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Dietary composition of the Indian pangolin (*Manis crassicaudata*) in Gir National Park, India

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Abstract

Background: The Indian pangolin is a globally endangered species and is accorded the highest level of protection under Indian legislation. The species has a wide distribution in the country. However, information on its ecology is scanty with limited accounts on the diet of the free-ranging population.

Results: We studied the diet of the Indian pangolin in a tropical dry deciduous forest of Gir National Park, India. A total of 12 faecal samples in the form of 22 pellets were collected between November 2019 and March 2020. The faecal matter's length, diameter and girth were 4.80 cm ± 0.40 SE, 2.72 cm ± 0.12 SE and 8.49 cm ± 0.41 SE, respectively. The dry weight of the faecal matter was 22.31 g ± 3.24 SE. The composition of the faecal content by weight was majorly contributed by insect matter (56.53%), followed by grit (42.35%) and plant matter (1.12%). Faecal content's analysis through microscopy revealed that insect matter was the most frequent constituent (53.59%), followed by grit (46.26%) and plant matter (0.05%); 0.1% of the constituents could not be identified. The ant genera contributing to the diet of the Indian pangolin include *Camponotus, Crematogaster, Dorylus, Lophomyrmex, Monomorium, Myrmicaria, Pheidole* and *Tetraponera*. The termite genera consumed by the Indian pangolin were *Odontotermes* and *Cryptotermes*.

Conclusions: The study's findings contribute to enhance the ecological knowledge in a hitherto unexplored habitat and hold implications in the *ex situ* conservation efforts and rescue and rehabilitation of Indian pangolins in similar landscapes.

Keywords: Indian pangolin, Gir National Park, Diet, Faecal matter analysis

Background

The Indian pangolin (*Manis crassicaudata*) is a globally endangered mammal species native to the Indian subcontinent. It ranges from northern and south-eastern Pakistan through much of India, parts of Nepal and Sri Lanka (Mahmood et al., 2019). They occur in various habitats, including forests, scrub, grasslands, arid regions, degraded habitats and human-altered landscapes, thus exhibiting high adaptability (Karawita et al., 2018; Roberts, 1977). Their presence is reported to be determined by the availability of abundant prey and protection (Mahmood et al., 2019). Thus, understanding the species' diet is imperative for planning conservation action (Challender, 2008). The Indian pangolin is primarily myrmecophagous with anatomical and physiological adaptations best suited to its diet (Heath, 1995; Prater, 1971). The species thus performs a vital role in the population regulation of insect pests (d'Aulaire & d'Aulaire, 1983). Records on the foraging ecology and diet of the Indian pangolin are available from some areas in its distribution range (Karawita et al., 2020). Indian pangolin's faecal matter analysis from the Potohar Plateau in Pakistan revealed that clay was the most voluminous component followed by insect matter with two ant species *Camponotus confucii* and *C. compressus,* and one termite species, *Odontotermes obesus,* in addition to ant eggshells contributing to the pangolin's diet (Irshad et al., 2015; Mahmood et al., 2013). In Sri Lanka, studies on foraging and diet were undertaken in Yagirala Forest Reserve.

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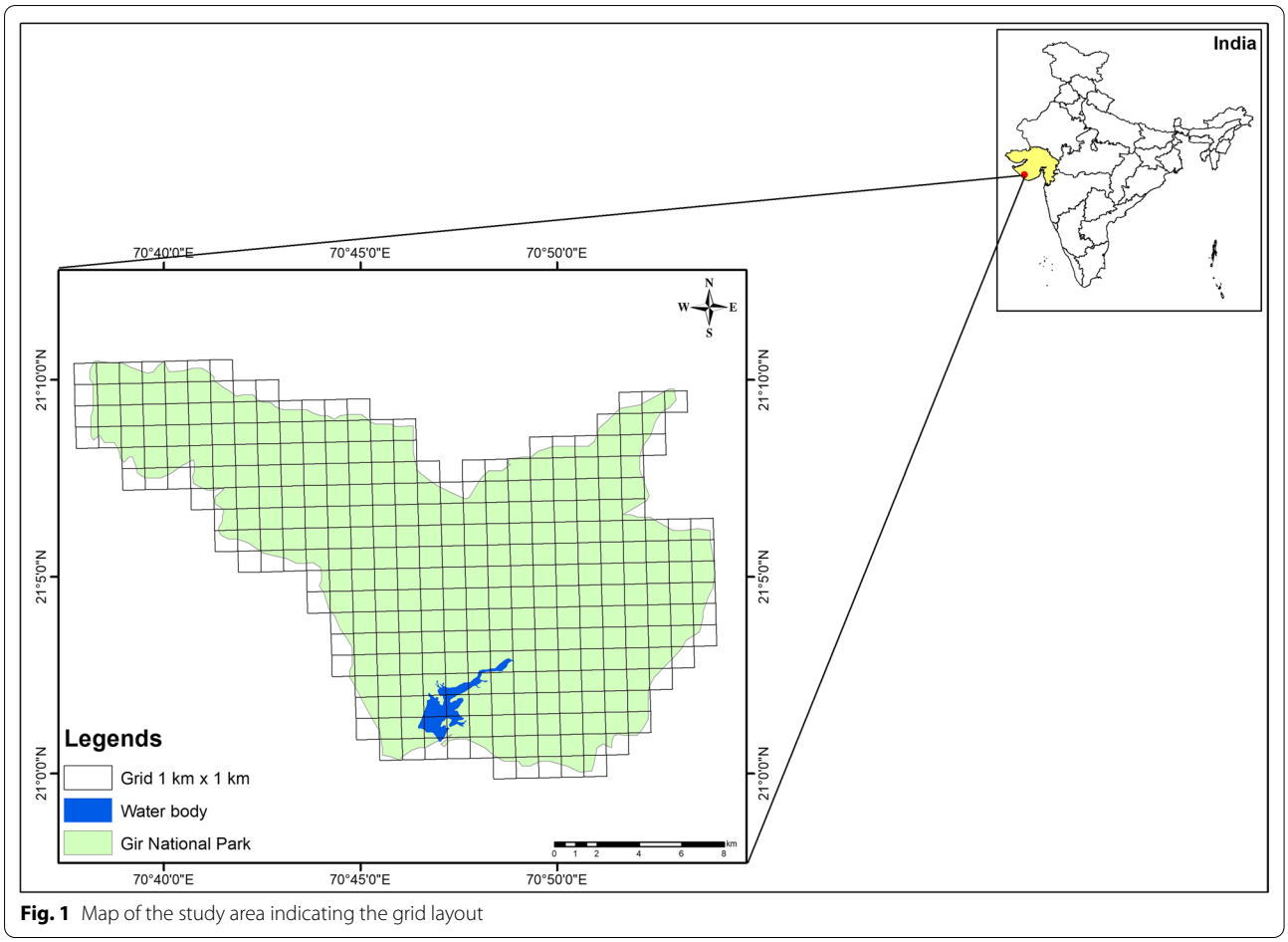

Fig. 1 Map of the study area indicating the grid layout

The study reported grit as the most abundant constituent in the faecal matter; the ant species consumed included *Monomorium* sp., *Camponotus* sp. *Anoplolepis* sp. and *Oecophylla* sp.; the termites of the genus *Odontotermes* including *O. horni* and *O. redemanni* were observed. In addition, body parts of beetles, the exoskeleton of a juvenile scorpion and juvenile lacewing were also observed (Karawita et al., 2020). In India, the Indian pangolin's diet is known from analyses of stomach content. In Nilgiris, the diet consisted of black ants, beetle wing sheath, cockroaches' remains and worms' skins (Hutton, 1949). The gut content analysis of a female Indian pangolin in Waynad revealed that the diet contained high grit content and was composed exclusively of *Leptogenys* sp. with a probable preference for ant eggs over adult ants (Ashokkumar et al., 2017). In captivity at the Nandankanan Zoological Park, the Indian pangolin's showed acceptance for *Oecophylla smaragdina* and their eggs (Mohapatra & Panda, 2014). Data on the free-ranging Indian pangolin's diet in other parts of India are lacking. We studied the Indian pangolin's diet in the tropical dry deciduous forest of Gir National Park in Western India to develop an understanding and contribute to the ecological knowledge of the species. This would further aid in devising conservation strategies. Limitations in understanding and replicating the Indian pangolin's dietary requirements in captivity have been reported to be the primary cause of concern in their husbandry (Mohapatra & Panda, 2014; Pattnaik, 2008; Yang et al., 2007). The study's findings also hold the potential to assist in the *ex situ* conservation efforts and in rescue and rehabilitation operations of Indian pangolins in the study area and similar habitats.

Methods

The Gir National Park is situated from degrees 21°00' to 21°10'N and degrees 70°38' to 70°54'E and lies 40 km from the Arabian Sea coast in the Saurashtra region of Gujarat, India (Fig. 1). It covers an area of 258.71 km^2. The altitude ranges from 100 to 608 m ASL. The terrain is undulating with north–south drainage. The area experiences four distinct seasons, like the rest of the country. Gir comprises one of the most extensive compact tracts of dry deciduous forest categorized as 5A/Cla: very dry

teak forests by Champion and Seth (1968). These were then classified into three broad classes: moist mixed, thorn forest and hill forest and further divided into eight subtypes, namely moist mixed forest, mixed forest, *Acacia—Tectona / Anogeissus*, *Acacia—Lannea—Boswellia*, *Tectona—Acacia—Zizyphus*, Thorn Forest, Scrubland and Savanna (Qureshi & Shah, 2004). Gir is inhabited by 37 species of mammals, over 300 species of birds, 46 species of reptiles, 8 species of amphibians, over 2000 species of insects and 635 species of plants (Meena & Kumar, 2012; Singh et al., 2017).

The study area was overlaid with a 1 km × 1 km grid layer for surveying the presence of Indian pangolin. These grids were systematically traversed through diagonal and permanently marked foot transects to search for evidence of the presence of the Indian pangolin (Karawita et al., 2020; Mahmood et al., 2014). The pangolin faecal samples were distinguished from other faeces based on size, shape and physical characteristics (Irshad et al., 2015; Karawita et al., 2020). Faecal samples that were highly disintegrated or difficult to attribute to a pangolin were disregarded. The morphometric measurements of the faecal samples were recorded using digimatic vernier callipers (Divinext Aerospace, India). The specimens of all species of ants and termites were collected from different microhabitats and locations in the Gir National Park for reference (Karawita et al., 2020; Mahmood et al., 2013).

The methodology used by Karawita et al., 2020 for the separation of faecal matter constituents was used in this study. The sample was taken in a 100-ml flask containing 70% alcohol and shaken on a rotary shaker at 60 rpm for 10 min. Microscopic observations of the constituents were carried out to analyse the relative frequency of the items in the faecal samples (Mehta et al., 2013). The majority of the insect matter in the faecal samples was in the form of minute body parts, which were difficult to identify. The faecal samples were separated into insect matter, plant matter and grit with the aid of a stereomicroscope (ZS-3152 T, Analytical Technologies Ltd., India) and dried at 60 °C for 36 h in a hot air oven (Karawita et al., 2020). The dry weight of these three constituents was measured for each faecal sample using an analytical balance (CWS-1002, Scaletec, India) to calculate percentage dry weights. The identifiable insect residuals from the separated insect matter were further examined to assess the species that contributed to the diet of the Indian pangolin. The species were identified to the level of family and genus or species when possible, using taxonomic descriptions and records in Roonwal and Chhotani (1989), Rathore and Bhattacharyya (2004), Tak (2008), Bharti et al. (2016), Antweb (2021) and through the help of subject experts. The frequency of ant and termite body parts in the faecal samples was also computed and statistically compared (Karawita et al., 2020).

Results

A total of 200 grids were surveyed, resulting in a search effort of 284 km between November 2019 and March 2020. A total of 12 faecal samples of Indian pangolin were collected in the form of 22 pellets. The pellets per scat sample ranged from one to four, with most singles ($n=12$). Most of the faecal samples were recorded in the proximity of living burrows ($n=7$), some were recorded near feeding burrows ($n=3$). In contrast, two samples were located on open ground away from the burrows. The faecal samples were either on the ground ($n=8$) or a hard rocky substrate ($n=4$). The faecal matter's mean length, diameter and girth were 4.80 cm ± 0.40 SE, 2.72 cm ± 0.12 SE and 8.49 cm ± 0.41 SE, respectively.

A total of 86,427 constituents in the faecal content were observed microscopically, which revealed that insect matter was the most frequent constituent (53.59%), followed by grit (46.26%) and plant matter (0.05%); 0.1% of the constituents could not be identified. A statistical significance between the percentage frequency of insect matter, grit and plant matter was recorded (one-way ANOVA, $F=13.49$, $p<0.001$). The Tukey's post hoc pairwise comparisons ($\alpha=0.05$) suggested that there was a statistically significant difference ($p<0.05$) between the percentage frequency of insect matter and plant matter as well as between grit and plant matter. No significant difference was recorded between the percentage frequency of insect matter and grit in the faecal samples. The average dry weight of the faecal samples was 22.31 g ± 3.24 SE. The composition of the faecal content by weight was also majorly contributed by insect matter (56.53% ± 4.34 SE), followed by grit (42.35% ± 4.58 SE) and plant matter (1.12% ± 0.48 SE). A statistically significant difference between the percentage weights of the faecal contents was recorded (one-way ANOVA, $F=62.01$, $p<0.001$). Tukey's post hoc analysis revealed statistically significant differences ($p<0.05$) among all three percentage weights of the faecal contents at $\alpha=0.05$ level.

A total of fifteen species of ants were collected for reference and were also observed in the diet of the Indian pangolin in the study area. These include two unidentified species of *Camponotus*, *C. compressus, C. angusticollis, Tetraponera rufonigra, T. allaborans, Dorylus labiatus,* one species of *Crematogaster*, one species of *Myrmicaria*, two species of *Lophomyrmex*, two species of *Pheidole* and two species of *Monomorium*. Among these, *C. compressus* was the most frequently observed species in the insect matter (15.94%), followed by *Camponotus* sp. (14.93%), *Pheidole* sp. (13.42%), *C.*

Table 1 Frequency of different body parts of ants and termites in the faecal matter of Indian pangolin in Gir National Park

Body part	Ant (Mean ± SE)	Termite (Mean ± SE)	*t*	*df*	*p*
Head	86.00 ± 4.59	1.33 ± 0.91	17.08	11	0.000000001
Thorax	13.58 ± 1.82	0.92 ± 0.56	6.07	11	0.000040333
Abdomen	6.67 ± 0.66	0 ± 0	10.17	11	0.000000311
Leg	53.83 ± 4.85	1.00 ± 0.49	11.28	11	0.000000109
Mouthparts	2.42 ± 0.50	0 ± 0	4.84	11	0.000259726
Whole-body	1.00 ± 0.56	0.08 ± 0.08	1.835653	11	0.046782480

angusticollis (7.76%), *Camponotus* sp. (5.79%), *Dorylus labiatus* (4.74%), *Tetraponera rufonigra* (4.49%), *Myrmicaria* sp, (3.65%), *Lophomyrmex* sp. (3.52%), *Pheidole* sp. (2.85%), *T. allaborans* (2.27%), *Crematogaster* sp. (2.06%), *Monomorium* sp. (0.84%), *Monomorium* sp. (0.76%) and *Lophomyrmex* sp. (0.29%) in addition to 4.36% of unidentified ant parts.

A total of nine species of termites were collected from the study area for reference, among which three could be identified in the insect matter of the faecal samples. Two species belonged to the genus *Odontotermes* and one to *Cryptotermes. Odontotermes* sp. were relatively more frequent in the faecal matter (0.88 and 0.13%), with 0.08% of the insect matter attributable to *Cryptotermes*. 11.16% of the termite parts could not be assigned to a species. Other insect body parts in the form of mouthparts and unidentified fragments were recorded with a percentage frequency of 0.08% in the insect matter.

There was a significant difference between the frequency of body parts of ants and termites in the faecal matter, ant body parts being recorded in higher frequency as compared to termite body parts (Table 1). On infrequent occasions, whole bodies of ants and termites were recorded in the faecal matter. The eggshell of a termite was observed once in the faecal matter. No wings were observed in any of the samples. One-way ANOVA indicated a significant difference in the frequency of undigested ant body parts in the faecal matter ($F = 148.90$, $p < 0.0001$), thus suggesting differential digestibility. Tukey's post hoc analysis at $\alpha = 0.05$ level revealed that ant heads and legs had the lowest digestibility among all body parts ($p < 0.05$). However, no statistical difference was observed in the frequency of undigested termite body parts in the faecal matter.

Discussion

The current study investigated the diet of the Indian pangolin in a tropical semi-arid dry deciduous forest through the analysis of the faecal matter. Other studies that have examined the diet of the Indian pangolin by employing this method have been carried out in a tropical wet evergreen forest (Karawita et al., 2020) and an arid region (Irshad et al., 2015; Mahmood et al., 2013). The faecal samples were recorded in the form of pellets ranging from one to four per sample. Karawita et al. (2020) observed faecal matter mainly in the form of single pellets and rarely doubled close to the living burrows and open rock outcrops. Our observations suggest that the faecal matter of Indian pangolins is mainly in the form of single pellets. However, the occurrence of multiple pellets in the faecal matter is possible. The faecal matter was observed to be on the open ground close to the living burrows and hard rocky substrate during our study as well. The average dry weight of the faecal samples was 22.31 g. The average weights of faecal matter in the Potohar Plateau, Pakistan, have been reported to range from 32 to 47 g (Irshad et al., 2015). These weights, however, are not comparable since we recorded the oven-dried weights.

In the current study, insect matter dominated the diet of the Indian pangolin. The studies by Mahmood et al. (2013), Irshad et al. (2015) and Karawita et al. (2020) reported insect matter to be the second most dominant component in the faecal matter. The insect matter chiefly consisted of ants and termites in the current study. Some studies recorded species of other insects and invertebrates in the faecal matter, suggesting that Indian pangolins are not exclusively myrmecophagous (Hutton, 1949, Heath, 1995, Irshad et al., 2015, Karawita et al., 2020). Indian pangolins are known to be selective for their prey (Ashokkumar et al., 2017; Irshad et al., 2015; Phillips, 1928; Prater, 1971). Fifteen species of ants and three species of termites were identified in the faecal matter in our study. These included two unidentified species of *Camponotus, C. compressus, C. angusticollis, Tetraponera rufonigra, T. allaborans, Dorylus labiatus,* one species of *Crematogaster*, one species of *Myrmicaria*, two species of *Lophomyrmex*, two species of *Pheidole* and two species of *Monomorium*, two species of *Odontotermes* and one species of *Cryptotermes*. The frequency of ant and termite body parts showed a notable difference in the faecal matter. Ant body parts were higher as compared to body parts of termites. Similar observations were recorded in the Potohar Plateau, Pakistan, where termite body parts accounted for only 3.8% of the faecal matter by volume as compared to 31% in the case of ants (Irshad et al., 2015). In Maharashtra, India, Indian pangolins have been recorded to feed on *Camponotus angusticollis, C. compressus, C. parius, Carebara affinis, Polyarchis menelas, Pheidole malinsii* and *Oecophylla smaragdina* (Mahmood et al., 2020). In Waynad, India, the gut content revealed the diet to be exclusively comprised of *Leptogenys* sp. In the Potohar Plateau, Pakistan, *Camponotus confucii, C.*

compressus and *Odontotermes obesus* were recorded in the pangolin diet (Irshad et al., 2015; Mahmood et al., 2013). In Yagirala Forest Reserve, Sri Lanka, *Monomorium* sp., *Camponotus* sp. *Anoplolepis* sp., *Oecophylla* sp., *Odontotermes* sp., *O. horni* and *O. redemanni* were observed in the faecal matter. Our study thus highlights the common presence of the *Camponotus, Monomorium, Pheidole* and *Odontotermes* genera in the diet of the Indian pangolin in its distribution range.

Grit was the second most abundant constituent and contributed 46.26% in terms of relative frequency and 42.35% by weight in the faecal matter in Gir National Park. Grit was reported to be the chief constituent of the faecal matter in Yagirala (mean 53.20% by weight) and Potohar plateau (mean 70.71% by volume). The grit content occurs in the faecal matter of Indian pangolin owing to their foraging habit and indigestibility (Karawita et al., 2020). The grit is believed to perform the role of mastication and facilitation of digestion (Prater, 1971). The percentage frequency of plant matter was 0.05%, and the mean percentage weight contributed was 1.12% in the faecal matter in Gir National Park. The mean percentage weight of plant matter in the pangolin diet at Yagirala Forest Reserve was 9.75%. In comparison, the mean percentage volume of plant matter at the Potohar Plateau was 0.39%. The ingestion of plant matter may be unintentional. However, it may play a role in facilitating digestion and has also been proposed to be added to the diet of captive pangolins (Cabana et al., 2017). The variability in the presence of the plant matter between Yagirala Forest Reserve, Gir National Park and Potohar plateau may be due to the corresponding variability in aridity and availability of vegetation.

The overall variations in the dietary composition of the Indian pangolin between Gir National Park, Yagirala Forest Reserve and Potohar plateau may be attributable to the variation in the habitats, seasonality of feeding and foraging options between the three areas. Mahmood et al. (2013) reported the mean length and diameter to be 5.69 ± 0.72 cm and 2.18 ± 0.17 cm, respectively, in Haddowali and 4.46 ± 0.53 cm and 2.11 ± 0.21 in Thatti Syedo Shah. Karawita et al. (2020) reported these to be 3.2 cm ± 0.4 and 1.7 cm ± 0.2, respectively. The mean length, diameter and girth of the faecal matter in Gir National Park were 4.80 cm ± 0.40 SE, 2.72 cm ± 0.12 SE and 8.49 cm ± 0.41 SE, respectively. Our findings suggest that the pellets in Gir National Park depict an intermediate size between the faecal pellets in rainforests and arid regions. Analysis of faecal samples collected from different locations within the distribution range of Indian pangolins may assist in establishing the effects of habitat types and ecogeography on the dietary composition and morphology of the faecal matter.

Conclusions

This study reports the dietary composition of the Indian pangolin in a tropical dry deciduous forest. As compared to other studies, we have found insect matter dominated the percentage composition of the faecal matter with 53.59%, followed by grit and plant matter with 46.26% and 0.05%, respectively, while 0.1% constituents were unidentified.The findings add to the current ecological knowledge and understanding of pangolins' dietary and nutrient requirements, which can further assist in the diet formulation for pangolins kept in captivity for *ex situ* conservation programmes or housed at rescue and rehabilitation centres in semi-arid landscapes (Mohapatra & Panda, 2014). Additionally, the findings have important implications in conservation planning and management for the Indian pangolins in the study area and similar semi-arid habitats.

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Authors' contributions

MR and DV took part in conceptualization; MR, DhM, DaM involved in methodology; MR, DaM, DhM took part in formal acquisition, analysis and investigation; DhM, DaM, MR involved in writing—original draft preparation; MR involved in writing—review and editing; MR involved in resources; MR and DV involved in supervision. All authors read and approved the final manuscript with the order of authorship.

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Availability of data and materials

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

The work was conducted by the competent authorities (Deputy Conservator of Forests & Chief Conservator of Forests) of the Gujarat Forest Department. Therefore, consent to participate is not applicable.

Consent for publication

Not applicable.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

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References

AntWeb Version 8.48.2 California Academy of Science, online at https://www.antweb.org. Accessed 20 Jan 2021.

Ashokkumar, M., Valsarajan, D., Suresh, M. A., Kaimal, A. R., & Chandy, G. (2017). Stomach contents of the Indian Pangolin *Manis crassicaudata* (Mammalia: Pholidota: Manidae) in tropical forests of southern India. *Journal of Threatened Taxa, 9*(5), 10246–10248.

Bharti, H., Guénard, B., Bharti, M., & Economo, E. P. (2016). An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). *ZooKeys, 551*, 1–83. https://doi.org/10.3897/zookeys.551.6767

Cabana, F., Plowman, A., Van Nguyen, T., Chin, S. C., Wu, S. L., Lo, H. Y., Watabe, H., & Yamamoto, F. (2017). Feeding Asian pangolins: An assessment of current diets fed in institutions worldwide. *Zoo Biology, 36*(4), 298–305.

Challender, D. (2008). Asian pangolins: how behavioural research can contribute to their conservation. In: S. Pantel, and S.Y. Chin (Eds.) *Proceedings of the workshop on trade and conservation of pangolins native to south and southeast Asia*. 30 June–2 July 2008. Singapore zoo, Singapore. TRAFFIC Southeast Asia. Petaling Jaya, Selangor, Malaysia. Pp. 95–102.

Champion, H. & Seth, S. (1968). *A revised study of the forest types of India*. Government of India Press, New Delhi, India.

d'Aulaire, E., & d'Aulaire, P. O. (1983). Pangolins are all the rage. *International Wildlife, 13*, 14–16.

Heath, M. (1995). Manis crassicaudata. Mammalian Species, 513, 1–4.

Hutton, A. F. (1949). Notes on the Indian pangolin (*Manis crassicaudata*). *Journal of the Bombay Natural History Society, 48*, 805–806.

Irshad, N., Mahmood, T., Hussain, R., & Nadeem, M. S. (2015). Distribution, abundance and diet of the Indian pangolin (*Manis crassicaudata*). *Animal Biology, 65*, 57–71.

Karawita, H., Perera, P., Dayawansa, N. & Dias, S. (2020). Dietary composition and foraging habitats of the Indian pangolin (*Manis crassicaudata*) in a tropical lowland forest-associated landscape in southwest Sri Lanka. *Global Ecology and Conservation, 21*, e00880.

Karawita, H., Perera, P., Gunawardane, P. & Dayawansa, N. (2018) Habitat preference and den characterization of Indian pangolin (*Manis crassicaudata*) in a tropical lowland forested landscape of southwest Sri Lanka. *PloS one, 13*(11), e0206082.

Mahmood, T., Challender, D., Khatiwada, A., Andleeb, S., Perera, P., Trageser, S., Ghose, A. & Mohapatra, R. (2019) *Manis crassicaudata*. The IUCN Red List of Threatened Species 2019:e.T12761A123583998. http://dx.doi.org/https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T12761A123583998.en

Mahmood, T., Irshad, N., & Hussain, R. (2014). Habitat preference and population estimates of Indian pangolin (*Manis crassicaudata*) in District Chakwal of Potohar Plateau Pakistan. *Russian Journal of Ecology, 45*(1), 70–75.

Mahmood, T., Jabeen, K., Hussain, I., & Kayani, A. R. (2013). Plant species association, burrow characteristics and the diet of the Indian pangolin, *Manis crassicaudata*, in the Potohar plateau Pakistan. *Pakistan Journal of Zoology, 45*(6), 1533–1539.

Mahmood, T., Mohapatra, R. K., Perera, P., Irshad, N., Akrim, F., Andleeb, S., Waseem, M., Sharma, S., & Panda, S. (2020). Indian pangolin *Manis crassicaudata* (Geoffroy, 1803). In D. W. S. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins* (pp. 71–88). Academic Press.

Meena, R.L. & Kumar, S. (2012). *Management plan for Gir protected areas*. Vol. 1; Gujarat Forest Department, Gujarat, India.

Mehta, D., Soni, V. C., & Sankar, K. (2013). Food habits of Nilgai (*Boselaphus tragocamelus*) as determined by pellet analysis in a human dominated landscape, Western Gujarat, India. *Scientific Transactions in Environment and Technovation, 7*(1), 7–13.

Mohapatra, R. K., & Panda, S. (2014). Husbandry, behaviour and conservation breeding of Indian pangolin. *Folia Zoologica, 63*(2), 73–80.

Pattnaik, A. K. (2008). Enclosure design and enrichment key to the successful conservation breeding of Indian pangolin (*Manis crassicaudata*) in captivity. *Indian Zoo Year Book, 5*, 91–102.

Phillips, W. W. A. (1928). A note on the habits of the Indian pangolin (*Manis crassicaudata*). *Spolia Zeylanica, 14*, 333–337.

Prater, S.H. (1971). *The book of Indian mammals*. Bombay Natural History Society. India.

Qureshi, Q. & Shah, N. (2004). Vegetation and habitat monitoring: In: Y.V. Jhala (Ed.) *Monitoring of Gir*. Technical report. Wildlife Institute of India, Dehra Dun. pp 8–14.

Rathore, N. S. & Bhattacharyya, A. S. (2004). *termite (Insecta: Isoptera) Fauna of Gujarat and Rajasthan - Present State of Knowledge*. Records of the Zoological survey of India. Occasional Paper No. 223. Zoological Survey of India. Kolkata, India. p. 77.

Roberts, T.J. (1977). *The Mammals of Pakistan*. Ernest Benn, London, UK.

Roonwal, M.L. & Chhotani, O.B. (1989). *The fauna of India and the adjacent countries. Isoptera (Termites) Volume 1 (Introduction and Families Termopsidae, Hodotermitidae, Kalotermitidae, Rhinotermitidae, Stylotermitidae and Indotermitidae)*. Zoological Survey of India. Kolkata, India. pp 672.

Singh, A.P., Nala, R.R., Mehta, D., Sukhadiya, D., Rushi, A., Fulvadia, A., Vala, K. & Ram, A. (2017). *Proceedings of the Workshop on Review and Update of Floral and Faunal diversity of Gir*. Report by the Field Learning Centre, BCRLIP-Gir. Sasan Gir.

Tak, N. (2008). *Ants (Formicidae) of Rajasthan*. Records of the Zoological survey of India. Occasional Paper No 288. Zoological Survey of India. Kolkata, India. pp 54.

Yang, C. W., Chen, S., Chang, C. Y., Lin, M. F., Block, E., Lorentsen, R., Chin, J. S. C., & Dierenfeld, E. S. (2007). History and dietary husbandry of pangolins in captivity. *Zoo Biology, 26*, 223–230.

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