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Tariq Mahmood, Shaista Andleeb & Faraz Akrim

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COMMUNICATION

Habitat preference of the Indian Pangolin *Manis crassicaudata* inhabiting Margalla Hills National Park, Islamabad, Pakistan

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Abstract: The Indian Pangolin *Manis crassicaudata*, is an 'Endangered' mammal species native to Pakistan but facing a risk of extinction due to hunting pressure for its scales used in trade. The current study investigated habitat preference of this unique species in the Margalla Hills National Park, Islamabad, from September 2011 to August 2012. Three habitat types, viz, human vicinity area, agricultural land, and wild/natural area, were searched for recording signs of Indian Pangolin. Data on habitat preference was collected from direct and indirect signs of the species by monitoring 85 line transects, each measuring 500m in length and 50m in width, in 17 different sampling sites. A total of 323 signs of Indian Pangolin were recorded including 299 burrows, 10 live sightings, and 14 scats of the species. The maximum number of signs were recorded in wild or unmodified natural area (55.1%), followed by those in vicinity to human use area (20.12%), while the least (24.76%) were found in agricultural area. Statistical comparison using one-way analysis of variance of pangolin field signs, among three different types of habitats studied, differed significantly (df= 48, F= 13.723, p <0.001). Similarly, LSD analysis further revealed that field signs of Indian pangolin recorded on natural or wild habitat significantly differed from those which were on agricultural land and human vicinity area (p <0.001). The study concludes that the Indian Pangolin prefers habitats in the wild or natural area over those close to human vicinity and agricultural lands.

Keywords: Burrow, endangered, hunting, pangolin, trade.

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Author contribution: TM and SA designed the study, TM supervised the study, SA collected field data, TM and FA analyzed the data and wrote the manuscript.

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INTRODUCTION

Animals make habitat choices as a result of balance between the costs and benefits perceived by them from effort and efficacy of result. Habitat use is driven by habitat-related variation in factors such as forage quality and availability, shelter, presence of predators, and breeding success. In fact, one of the most common significance is when open habitats provide good forage and closed habitats provide shelter from predation. The relative importance of finding food, mates and avoiding predators will change across different animal species but may also vary in space and time within populations of a single species.

Mammals have a 24-hour activity rhythm, based on the endocrine melatonin rhythm of the pineal gland, synchronized with the environment by means of the light/dark cycle (Bartness 1989). All activities carried out during the circadian cycle have fitness costs and benefits (Daan & Aschoff 1982). If different habitats have differential survival costs/benefits for active behaviour than for resting/sleeping, an individual's space and habitat use is likely to differ between the active and the inactive part of the circadian cycle (Halle 2000).

The Indian Pangolin *Manis crassicaudata*, is a medium-sized mammal, covered over on the dorsal side by hard keratinized scales, whereas its ventral side is without scales. The species occurs in five different countries including Pakistan, India, Sri Lanka, Nepal, and Bangladesh (Mahmood et al. 2019). It generally inhabits tropical and sub-tropical forests, dry mixed-evergreen monsoon, sub-mountain, and riverine forest (Roberts 1977; Phillips 1981). It also occurs in mangrove forest, grasslands, agricultural land, artificial landscapes (plantations), home-gardens, scrubland, and desiccated areas (Roberts 1977; Pabasara et al. 2015; Karawita et al. 2018). It is an 'Endangered' species throughout its range because of illegal trade for its scales and meat, placed in the Appendix I of the CITES, and is also the world's most trafficked mammal (Mahmood et al. 2019)

In Pakistan, the Indian Pangolin occurs in, and may have a preference for, sub-tropical thorn forests and barren hilly areas (Roberts 1977). Mahmood et al. (2014) reported that in the Potohar Plateau, there is a close association between the occurrence of the species and its burrows, and dominant tree Arabic Gum Acacia nilotica, Indian Plum *Zizyphus mauritiana*, Phulai *Acacia modesta*, shrubs (*Zizyphus nummularia*, *Calotropis procera*), and Mesquite *Prosopis juliflora* species. In Margalla Hills National Park, an earlier study reported that Indian Pangolin was recorded in areas dominated by Phulai, Northern Indian Rosewood Dalbergia sissoo and Chir Pine *Pinus roxburghii* while West Indian Lantana *Lantana camara* and Pomegranate *Punica granitum* appear important to the species' ecology (Mahmood et al. 2015). Since its habitat includes hilly areas, forest as well as grasslands, selection of habitat depends upon food availability (Jacobson et al. 1991). It forages exclusively on ants and termites species (Roberts 1997) in its habitat.

The Indian Pangolin has got an important economic role in agricultural crops and buildings (Roberts 1997). There are evidences on varied diet of the species that may consume insects, plant matter as well as grits (Karawita et al. 2020). It also plays vital role in the ecosystem concerning pest control. It is estimated that one adult pangolin can consume approximately more than 70 million insects annually (d'Aulaire & d'Aulaire 1983). Moreover, burrowing animals are very important to add up valuable contribution to increase animal's diversity and population as their burrowing activity provides shelter or breeding habitat for many other animals and thus this action increases animal diversity (Hansell 2003). Being the world's most trafficked mammal, mainly because of illegal trade in its scales, it faces a high risk of extinction in the wild (Challender et al. 2014). Without conservation efforts, its population is expected to keep on declining and the vital species may very soon be lost. For the conservation of this species, it is necessary to have baseline information about its ecology and biology including habitat preferences. So, keeping in view the importance of Margalla Hills as an important habitat of the Indian Pangolin in the country, the present study assessed its habitat preference in the Margalla Hills National Park (MHNP), Islamabad.

MATERIALS AND METHODS

Study area

The study was carried out in MHNP, Islamabad (Image 1), located between 33.716N and 73.916E, occupying approximately 17,386ha area, and it comprises of different compartments in Margalla Reserve Forest and 1–25 of the Military Grass Farms (Pakistan 2009). It also covers the Margalla Hills 12,802ha, Rawal Lake 1,702ha, and Shaker Parian 1,376ha. Since its establishment the Park is under the control of CDA (Capital Development Authority) vide notification number 443[1] / 80 (Anwar & Chapman 2000). But more recently, the MHNP has been handed over to "Islamabad Wildlife Management Board (IWMB) which has been established under the control of

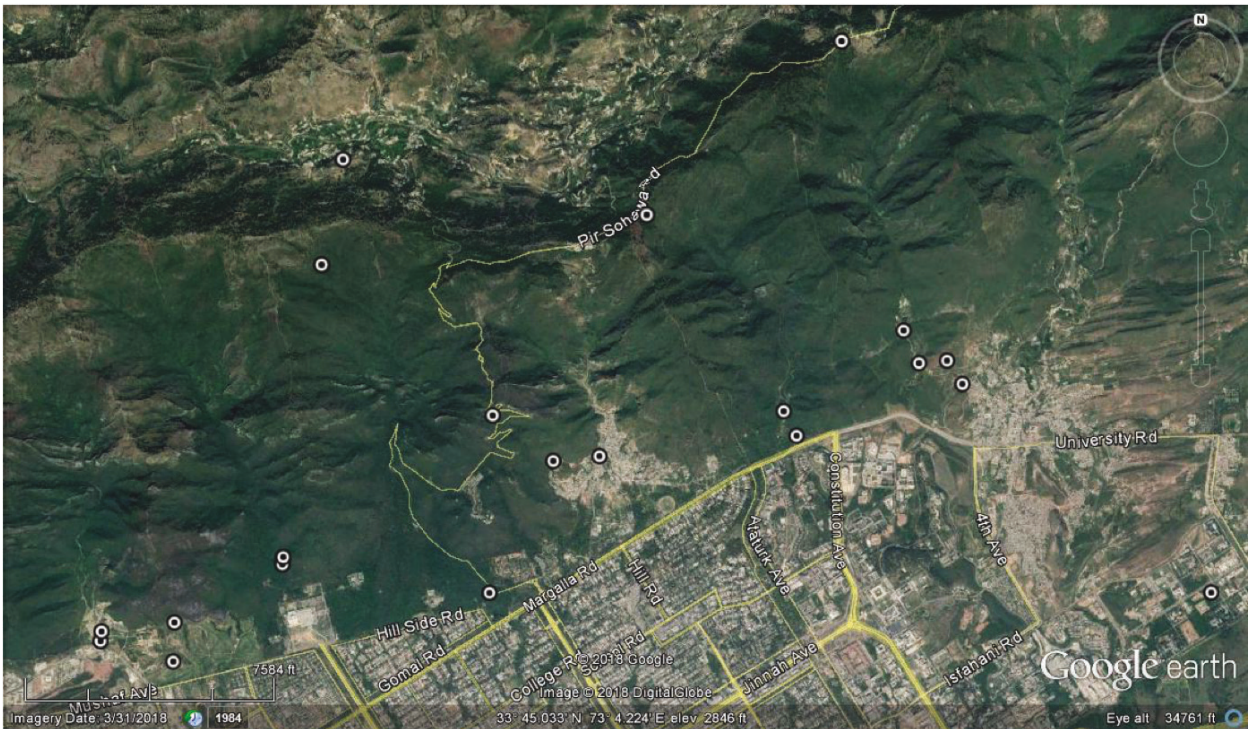

Image 1. Map of the Margalla Hills National Park, Islamabad showing locations where signs of Indian Pangolin were recorded in the Park at three different habitat types (Modified from Google Earth Inc.).

Ministry of Climate Change (MoCC), Islamabad.

The northern part of the MHNP follows the Haripur-Islamabad and Rawalpindi-Islamabad district boundaries while the forest compartments in the periphery of 37 reserve forest (RF) and 41 RF are followed by the western part of the Park boundary. Southern side of the boundary moves with the border of the forest compartments, existing boundary pillars, Siachen and Margalla road and also the center line of the nullahs like Rumli and Mandla. The eastern part of the Park boundary follows the forest compartment boundary along with the Rawalpindi-Islamabad district boundary. Finally, the boundary of Rawal Lake follows the Kashmir Highway, Murree road, Shaker Parian, the highest water mark of Rawal Lake along with 2km buffer zone and CDA pillars at some places (Pakistan 2009).

Topography of the study area is uneven, mostly comprising slopes and gullies. The rock composition is basically limestone. Its elevation ranges 450–1,580 m above sea level (Jabeen et al. 2009). On the western side elevation of the mountain is about 1,600m, which increases towards the eastern side (Anwar & Chapman 2000). The soil is colluvial, wind deposited, ranging dark brown to yellowish-brown in color with a fine texture (Hijazi 1984).

The climate is sub-tropical to semi-arid. The average maximum and average minimum temperatures of the area are 34.3ºC and 3.4°C, respectively. The area receives a reasonably high monsoon rainfall, and the annual rainfall is up to 1,200mm. Underground water table is in moderate condition having pH of 7.4 (Shinwari & Khan 1998).

The biodiversity of the park harbors about 616 species of plants, 250 birds, and 35 mammals in the National Park (Rasheed et al. 2005). The Park flora is generally dry, tropical, deciduous forest on lower slopes and sub-tropical on higher altitude. There are primarily five plant communities, on the basis of physiognomy, floristic composition and dominance, including *Olea ferruginea-Acacia modesta, Acacia modesta-Carissa opeca, Olea ferruginea-Carissa opeca, Myrisine Africana-Dodonea viscose,* and *Pinus roxburghii-Quercus incana*. The *Pinus roxburghii-Quercus incana* community is present at 900m elevation where Chir Pine are found in patches and understory cover is dominated by grasses (Anwar & Chapman 2000).

Field surveys and data collection

A reconnaissance was conducted on motor vehicle (average speed 25–30 km/h) in natural and wild areas of the park to find out the potential habitat of Indian pangolin. The potential areas were marked and their

geographical coordinates were recorded. The potential areas of the animal species were identified on the basis of its burrows and fecal samples present over there and also by interviewing local people. The burrows of the Indian pangolin were distinguished from those of other vertebrates identified on the basis of their characteristics shape (being circular at their opening). The species excavates two types of burrows. These are the feeding burrows and living burrows. The feeding burrows are less deep and excavated during foraging on ants and termites, while the second types of burrows are "permanent" burrows or living burrows, which are excavated by the species for living purposes, and these are much deeper. The local people were also asked about the occurrence of pangolins in their area, just to confirm existence of the species in the study area. Information provided by the local people were verified by searching for and identifying the field signs like burrows and scats of the Indian Pangolin.

For investigation of the habitat and collection of data on the species, 17 representative sampling sites were randomly selected. Each sampling site comprised an area of about 1km². Five line transects, each measuring 500m in length and 50m in width on either side of the transect (area of each transect was 0.05km2) were established in each sampling site. Total numbers of transects searched were N= 85. Fortnightly visits to the selected sites were conducted for data collection from July 2011 to June 2012. The selected sites ranged in their elevation from 462m (Malpur) to 1,046m (Trail-3). Each visit comprised of three consecutive days. The total numbers of days of observations were N= 72. In order to ensure that we did not double count the field signs of Indian Pangolin, as the burrows were permanent signs, the scats were collected during each field visit.

Each sampling site was further divided into three different habitat types, viz., human vicinity area (HVA), agricultural lands (AGL), and wild or natural area (WNA); all these habitat types were searched for recording direct and indirect signs of the Indian Pangolin. Besides the presence of burrows and faecal matters, other signs that were searched included their foot prints and body prints, especially around the newly dug burrows (Table 1). The feeding and permanent burrows of the species were distinguished on the basis of the burrow depth; the depth of the feeding burrows was much less than the living or

Image 2. Field photographs of burrows of Indian Pangolin in the Margalla Hills National Park, Islamabad: A—living or permanent burrow | B—a feeding burrow | C—inactive living burrow | D—active living burrow. © Shaista Andleeb.

permanent burrows (Image 2). Similarly, inactive and active living burrows of the species were distinguished on the basis of activity signs around the burrows (Image 2). Also, questionnaires were developed for collecting information from the local people in different areas of the park. Data on habitat preference of the pangolin was collected from direct and indirect signs monitored along 85 line transects established in 17 sampling sites. The transects where direct and indirect signs of pangolin were found, their geographical coordinates were recorded by using geographical positioning system (Garmine Trex Vista H), later to construct a distribution map of the animal species in MHNP.

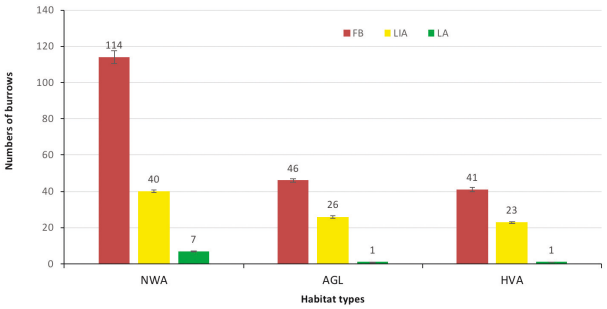

Figure 1. Numbers of burrows (Feeding burrows FB, living inactive LIA, and living active LA) of Indian Pangolin recorded in MHNP, at three different habitat types in the study area: HVA—Human vicinity area | NWA—Natural Wild area | AGL—Agricultural land.

RESULTS AND DISCUSSION

The Indian Pangolin occurs in a diversity of habitats, ranging from hilly areas to forests and grasslands, depending upon the availability of its food resources. Growing concerns over population declines due to poaching and trafficking (Challender et al. 2015; Ingram et al. 2019) have emphasized the need for more concerted conservation efforts for the species, which according to the IUCN Red List of Threatened Species, is listed as 'Endangered' due to past and anticipated population declines caused by illegal hunting (Mahmood et al. 2019). The species is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Mahmood et al. 2019).

In the current study, we aimed at investigating the preferred habitat of the Indian Pangolin, among three habitat types, viz., natural or wild area (NWA), agricultural land (AGL) and human vicinity areas (HVA), in the MHNP, Islamabad. The earlier published literature shows that the species can occur in a variety of habitats like forests, grasslands, and semidesert areas (Roberts 1997).

In our study of the Indian Pangolin, a total of 323 signs were recorded, out of which 299 were burrows, 10 were live sightings and 14 were scats of Indian pangolin (Table 1). The results showed that among all field signs the maximum signs were recorded in habitat type-III (Table 2; Image 2; Figure 1), wild or natural area (n= 178; 55.1%), followed by human vicinity area (n= 80; 24.76%), while the least signs of the species (n= 65; 20.12%) were found in the agricultural land area. The maximum signs of pangolin were found in Malpur (n= 125; 38.70%) sampling site while the least signs were recorded at Trail-3 (n= 3; 0.92%) of MHNP. These findings suggest

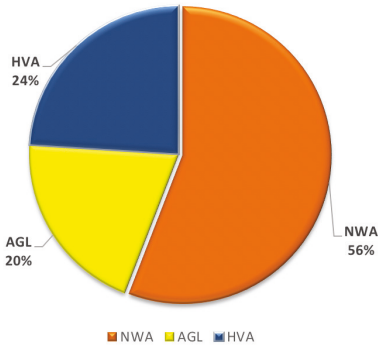

Figure 2. Percent use of each of the three habitat types by Indian Pangolin in MHNP Islamabad.
HVA—Human vicinity area | NWA—Natural Wild area | AGL—Agricultural land.

that the Indian Pangolin prefers for wild natural area over human vicinity area and agriculture land in the Park.

Karawita et al. (2018) investigated the habitat preference of Indian Pangolin in a tropical lowland rainforest in southwestern Sri Lanka. They recorded a total of 75 burrows, that included 54 feeding burrows and 21 resting burrows in four different habitat types—secondary forest, Pine-dominated forest, rubber cultivations, and tea-dominated home gardens bordering forest. The observations were made using fixed-width transects in order to characterize resting and feeding burrows of this species. They concluded that the Indian Pangolins exclusively prefer habitats with rocks and boulders under which they dig resting burrows while the location of feeding burrows largely overlaps with the distribution of prey species. In our current study in MHNP Islamabad, however, we did not find any burrows of Indian Pangolin in the rocks, but a majority were in the soft soil, and under the vegetation.

Similarly, Mahmood et al. (2014) studied the habitat

Table 1. Detail of field surveys/ transect surveys conducted on motor vehicle for Indian Pangolin distribution of in Margalla Hill National Park, Islamabad, during current study period.

Sr. #	Location	Starting transect	Geographic coordinates	Ending transect	Geographic coordinates	Distance covered	Result +/-
1	Phulwari	Phulwari Village entrance (QAU)	N: 34.001 E: 73.303 Elev: 595m	Phulwari Village (QAU)	N: 33.846 E: 73.190 Elev: 595m	6km	+Ve
2	Kalanjir	Kalanjir Valley	N: 33.918 E: 73.039 Elev: 598m.	Gandian Village	N: 33.877 E: 73.157 Elev: 579m.	4km	+Ve
3	Rumli	Ramli Village entrance	N: 33.997 E: 73.275 Elev: 591m	Ramli Village	N: 33.853 E: 73.208 Elev: 634m	6km	+Ve
4	Shahdara	Shahdara Village	N: 33.947 E: 73.318 Elev: 702m.	Mandla Village	N: 34.040 E: 73.306 Elev: 653m.	6km	+Ve
5	Gandian	Gandian Village (DaraKaao'nwni)	N: 33.751 E: 73.036 Elev: 606m.	Gandian Village	N: 33.761 E: 73.215 Elev: 619m.	8km	+Ve
6	Kalanjir	Kalanjir Village	N: 33.906 E: 73.036 Elev: 597m.	Kalanjir Village	N: 33.931 E: 73.163 Elev: 602m.	3km	+Ve
7	Rattahottar	Rattahottar	N: 33.770 E: 73.141 Elev: 643m.	Ratta Hottar	N: 33.812 E: 73.330 Elev: 631m.	3km	+Ve
8	Bari imam	Bari imam	N: 33.767 E: 73.356 Elev: 627m.	Bari imam (Mahallakamalpur)	N: 33.999 E: 73.168 Elev: 616m.	2km	+Ve
9	Trail-5	Darajangla (trail 5)	N: 33.928 E: 73.153 Elev: 630m.	Muradgalli	N: 33.926 E: 73.209 Elev: 1164m.	7km	+Ve
10	Trail-3	Trail 3 (from monal restaurant)	N: 33.962 E: 73.163 Elev: 1046m	Trail 3 (Darajangla)	N: 33.962 E: 73.131 Elev: 624m	5km	+Ve
11	Lakeview park	Lakeview park side	N: 33.970 E: 73.326 Elev: 542m	Malpur Village	N: 33.782 E: 73.100 Elev: 527m	3km	+Ve
12	Saidpur	Saidpur Village.	N: 33.900 E: 73.086 Elev: 592m	Saidpur Village.	N: 33.894 E: 73.271 Elev: 648m	3km	-Ve
13	Malpur	Malpur Village	N: 33.774 E: 73.226 Ele15v: 462m	Malpur Village	N: 33.774 E: 73.226 Elev: 467m	4km	+Ve
14	Daman -e- koh	Enterance Daman-e-koh road	N: 33.971 E: 73.130 Elev: 579m	Bodlabann	N: 33.958 E: 73.175 Elev: 869m	6km	-Ve
15	Talhar	Entrance Talhar Village	N: 33.780 E: 73.196 Elev:932m	Chak Khanna point (18RF)	N: 33.898 E: 73.168 Elev:995m	2.5km	+Ve
16	Sangjani	Sangjani Wild area	N: 33.718 E: 72.918 Elev:506m	Sangjani	N: 33.725 E: 72.919 Elev:511m	4km	+Ve
17	Shah-Allah-Ditta	Shah-Allah-Ditta Wild area	N: 33.826 E: 72.994 Elev:581m	Shah-Allah-Ditta area	N: 33.839 E: 72.998 Elev:578m	3km	+Ve
	Total					75.5km	

and population of the Indian Pangolin in Chakwal District, Pakistan. They reported that trees, herbs, and shrubs form important components of its habitat. They found the Indian Pangolin closely associated with *Acacia nilotica, Zizyphus mauritiana, Z. nummularia* and *Prosopis cineraria*. *Lantana camara* was also among the preferred vegetation type. They suggested that tree species like *Prosopis, Zizyphus* and *Acacia nilotica* may be important for the Indian Pangolin from the point of view of food because abundant termite mounds and ant's colonies occur on the soil below and on the trunks of these tree species. Moreover, *Zizyphus nummularia* and *Lantana camara* may have an important role of providing protection to the animal species. In the current study in MHNP Islamabad, the habitat type-III (NWA) is also having a similar kind of vegetation with similar species

Table 2. Percentage (%) of habitat use by Indian Pangolin *Manis crassicaudata* in MHNP, Islamabad.

Site No.	Sampling sites	Elevation (m)	Human vicinity area (%)	Agricultural lands (%)	Natural/wild area (%)
1	Malpur	462	4	18	78
2	Lake view	542	27	15	58
3	Banni galla	514	37	14	49
4	Shahdara	702	26	23	51
5	Ramli	591	24	63	13
6	Phalwari	595	47	24	29
7	Gandian	603	57	24	19
8	Kalinjir	598	47	29	24
9	Bari Imam	627	45	21	34
10	Ratta Hottar	643	12	51	37
11	Darra Jangala	630	3	0	97
12	Trail-3	1046	2	0	98
13	Talhar	932	3	8	89
14	Sangjani	506	11	7	82
15	Shah-allah-Ditta	581	2	13	85
16	NARC	496	27	32	41
17	Saidpur	670	34	0	66
	Mean ± SE		**24 ± 4.47**	**20.11 ± 4.15**	**55.88 ± 6.84**

of herbs, shrubs, & trees, which indicates why the Indian Pangolin preferred such a kind of habitat. The Indian Pangolin was found distributed at various sites surveyed including Phalwari, Kalinjar valley, Gandian Valley, Rumli, and Shahdara areas of the Park. It was also recorded in Ratta-Hottar and Bari-Imam areas of the Park. The occurrence of some old burrows at Trail-3 and Trail-5 of MHNP showed that the animal species did occur in these areas in the near past. No direct or indirect signs of the animal were found in Saidpur area; however, it was confirmed to occur around Lake View and Malpur areas. In Sangjani and Talhar areas, some old burrows revealed its presence.

During the current study period, the Indian Pangolin was found to occur at Malpur site near Rawal Lake, Phalwari area, Kalinjar Valley, Gandian Valley, Ramli and Shahdara, Ratta Hottar, NARC, and Bari Imam areas of the MHNP, at an elevation ranging 462–1,046 m. Some old living/permanent burrows of the animal species were recorded at Trail-3 and Trail-5 areas of the park, which indicates that the Indian Pangolin did occur at these sites in the past but it has moved to some other places from there now. Similarly, at Sangjani and Talhar areas of the Park, occurrence of old permanent burrows indicates its occurrence in the past at these sites. In the area of Shah-Allah-Ditta (995m), its occurrence was confirmed whereas in the area of Daman-e-Koh (579–869 m), no signs of the animal species were found. Roberts (1997) had reported that the Indian Pangolin occurs in the subtropical thorn forest of Potohar Plateau and in Rawalpindi foothills up to 750m elevation, but in the current study it has been recorded up to an elevation of 995m. The MHNP also has subtropical thorn forest.

Results of the current study confirm that the Indian Pangolin prefers natural wild area (55.88%) over human vicinity areas (24%), and agricultural land (20.11%) (Table 2; Figure 2). Statistical comparison using one-way analysis of variance (ANOVA) of pangolin field signs among three different types of habitats studied differed significantly ($df = 48$, $F = 13.723$, $p < 0.001$). Similarly, LSD analysis further revealed that field signs of the pangolin recorded at natural wild area habitat type significantly differed from agricultural land and human vicinity area habitat types ($p < 0.001$). Waseem et al. (2020) investigated the habitat suitability of the pangolin in Potohar Plateau and Azad Jammu & Kashmir areas. We recorded evidence of pangolin occurrence in three different types of habitats in study area; viz., natural forests, agricultural land, and the grassland. Results indicate that the natural forest land is the preferred habitat of the pangolin. This preference indicates that compared to grassland and agricultural land, more

cover might be available to pangolins for refuge and protection. These results support the findings of the current study where the Indian Pangolin preferred natural wild area habitat over agricultural land and vicinity areas. The findings of the current study also get support from Perera & Karawita (2020) who reported that the the Indian Pangolin inhabits a variety of habitats, ranging from natural to anthropogenic. Subtropical/tropical shrubland, subtropical/tropical dry forest, and subtropical/tropical moist lowland forest were the habitat types. Interestingly, 15 confirmed records of the Indian Pangolins were reported from subtropical/tropical moist montane forests, which represent the lower and upper montane forests (cloud forests) at altitudes above 1,200m.

CONCLUSION

The current study provides information regarding habitat utilization of the Indian Pangolin. The species prefers habitats in natural or wild area over agricultural land and human vicinity areas ($p < 0.001$). The results are expected to help in managing the Indian Pangolin by conserving its preferred habitat type in the study area of Margalla Hills National Park, Islamabad, in addition to controlling its illegal trade.

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