<u>**Research Article**</u>

Distribution of Chinese pangolin (*Manis pentadactyla*) in Nagarjun forest of Shivapuri Nagarjun National Park, Nepal

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Abstract

The Chinese pangolin (*Manis pentadactyla*) is one of the world's critically endangered species, and its distribution is little known in Nepal. This study aimed at understanding the distribution of Chinese pangolin in Nagarjun forest of Shivapuri-Nagarjun National Park, Nepal from September 2017 to May 2018. A total of 15 infrared cameras were used, these were installed randomly in the forest. Only three cameras at three different locations were able to capture photographs of Chinese pangolin. Altogether, three events, comprising 21 still photos of pangolin, their sign and other mammal species in the area were recorded. In addition, 94 pangolin burrows were noticed in the study area. The distribution of Chinese pangolin is influenced by the food, tree canopy and aspect of the area. Majority of the active burrows were found near to feeding burrows where ants and termite's nest were found abundantly. In addition to Chinese pangolin, the study was able to capture twelve mammalian species including masked palm civet (*Paguma larvata*) and yellow-throated marten (*Martes flavigula*). These two species were often seen to enter or try to enter the active burrows of pangolins. The results suggest that Nagarjun Forest serves an important role in mammal conservation with high mammalian biodiversity.

Keywords: Burrows, Camera traps, Critically endangered, Mammals

1 | Introduction

Pangolins (*Manis* spp.) are Evolutionarily Distinct and Globally Endangered (EDGE) mammals constituting the order Pholidota (Gaubert & Antunes 2005). Often called "scaly anteater", pangolins possess scale-covered bodies and feed on ants and termites (Thomas and Lydekker 1911). They are nocturnal, shy, non- aggressive, solitary and elusive burrowing mammals (Wilson 1994) which have received little scientific attention till date (Pantel & Chin 2009, Challender & Waterman 2017). Pangolins roll into a ball as a defense such that all soft tissues are hidden or protected by scales (Heath & Vanderlip 1988). They play an important role in controlling ant and termite populations in natural ecosystems (Wu et al. 2004). Eight extant species of pangolins are recognized (Gaudin et al. 2009), with four species distributed in the Afro-tropics and four species in the Indo-Malayan regions of Asia. All species are listed as threatened on the International Union for Conservation of Nature Red List (IUCN 2019). Currently, all the species are under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2019).

Nepal supports the occurrence of two pangolins species, Chinese pangolin (*Manis pentadactyla*) and Indian pangolin (*M. crassicaudata*) (Gurung et al. 1996, Baral & Shah 2008, Jnawali et al. 2011, Suwal 2011, Bhandari & Chalise 2014, Thapa et al. 2014, Sharma 2017, Katuwal et al. 2017, DNPWC & DoF 2018, Khatiwada 2020, Sharma et al. 2020a, b, c, d, Suwal et al. 2020). Globally, the species is reported up to 3000 m of elevation (Challender et al. 2019), however in Nepal the species is found up to 2406 m of elevation (Thapa et al. 2014). Chinese pangolin is reported from 25 districts of Nepal (DNPWC & DoF 2018). Chinese pangolins are found in a wide range of habitats, including

primary and secondary tropical forests, limestone forests, bamboo forests, broad-leaf and coniferous forests, grasslands and agricultural fields in both protected and non-protected areas (Gurung 1996, Chao 2001, Katuwal et al. 2017, Sharma et al. 2020a, Suwal et al. 2020). Their occurrences in these wider habitats are influenced by different covariates, such as forest, canopy cover, soil type, aspect, ground vegetation, water, and anthropogenic factors such as poaching, human settlements and agricultural land (Gurung et al. 1996, Baral & Shah 2008, Jnawali et al. 2011, Suwal 2011, Bhandari & Chalise 2014, Sharma 2017, Khatiwada 2020, Sharma et al. 2020a, b, c, d, Suwal et al. 2020). This species generally digs their own burrows and sometimes enlarge passages made by termites (Heath & Vanderlip 1988). They used these burrows for termites foraging and to sleep (Newton 2008). The home range size of the species is assumed

less than 1 km^2 (Heath & Vanderlip 1988) although the concrete data is lacking. Chinese pangolin's ecology and their behavior is little known in Nepal (Gurung 1996, Bhandari & Chalise 2014), however people's knowledge on the species role in an ecosystem indicated some of the information on their ecological role (Sharma et al. 2020c). Due to illegal trade and habitat destruction (Katuwal et al. 2017, Sharma 2017, Ghimire et al. 2020, Sharma et al. 2020d), the population of the Chinese pangolin is decreasing at an alarming rate (Challender et al. 2019). Even though Chinese pangolin is critically endangered species, its current spatial distribution in some of the areas of Nepal is little known. It may create problem to develop site- and species-specific management plan. Therefore, we aimed to explore the distribution of Chinese pangolin in Nagarjun forest near by Kathmandu city using infrared cameras.
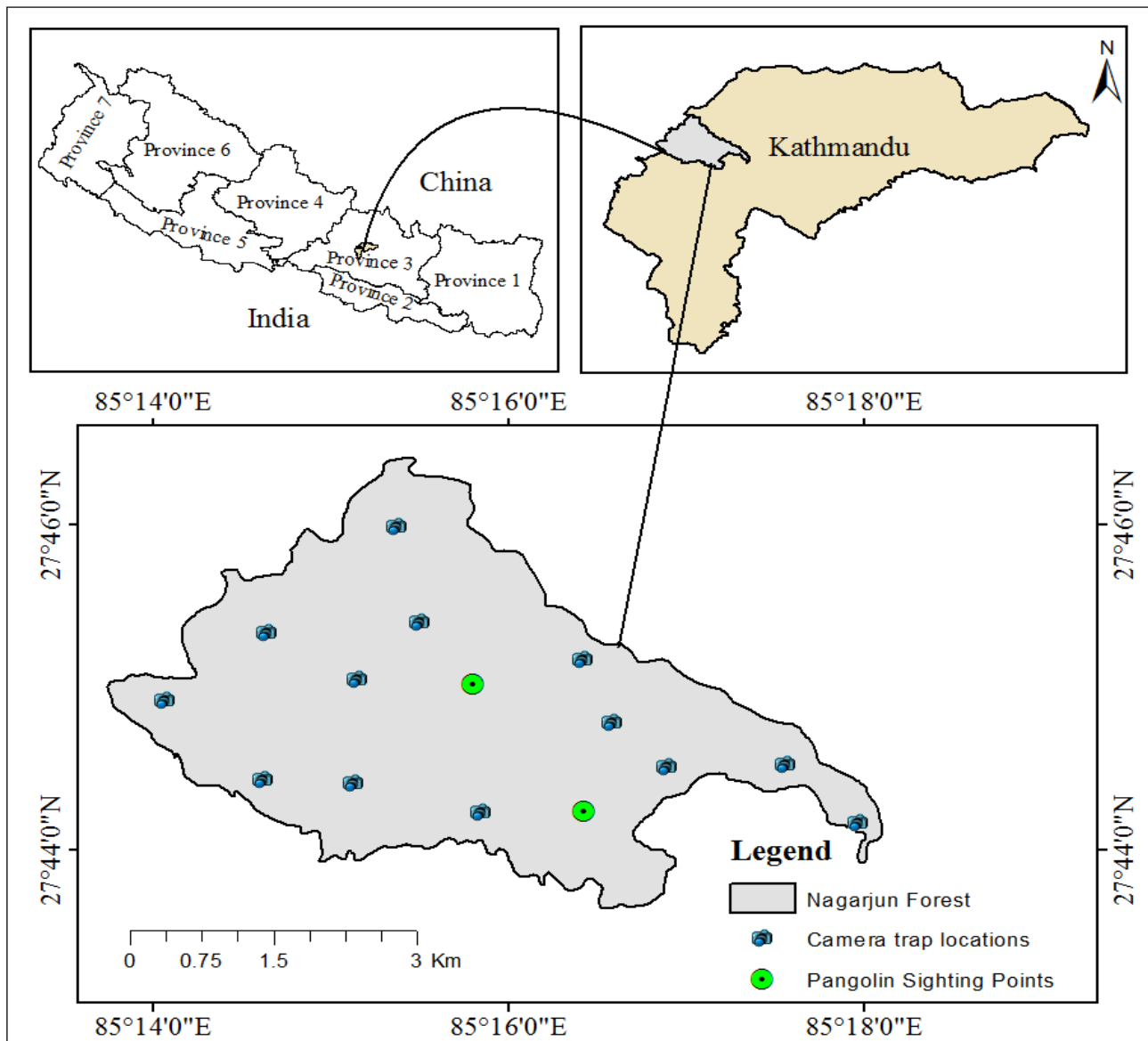

Figure 1. Map of the Nagarjun forest of SNNP showing camera trap locations

2 | Materials and methods

2.1 | Study area

The study was focused in Nagarjun forest, a part of the Shivapuri-Nagarjun National Park (SNNP) (27°43'37.13" to 27°46'22.84" N and 85°13' 2.97" to 85°18'14.38" E). Nagarjun forest covers an area of about 15 km^2 of Shivapuri-Nagarjun National Park (DNPWC 2019) between the elevation of 1350 m to 2100 m asl (Fig. 1). Nagarjun forest supports a mid-hill forest ecosystem and has a sub- tropical climate grading to temperate climate (SNNP 2017).

2.2 | Data collection

A preliminary study was carried out from 5-6 August 2017 to conceptualize the conditions of the forest before starting research. During survey, potential sites of pangolin were identified while walking around the forest with National Park staff. Different types of burrows belonging to pangolin were recorded throughout the study site along elevational gradients by opportunistic sampling method between November and December 2017. Number of active burrows, feeding burrows and passive burrows were counted. The burrows that were less deep visually with small opening hole were classified as feeding burrows (Mahmood et al. 2013). Likewise, the burrows that had leaves, spider webs, dry and compact soils were considered to be passive burrow and the burrow that had fresh, loose soil and fresh scratched marks were taken as active burrows (Suwal 2011, Katuwal et al. 2017, Sharma 2017, Sharma et al. 2020b). A square plot of 10 m × 10 m was established keeping burrow at the centre of the plot for collecting information on habitat covariates. The habitat covariates including elevation, aspect, canopy cover (%) and presence/absence of food source (number of ant nests/termite mounds) were also noted to determine the habitat preference of the species. The latitude and longitude, elevation and aspect of burrows were recorded by using GPS Garmin Etrex 30 and android app clinometer-bubble, respectively. Visual estimation was done for the canopy cover and ground cover keeping burrows at centre of the plot. A total of 15 infrared cameras were set in site with reference to fresh/active burrows used by pangolins following the method of Marler (2016). Cameras were set near active pangolin burrow around 1-2 feet above the ground depending on the slope of the land and were set at least 500 m apart from each (Fig. 1). Camera trapping was carried out from September 2017 to May 2018 at elevations between 1350 m asl

and 2100 m asl. Two types of Bushnell Trophy Camera were used: Model #119537C and Model #119405C. These cameras were set with one-second trigger time between trigger events to take photographs of Chinese pangolin. The cameras functioned for 24-hours each day, and used infrared Light Emitting Diode to capture night images. Data and images collected by the cameras were downloaded at interval of 15 days, and the status of camera, battery and memory card were also checked.

3 | Results

A total of 94 burrows were recorded in Nagarjun forest of Shivapuri-Nagarjun National Park, of which 10 were active burrows, 62 passive burrows and 22 feeding burrows. The feeding burrows were recorded near to living burrows with ants' nests and termite molds. Most burrows (41.48%) were distributed in East aspect and few (6.38%) were found in South East aspect. Most of the burrows (69.14%) were distributed in dense forested area having canopy cover between 25% - 50%. Majority of the burrows (79.78%) were distributed between the elevational ranges of 1400 – 1600 m asl. Burrows were not observed at elevations between 1600-1700 m asl and 1800-1900 m asl, and few burrows were found between 1700 – 1800 m asl (4.2%) and 2000 – 2100 m asl (15.93%). A total of three events consisting of 21 photographs were recorded throughout the study period. Even though cameras were set in September 2017, the first photograph of pangolin capture was recorded on 27 December 2017 at 20:06 at elevation of 1400 m asl (Supplementary Fig. 1, Photograph 1). A second event of pangolin was captured on December 31, 2017 at 01:55 at elevation of 1900 m asl (Supplementary Fig. 1, Photograph 2). In this event, three images of a pangolin crossing the trail were captured. During January, a rapid growth in numbers of fresh feeding burrows around the site of installed cameras was observed over the course of two week (Supplementary Fig. 1, Photograph 3). Following the appearance of new fresh burrows, the final event of the pangolin's camera capture of this study was recorded on 27 February 2018. On that day, 12 photos were recorded. During the study period (September 2017 to May 2018), twelve mammalian species other than Chinese pangolin were recorded by camera traps. The recorded mammalian species were Assamese macaque (*Macaca assamensis*), barking deer (*Muntiacus vaginalis*), crested porcupine (*Hystrix indica*), masked palm civet (*Paguma larvata*), Leopard cat (*Prionailurus bengalensis*), sambar deer (*Rusa*

unicolor), leopard (*Panthera pardus*), orange-bellied Himalayan squirrel (*Dremomys lokriah*), yellow-throated marten (*Martes flavigula*), jungle cat (*Felis chaus*), large Indian civet (*Vivera zibetha*) and wild boar (*Sus* sp.) (Supplementary Fig. 1, Photograph 4-15).

4 | Discussion

The burrows of Chinese pangolin in Nagarjun forest of Shivapuri-Nagarjun National Park are randomly distributed along elevational gradients. Termite abundance and its colony size might be the possible factors to determine the number of pangolins, as observed in *Manis temminckii* by Swart et al. (1999). The distribution of ants and termites were also found to be random with respect to aspect in the study areas and so were the burrows. The preference of Chinese pangolin for burrow construction towards east and south aspects (Gurung 1996, Acharya 2001, Wu et al. 2003, Wu et al. 2004) might be for providing direct light penetration to the burrows potentially for maintaining the temperature during the winter season. However, more study is needed for year-round including summer season to confirm their preferences. In addition, the occurrence of Chinese pangolin in this area might also be influenced from the people's movement for pilgrim visit. Generally, their detection probability is low in human dominated landscape (non-protected area) than low human influenced area (protected area) (Sharma et al. 2020b).

The occurrence of Chinese pangolin was found under the moderate dense canopy cover (25% - 50%) probably for getting more termites and ants, and easier to construct burrows due to less litter fall on the ground. Our finding corroborates with other findings of Bhandari and Chalise (2014), Dorji et al. (2016), Katuwal et al. (2017) and Sharma et al. (2020b). The higher density of termites and other prey species occur in drier areas under the canopy cover <50%, and potentially it prevents the excessive soil erosion (Hemachandra et al. 2014, Katuwal et al. 2017).

The higher abundance of burrows between the elevational range of 1400 m asl – 1600 m asl indicated the most preferred habitat of Chinese pangolin in the study area, however, our study has limited cameras to capture the evidences. At higher elevation, i.e. between 1800 m asl – 2000 m asl, the least number of burrows are recorded, which might be because of less suitable habitat having sloppy or stiff areas or the continuous flow of people to reach Jamacho Tower (a pilgrimage spot).

Chinese pangolin co-occurs with several other mammalian species in study area. Captured photographs and videos revealed that there might be some association between the pangolin and Masked palm civet and Yellow-throated marten, which were seen entering or try to enter the burrows of pangolins. It is possible that there is some prey-predator relationship existing between these three mammals, or these species may depend on pangolins burrows for foraging or dinning. Thus, further study of the pangolin may also contribute to the conservation of other mammalian species in the study area.

5 | Conclusions

Chinese pangolins were distributed randomly in Nagarjun forest of Shivapuri Nagarjun National Park and are hard to capture in infrared camera. Their distribution is influenced by various factors like elevation, aspect, trees' canopy cover and food availability. Feeding burrows were near active burrows in regions where ants and termites were distributed in higher numbers and were away from external disturbances.

6 | Research Implications

This research work has confirmed the presence of critically endangered Chinese pangolin from Nagarjun forest through photographical evidence. Hence, this work can help in the conservation of this species significantly in that area.

Acknowledgements

Authors' contributions

Dhital, S. designed the research, and collected data; Paudel, S. M. worked for camera trapping; Thapa, S. collected data, and wrote the manuscript; Bleisch, W. V. helped in field work and wrote manuscript; Shrestha, A. analyzed the data and wrote the

manuscript; Koju, N. P. supervised research work and wrote the manuscript.

Conflicts of interest

Authors declare no conflict of interest.

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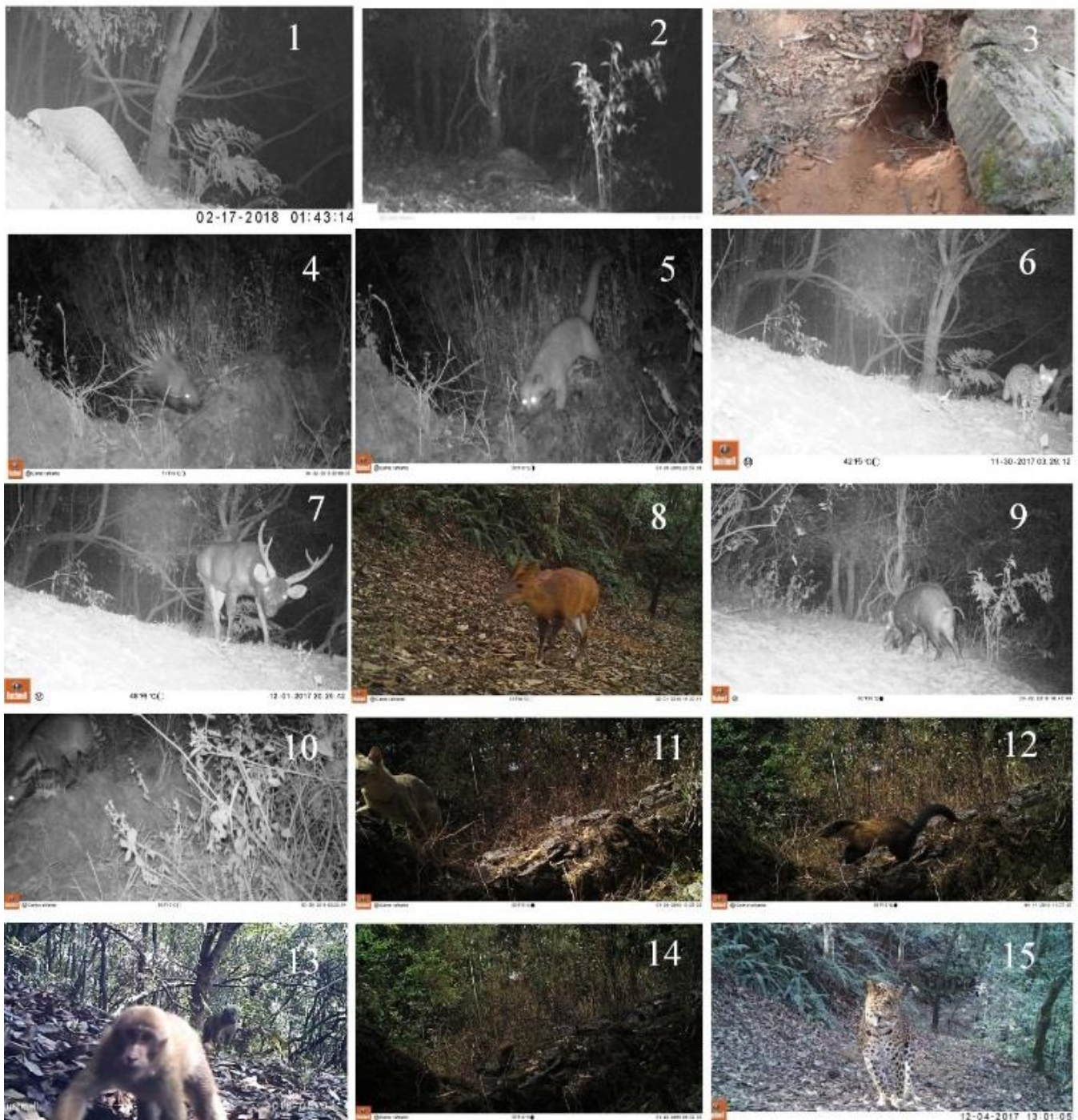Narayan Prasad Koju ⓘD https://orcid.org/0000-0002-4303-0520

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Supplementary Figure 1: Photographs 1-15

Photograph 1: Chinese pangolin captured by camera trap at elevation of 1400 m asl; 2: Chinese pangolin captured by camera trap at an elevation of 1900 m asl; 3: Fresh burrow of Chinese pangolin in Nagarjun forest; 4: Crested porcupine (*Hystrix indica*); 5: Masked palm civet (*Paguma larvata*); 6: Leopard cat (*Prionailurus bengalensis*); 7: Sambar deer (*Rusa unicolor*); 8: Barking deer (*Muntiacus vaginalis*); 9: Wild boar (*Sus* sp); 10: Large indian civet (*Vivera zibetha*); 11: Jungle cat (*Felis chaus*); 12: Yellow-throated marten (*Martes flavigula*); 13: Assamese macaque (*Macaca assamensis*); 14: Orange- bellied Himalayan squirrel (*Dremomys lokriah*); 15: Leopard (*Panthera pardus*).