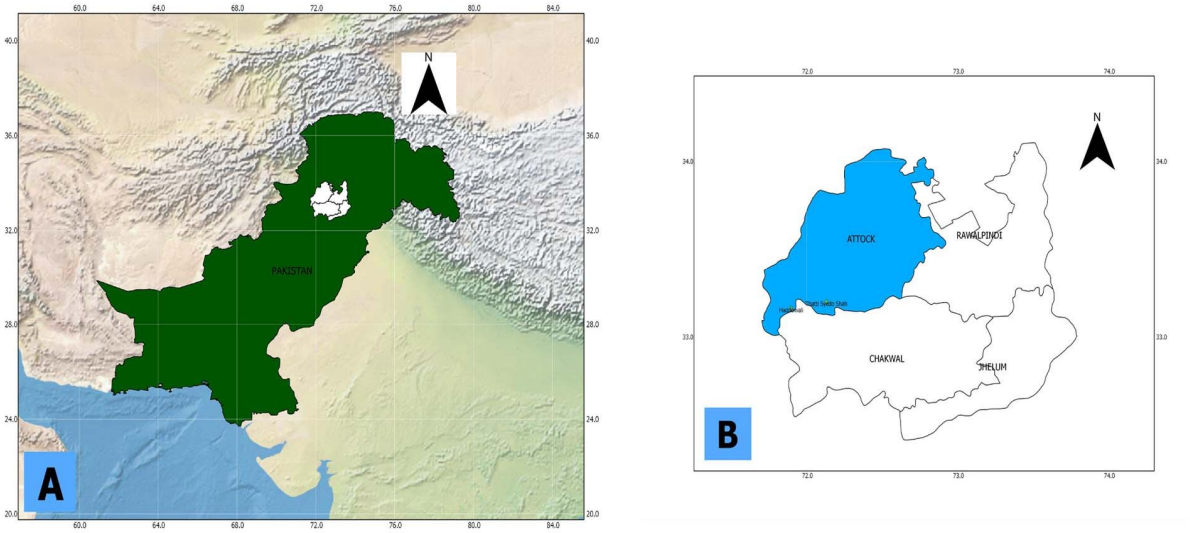

Fig. 1. **A.** Map of Pakistan showing location of District Attock in Potohar Plateau. **B**. Showing location of two study sites; Haddowali and Thatti Syedo Shah (blue background color) in the Potohar Plateau.

There is enough published literature available about other pangolin species occurring in Asia and Africa, but the Indian pangolin has yet stayed neglected in this context not only in Pakistan but also in southern Asia. It is one of the least studied animal species and very scanty scientific record exists in Pakistan. Therefore, the current study investigated plant species association and the diet composition of this species in district Attock of Potohar Plateau.

MATERIALS AND METHODS

The current study was conducted in the district of Attock (33° 54' 26"N, and 72° 18' 40"E) located in the Potohar region of Punjab province (Fig.1A). The study district is spread over an area of 6,857 km² and is subdivided into six administrated Tehsils (Anonymous, 2007). Initially, surveillance surveys were conducted on motor vehicle (average speed 25-30 km/hr) in wild areas of the district; potential areas were marked, and identified on the basis of the presence of burrows of animals, faecal samples as well as interview with local people. Two representative study sites of the district *viz.*, Haddowali ((33° 08'.502"N, 071° 54'.276"E) and Thatti Syedo Shah (33° 11'.896"N, 072° 07'.702"E) were selected for data collection (Fig.1B), each having an area of approximately two square kilometers (km^2). Data collection was done on monthly basis from August 2010 to July 2011.

Habitat features of the selected sites being utilized by the Indian pangolin were analyzed by quantifying plants species. Trees were recorded using "Point Centered Quarter" method (Cottom and Cartis, 1956). For shrub and herb species, data were collected using "Quadrate Method" (Emlen, 1956; Schemnitz, 1980). For shrub species, quadrates of 4m x 4m and for herb species quadrates of 1m x 1m were established to collect data.

The Indian pangolin digs out two types of burrows; temporary and permanent (living) burrows. Both types of burrows were searched and their characteristics such as depth, length, width and diameter were recorded in the field. The ants and termites colonies in the selected study sites were also searched and prey species were collected as reference samples, identified up to order level and compared with those prey items recovered from the faecal samples after analysis.

The characteristics of both types of burrows (feeding and living burrows) of the Indian pangolin including the number of feeding and living burrows, height and width of burrow openings and depths of feeding and living burrows were compared by applying student's *t*-test for two samples by using

the software "past".

Diet composition of the Indian pangolin was investigated by analyzing its faecal samples. A total of 50 faecal samples were collected (30 samples from Haddowali and 20 from Thatti Syedo Shah. Faecal samples were analysed by using slightly modified procedures of Schemnitz (1980), Siddiqui *et al*. (2004) and Dawson *et al*. (2007). Segregates of faecal samples (ant's body parts) were identified and compared with reference samples collected from the same study sites.

RESULTS

Trees, shrubs and herbs

Four tree species were recorded at Haddowali with *Acacia modesta* having the highest relative density and relative cover (50 and 55, respectively), while *Salvadora oleoides* (8.33) having the least (8.33 and 10.3, respectively). Six tree species were recorded at Thatti Syedo Shah with *Zizyphus mauritiana* had highest relative density (29.2) and relative cover (40), while *Dalbergia sissoo* having the least (8.32 and 10, respectively) (Fig. 2).

Four species of shrubs were also recorded at Haddowali, *Ziziphus nummularia*, and *Acacia modesta*, had the highest relative density (37.5), *Acacia modesta* had the highest relative cover (55), while *Salvadora oleoides* had the least relative density and relative cover (6.25 and 9.16, respectively). Among the three shrub species recorded at Thatti Syedo Shah, *Acacia modesta* had the highest relative density (50) and relative cover (56.6) (Fig.3).

A total of 41 herb species were recorded at Haddowali that their highest average density (33.33±11.28/m²) was recorded in summer 2011 and the lowest (5.88±1.22) in spring 2011, whereas at Thatti Syedo Shah, a total of 36 herb species were recorded with the highest average relative density (25±8.42/m²) in summer 2011 and the lowest (6.65±0.89/m²) in spring 2011.

Burrow characteristics

Feeding burrows

A total of 344 feeding burrows were recorded at Haddowali, out of which 60 were quantified. Similarly, at Thatti Syedo Shah, a total of 280

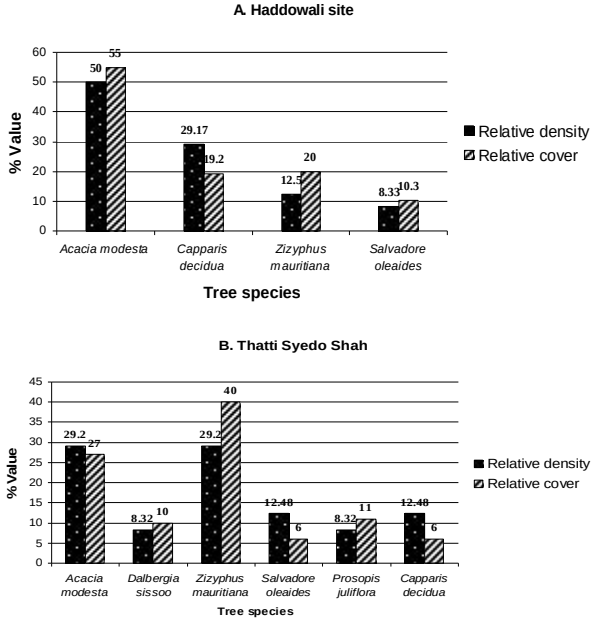

Fig. 2. Relative density and relative cover of tree species (maximum and minimum) at two selected study sites (Haddowali and Thatti Syedo Shah) constituting the habitat of the Indian pangolin (*Manis crassicaudata*) in the district of Attock.

feeding burrows were observed and 55 were quantified (Table I). The average height of feeding burrow at both study sites was found to be 19.73.±2.78 cm while its average width and depth were 19.46±2.86 cm and 0.37± 0.02 m, respectively. Statistical analysis showed significant difference between the total numbers of feeding burrows of both sites ($p < 0.05$).

Living burrows

A total number of 26 living burrows at Haddowali and 19 at Thatti Syedo Shah were recorded during the study period. The average burrow height at both sites was found to be 25.65±0.92 cm. The average width of burrow opening was 24.70±0.99cm, while the average burrow depth was 2.95±0.10m The average number of inactive burrows was found greater, while those of active burrows was less at both sites (Table II). The number of feeding and living burrows differed significantly ($p<0.01$), similarly the height ($p<0.05$) width ($p<0.05$) and burrow depths ($p <0.05$) of two

types of burrows showed significant difference (Table II).

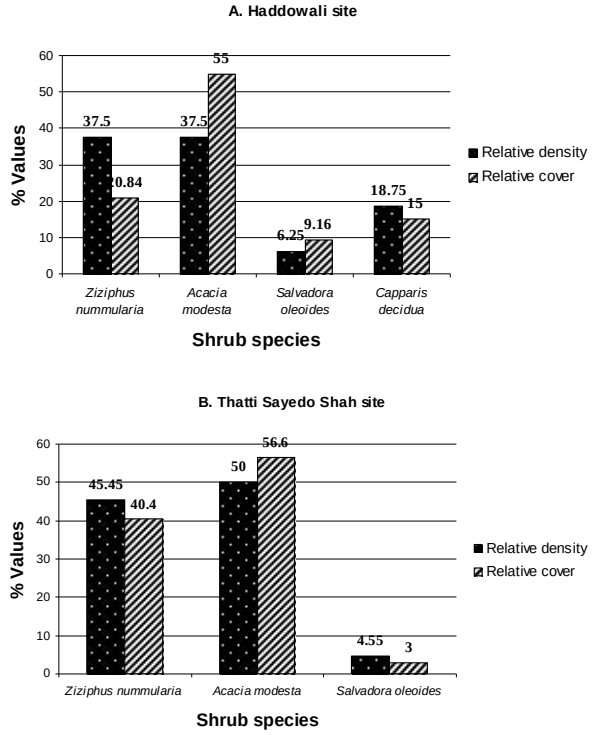

Fig. 3. Relative density and relative cover of shrub species at two selected study sites (Haddowali and Thatti Syedo Shah) constituting the habitat of the Indian pangolin (*Manis crassicaudata*) in the district of Attock.

Diet composition

A total of 50 faecal samples of the Indian pangolin were collected during the study period from the selected sites; n= 30 samples from Haddowali and 20 from Thatti Syedo Shah. The average lengths, diameters and weights of faecal samples collected from Haddowali were slightly greater than those collected from Thatti Syedo Shah (Table III).

Faecal analysis revealed body parts of ants, some plant matter, stones, sand and clay. All 30 faecal samples collected from Haddowali contained ants' body parts and clay (100% frequency). Egg shells represented 20% of samples, sand 86%, and plant matter 33% (Table IV). Clay was recovered in the highest volume (50%). Major prey items recovered were ants (27% by volume); abdominal parts of ants were in maximum volume (20.58±2.64%), followed by their leg remains (6.03±0.62%).

Faecal analysis of Thatti Syedo Shah showed almost similar results (Table IV). All 20 samples contained ants and clay, while sand and stones were present in 80% and 10% of the samples, respectively. The clay contributed approximately 45% by weight, ants 29% in the form of different body parts and sand 24%; stones were recovered in minor percentage (0.2%).

On the average, insects (ants) contributed 29% by volume, clay 48%, sand 22%, plant matter and stones in minor percentage (0.33% and 0.1%, respectively (Fig. 4).

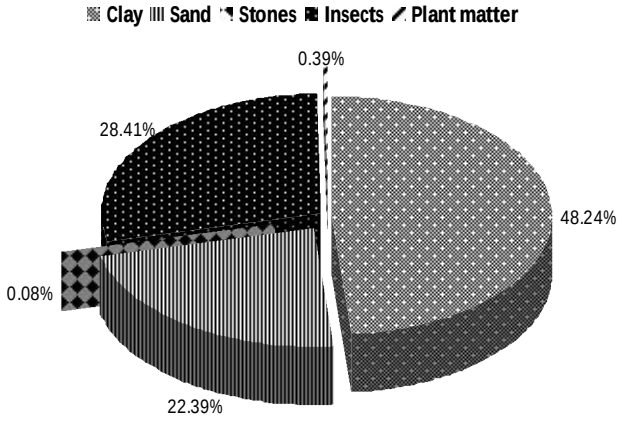

Fig. 4. Average composition of faecal samples of the Indian pangolin (*Manis crassicaudata*) collected from study sites in the district of Attock.

Student's paired *t*-test for comparison between volume (%) and occurrence of faecal segregates of the selected sites of the study district showed no significant difference ($p > 0.05$, df = 4, t= 2.13).

Identification of prey species

Two species of ants were identified as major prey items constituting the diet of the Indian pangolin *viz. Camponotus confucii* and *Camponotus compressus*. But no remains of termite species could be recovered from the faecal samples. Since the Indian pangolin does also consume termites in

Table I.- Characteristics of feeding and living/permanent burrows quantified at two study sites in the district of Attock.

Burrow characteristics	Haddowali	Thatti Saydo Shah	TOTAL	Mean±SE
Feeding burrows				
Total number	344	280	624	312
Height of burrow opening (cm)	19.26±2.87 (N=60)	20.26 ± 2.70 (N=55)	39.52 (n=115)	19.73±2.78
Width of burrow opening (cm)	19.12 ± 2.93 (N=60)	19.85 ± 2.80 (N=55)	20.97 (n=115)	19.46±2.86
Depth of burrow (m)	0.36 ± 0.03 (N=60)	0.39 ± 0.02 (N=55)	0.75 (n=115)	0.37±0.02
Living/Permanent burrows				
Total number	26	19	45	22.5
Height of burrow opening (cm)	26.33 ±1.16 (N=12)	24.91 ± 0.67 (N=11)	51.24 (n=23)	25.65±0.92
Width of burrow opening (cm)	24.71 ± 1.17 (N=12)	24.69 ± 0.81(N=11)	49.4 (n=23)	24.70±0.99
Depth of burrow (m)	3.09 ± 0.15 (N=12)	2.8 ± 0.06 (N=11)	5.89 (n=23)	2.95±0.10

Table II.- Statistical analysis of the characteristics of feeding and living burrows of the Indian pangolin (*Manis crassicaudata*) quantified at two selected sites in the district of Attock, by applying *t*- test for two samples using the software "past".

Burrow characteristics	Feeding burrows (n=115)	Living burrows (n=23)	*t*-value	*p*- value
Number of burrows (n)	312 ± 32	22.5 ± 3.5	8.99	< 0.01
Height of burrow opening (cm)	19.76 ± 0.5	25.62 ± 0.71	-6.74	< 0.05
Width of burrow opening (cm)	19.48 ± 0.36	24.7 ± 0.01	-14.28	< 0.05
Burrow depth (m)	0.37 ± 0.01	2.99 ± 0.14	-25.86	< 0.05

Table III.- Physical characteristics of faecal samples (N =50) collected from the district of Attock for investigating the diet of the Indian pangolin *(Manis crassicaudata*).

Study sites	N (50)	Average weight (g)	Average length (cm)	Average diameter (cm)
Haddowali	30	98.48	5.69±0.72	2.18±0.17
Thatti Syedo Shah	20	82.61	4.46±0.53	2.11±0.21

Table IV.- Percent frequency of occurrence (%F) and percent volume (%V) of segregates recovered from faecal samples of Indian pangolin collected from selected sites during the current study period.Student's paired t-test for comparison between %V occurrence of faecal segregates of two selected sites of the study district showed no significant difference (*p*> 0.05, df = 4, t= 2.13).

Faecal segregates		Haddowali (n=30)		Thatti Syedo Shah (n=20)		Mean ± SE (n=50)
		%F	%V	%F	%V	(%V)
Ants body parts	Heads	100(30)	0.59±0.06	100(20)	0.91±0.23	**0.71±0.12**
	Legs	100(30)	6.03±0.62	100(20)	8.61±1.61	**7.06 ±1.01**
	Abdomen	100(30)	20.58±2.64	100(20)	20.62±2.73	**20.42.± 2.67**
	Egg shells	20(6)	0.26±0.12	5(1)	0.16±0.16	**0.22 ±0. 13**
Plant matter		33.33(10)	0.66±0.25	0(0)	0(0)	**0.39 ±0.15**
Stones		0(0)	0(0)	10(2)	0.20±0.14	**0.08 ± 0.05**
Sand		86.66(26)	20.95±2.50	80(16)	24.56±4.09	**22.39 ± 3.13**
Clay		100(30)	50.48±2.76	100(20)	44.90±4.26	**48.24 ±3.36**

addition to ants, reference samples of termites of the same study sites revealed one termite species (*Odontotermis obesus*) as potential prey item.

DISCUSSION

The Indian pangolin (*Manis crassicaudata*) is the only species occurring in Pakistan among four Asian pangolin species (IUCN, 2008). It is a nocturnal species of significant importance because it plays a vital role in the ecosystem and agriculture by consuming insects (feeding on ants and termites species) and fossorial. There are reports that the Indian pangolin is hunted illegally from its habitat, traded, and killed (Mahmood *et al.*, 2012) for various reasons such as for its flesh, for obtaining its scales and for obtaining its body fats. Results of vegetation analysis in the present study have shown that the Indian pangolin has got special association with or prefers *Capparis decidua* and *Salvadora oleoides* species; most probably for making its permanent burrows. Also these plant species may provide conducive, humid environment in their roots for building up of ants and termites colonies in the habitat of the Indian pangolin, although Akhter and Rashid (2001) in their study had collected termites from *Acacia modesta* and *Dalbergia sissoo* species. On the average, the relative density, and relative cover of shrubs of Thatti Syedo Shah were found higher than those at Haddowali. It is noticeable that shrubs may be helpful in providing prey species to the Indian pangolin. In the current study, many trails of ants were found on *Acacia modesta* and *Ziziphus nummularia*, as ants have association with both the trees species for nectars and fruit.

The occurrence of the Indian pangolin (*Manis crassicaudata*) at both study sites was also confirmed by the presence of typical types of burrows and also by interviewing the local people. The average height, width and depth of feeding burrows at Thatti Syedo Shah were generally greater than those occurring at Haddowali. The feeding burrows depend upon the availability of prey abundance. The highest numbers of feeding burrows during the present study were recorded during spring season at both study sites, most probably due to greater availability of prey species (ants and termites) during this season.

Living burrows of the Indian pangolin were entirely different from those of feeding ones in shape and size by being more circular and also much deeper. The average height of living burrows ranged from 24.91cm to 26.33cm, average width from 24.69cm to 24.71cm while their depth ranged from 2.8 m to 3.09 m at both study sites. Although no previous published scientific record is available for dimensions of the burrows of the Indian pangolin n the country, however, Pai (2008) reported that burrows of the Indian pangolin vary in different habitats depending on the soil composition; in rocky soils its depth varies from 1.5m-1.8m while it may be more than 6 m in soft soils.

The Indian pangolin generally uses living burrows for sleeping and resting purposes during day time. By comparison of the total number of inactive and active living burrows at both selected sites, it was noticeable that the Indian pangolin usually abandons its living burrows after few months and digs new one close to the availability of prey species, however, re-shifting to the older living burrow had also been observed during the current study. A close association of the Indian pangolin with the trees of *Capparis decidua* and *Salvadora oleoides* was noticeable since most of living burrows were found under the stems and among the roots of both plant species. The logical reason behind this association between the Indian pangolin and both tree species might be the presence of termite nests which the Indian pangolin consumes as its prey items in its habitat.

Results of faecal analysis revealed ants body parts (heads, legs, abdomens and egg shells), plant matter, sand, stone and clay. The ant's body parts and clay were found in the highest percent frequency while egg shells of ants were found in lowest percent frequency. From both study sites, clay with highest %V (50.84±2.76 at Haddowali and 44.90±4.26 at Thatti Syedo Shah), and egg shells with the lowest percent volume occurrence (0.26 ± 0.12 at Haddowali and 0.16 ± 0.16 at Thatti Syedo Shah) were recovered. According to Roberts (1997), the Indian pangolin is extensively insectivorous; it uses its long, sticky tongue to catch ants and termites. Similarly, Pai (2008) showed that insect and termite eggs are likely to be more relished than the adults. The Indian pangolin is attracted by the leaf nests of large red ants in particular, which hold the swarms of adult ants and also their eggs.

It looks quite probable that clay, sand, plant

matter and stones recovered from the faecal samples of the Indian pangolin were actually not included in its usual diet bur rather taken up by the animal species passively during foraging on its prey species. However, it is quite possible that stones play important role in grinding and churning of chitin of ants species in the stomach of the Indian pangolin since Pai (2008) showed that during foraging, Indian pangolins directly take food into their stomach due to the lack of teeth and strong musculature in the stomach helps in grinding food items including pebbles collected during the feeding process.

Two ant species including *Camponotus confucii*, and *Camponotus compressus* and one termite species *Odontotermis obesus* have been found included in the diet of the Indian pangolin in the study area, the same prey species of the Indian pangolin are hereby being reported for the first time. Yang *et al.* (2007) showed that the Indian pangolin is insectivorous in its food habits, predominantly foraging on ants and termites and similar results were reported by Roberts (1997). Earlier studies about some other pangolin species have listed the ants and termites species in their diet. For example, Coulson (1989) showed that four termite and six ant species were recovered from the stomach contents of the African pangolin. Similarly, Gao (1934) had identified five ant species in the stomach of the Formosan pangolin. However, no record or information exists about the prey species which constitute the diet of the Indian Pangolin in Pakistan.

In the present study, egg shells were also recovered from the analyzed faecal samples in low frequency and volume from both study sites while adult ants were recovered from the faecal samples in large quantity. It indicates that the Indian pangolin also feeds on egg shells of ants along with the adult ants and termite species. Similar findings were reported by Pai (2008) that the Indian pangolin is highly specialized in its foraging habits and insects and termites eggs are more likely to be relished than the adults.

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