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HABITAT PREFERENCE AND CURRENT DISTRIBUTION OF CHINESE PANGOLIN (*MANIS PENTADACTYLA* L. 1758) IN DOROKHA DUNGKHAG, SAMTSE, SOUTHERN BHUTAN

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C O M M U N I C A T I O N

Habitat preference and current distribution of Chinese Pangolin (*Manis pentadactyla* L. 1758) in Dorokha Dungkhag, Samtse, southern Bhutan

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Abstract: The Chinese Pangolin (CP), *Manis pentadactyla* L. is one of the two pangolin species recorded in Bhutan. Not many studies, however, were carried out on the species in Bhutan. The present study was carried out to assess the habitat preference and current distribution of CP, *Manis pentadactyla* in Dorokha Dungkhag, Samtse from January to March 2017. Belt transect method consisting of 100 x 100 m each was used to assess the habitat preference and estimate burrow density, coupled with an extensive search of indirect signs of pangolin presence (burrows, scat, footprint, scales, scratches) was utilized to determine the current distribution of the CP. Modelling of habitat was carried out using QGIS and Maxent. A total of 181 burrows were recorded from 48 plots with burrow density of 0.104 per hectare. These were mostly distributed in the habitat dominated by needlework trees (*Schima wallichii*), evergreen broadleaf (*Castanopsis hytrix*) and shrubs (*Viburnum* species). The preferred habitat of the CP was recorded to range from an altitude of 1,300–1,700 m, with highest feeding activities recorded within the periphery of cardamom plantation and adjacent forested area. A higher burrow density was recorded in humid soils, with high termite presence, and in the vicinity of human settlements. Habitat modelling revealed that 23.57km^2 of the study area was highly suitable and 37.88km^2 was a suitable habitat for the species. Similar studies are suggested to be carried out in other parts of Bhutan in different seasons to better understand the species and its distribution in the country.

Keywords: Burrow, *Manis pentadactyla*, density, distribution, modelling, threatened species

INTRODUCTION

The Chinese Pangolin (CP) *Manis pentadactyla* L. is one of the eight species belonging to the order Pholidota, family Manidae, and genus *Manis* (IUCN Pangolin Specialist Group 2020). The word "Manis" is from 'manes' which is Latin for spirit of the dead (Gotch 1979), while "pangolin" is derived from the Malay phrase 'Pen Gulling' meaning "rolling ball" (Pearsall 2002). In Bhutan the pangolin is known as 'Saghu' (in Dzongkha, the national Language) and 'Salak' (in Lhotshamkha, the southern Bhutan dialect), due to its scaly armored body (Wangchuk 2013).

Pangolins are nocturnal, elusive, non-aggressive, solitary, insectivorous, and are known to utilize burrows (Gaubert 2011). Of the four species found in Asia, the CP is found in eastern Asia, northern southeastern Asia and parts of southern Asia (Katuwal et al. 2015; Wu et al. 2020). It is found in Bhutan, Bangladesh, China, Hong Kong, Taiwan, India, Laos, Myanmar, Nepal, Thailand, and Vietnam (Challender et al. 2019). In neighboring India, the CP is reported to occur in northern Bihar, south of the Nepalese border (Muarya et al. 2018), while in the north-east which borders Bhutan, the species has been recorded in Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Tripura, and Mizoram (Zoological Society of India 2002; Srinivasulu & Srinivasulu 2012). The species occupies a number of different habitats including primary and secondary forest, tropical forests, bamboo forest, grassland and agriculture fields (Katuwal et al. 2015). In Bhutan, the CP is mostly found in southern districts such as Samtse, Samdrup Jongkhar, Sarpang, Pemagatshel, and Chukha (Wangchuk et al. 2004).

In recent decades, there has been a notable decline in the population of CP across its range. Its numbers and population are decreasing, primarily due to hunting, poaching, and habitat destruction (Challender et al. 2019). Unsustainable hunting and poaching for international and local use are currently the main threats to the CP (Wu et al. 2020), as pangolins are poached mainly for their scales that are used in traditional medicine and for their meat (Newton et al. 2008). Due to its rampant population decline, it was listed as Critically Endangered (IUCN 2014) and in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2016).

In Bhutan, habitat destruction and illegal poaching had become rampant issues (Wangchuck 2013) which might lead to localized extinction of the CP. As such, a clear understanding of the species habitat ecology, habitat preferences and local distribution pattern is immensely important for any species-specific conservation plan. Most information on the ecology of the CPs, however, is from Taiwan and southern China studies (Wu et al. 2020) and there is no reliable information on CP in Bhutan, despite their paramount ecological roles (Fairhead et al. 2003; Challender et al. 2014) in the ecosystems. This could have severe implications on the conservation of the Critically Endangered CP. Therefore, the results of this study will contribute to the scientific information about the habitat preferences and also the current distribution of CP in the southwestern part of Bhutan for better conservation measures in the near future.

METHODS

Study area

The study was conducted in Dorokha Dungkhag block (27.07–26.95˚N & 89.09–89.30˚E) which spans an area of 256.4km² under the Samtse District in southwestern Bhutan (Figure 1). The Dungkhag consists of three blocks (geog), namely, Dophuchen, Dumtoed, and Denchukha, with the altitude ranging from 1,000–2,500 m, with daily temperature between 12–15°C in winter to 26–32°C in summer. The climatic condition is hot and wet in summer, and cold and dry in winter with mean annual rainfall ranging from 1,200 to 3,000 mm. The study area is mostly covered by Himalayan subtropical broad-leaf forest and few shrub species. The broadleaved forests are mostly dominated by needlework trees (*Schima wallichii*), evergreen broadleaf (*Castanopsis hytrix),* *Beischmiedia roxburghian*, and shrubs like *Viburnum* sp., while the agricultural landscape consists of cardamon (*Amomum subulatum)* plantations. For this study, the vegetation was classified as cool broadleaved forest (CBL), which is found on moist exposed slopes, and along the foothills, and warm broadleaved forest (WBL) which is found higher up, extending to 2,000m.

Field data collection

A preliminary survey was carried out to assess the current status of CP in the study area and to identify the potential sites where the CP could occur. The survey was conducted after discussion with the Dorokha Forest Range staff, local community and community forest members from the three geogs to ascertain and validate the presence of CP. Based on the information obtained, an extensive survey of 90 days was carried out from 01 January 2017 to 30 March 2017 in the identified areas to determine the presence/absence of the species and to know the general distribution of the CP in the study area.
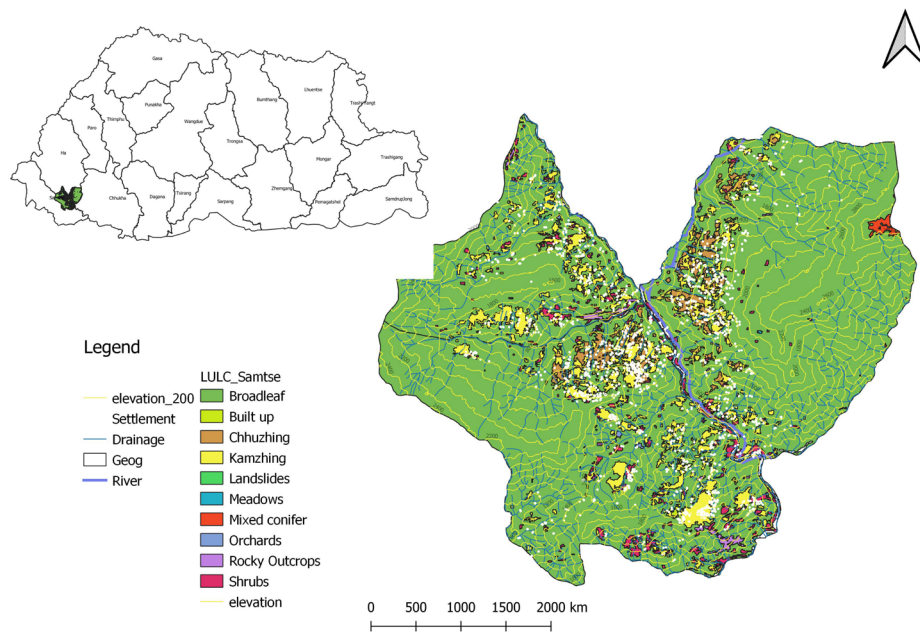
Figure 1. Study area, Dorokha Dungkhag.
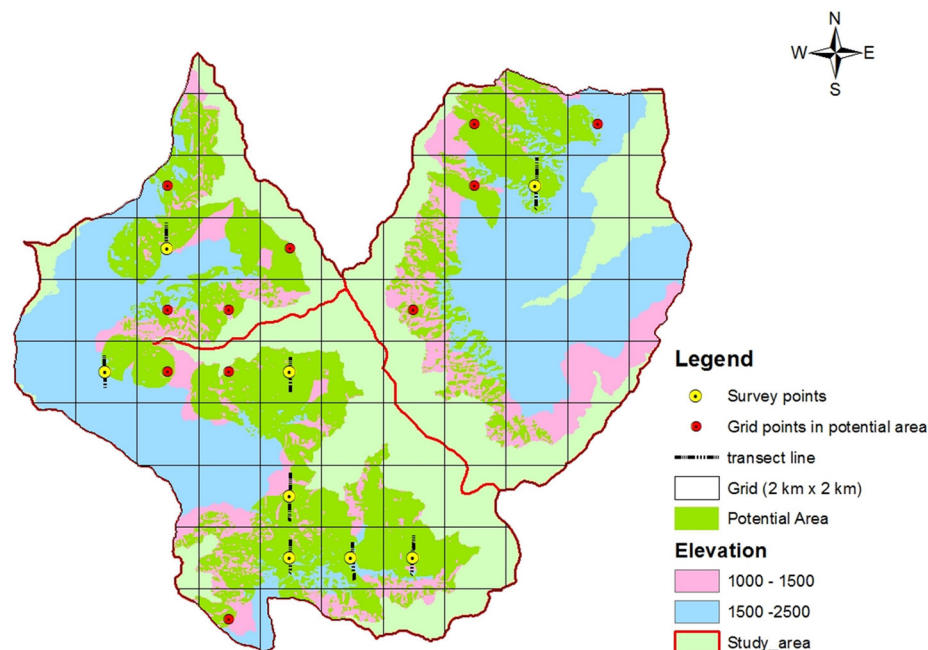
Figure 2. Distribution of transects plots used for the study.

Field sightings and records of indirect signs were used to investigate the current distribution of CP in the study area (Mahmood & Hussain 2014). The whole Dorokha Dungkhag area was searched for direct sighting and indirect signs (burrow, footprint, scales, scat) of CP, and coordinates using the global positioning system (GPS) was recorded wherever the indirect and direct sightings of the species were observed. The QGIS software (version 2.18.20) was then used to generate a

map illustrating the current distribution pattern of the CP in Dorokha Dungkhag.

We adopted the belt transect method for investigating CP habitat preference and burrow density (Rogor 1991). This method is usually used for low density, rare and elusive animals. A total of eight transects with a plot of 100m x 100m size was laid out at every 100m with a total of six plots per transect (Figure 2). Habitat parameters such as altitude, ground and canopy cover, dominant

species, soil type, nearest distance from water body, road, settlements were recorded (Chalise & Bhandari 2014). Indirect signs like burrows, scats, footprints, scales and scratches in each plot were also recorded to assess the habitat preference and burrow density.

The burrows were classified into two different types, namely living burrows which are much deeper in depth than feeding burrows and feeding burrow (less than 1m depth with presence of ants and termite colonies). A living burrow is categorized as active if any indirect signs of the species such as footprints, scale prints or presence of faecal samples are recorded around that particular burrow (Mahmood et al. 2014). Feeding burrows were further classified into new burrows (recently active) and old burrows (more than one year old) (Chalise & Bhandari 2014). The burrow density was estimated by counting the number of active living burrows in all the plots in a transect according to Irshad et al. (2015).

The habitat preference in different habitat parameters namely canopy and ground cover, elevation, slope, aspect, soil type, distance from water bodies and settlements were assessed using the Statistical Package for Social Science (SPSS) version 23 and Microsoft Excel. A non-parametric Kruskal-wallis test was performed to compare the relationship between the habitat parameters and numbers of CP evidences. Spearman rho correlation was conducted between number of CP burrow with slope, elevation, crown, and ground cover to evaluate their association. The burrow density (D) was estimated at eight selected sampling sites by counting active living burrows following Begon (1979).

We used MaxEnt (version 3.3.3k) for estimating the probability distribution of the CP in the area and for predicting potential suitable habitat for the species (Jennings & Vern 2011; Wilting et al. 2010). Indirect active signs and direct sightings of the CP were used as presence points and we took eight related environmental variables (elevation, aspect, slope, settlement, drainage, landuse, temperature, precipitation) to estimate the probability distribution for its occurrence. Maxent models help to assess the importance of each environmental variable on a species distribution and the mean value generated by the model is used for the whole targeted area (Elith et al. 2011; Phillips et al. 2006).

All the spatial layers were processed using QGIS software (version 2.18.20). We converted all the layers (raster format) into ASCII format with a standard cell size of 30 m based on the resolution of the Digital Elevation Model (DEM) and occurrence record in comma separated value (.csv) format which was then imported to the Maxent software.

Model performance was assessed by using the training and test data for the area under the curve (AUC) of the receiver-operating characteristic (ROC) plot. The data were jackknifed by the inbuilt model's feature for evaluating each environmental variable's influence on the predicted suitable habitat distribution of CP. The percent contribution of each variable was calculated on the basis of how much the variable contributed to an increase in the regularized model gain as averaged over each model run. The habitat suitability for wildlife then was classified based on the logistic threshold value of maximum of test sensitivity and specificity (Jiménez & Lobo 2007) with area above the logistic threshold of maximum test sensitivity and specificity classified as being suitable habitat.

RESULTS AND DISCUSSION

General information on burrow characteristics

A total of 181 burrows and two direct sightings of the CP was reported during the sampling period of three months (Table 1).

Habitat preference of the CP

Among 181 burrows and two direct sightings observed from three different habitat types—agricultural land (AL), WBL, and CBL. The highest number of burrows (n = 87) was observed from AL. One-way ANOVA showed significant difference in the numbers of CP evidence recorded in different habitats (Kruskal-Wallis chi-squared H (3) 6.537, p .038). The presence of more burrows in the AL could be due to the availability of prey (ants and termites inside burrow) which was comparatively higher in AL (cardamom cultivation area) as compared to other habitat types during the field survey. Similarly, Wangchuk (2013) observed more pangolin evidence in cardamom area in Tendruk and Norgaygang block in Samtse.

Generally, pangolins are found in a wide range of habitats including primary and secondary tropical forests, limestone forests, bamboo forests, broadleaf and coniferous forests, grasslands and agricultural fields (Gurung et al. 1996; Azhar et al. 2013; Katuwal et al. 2015). In China, Wu et al. (2003) reported that CP preferred broad-leaved forest dominated by *Schima superba, Machilus chinensis* and undergrowth with good shelter mainly comprised of *Woodwardia japónica, Blechnum orientale, Dicranopteris dichotoma* while in Nepal, pangolins are found in forest patches and agricultural land near human dominated landscapes

Table 1. Number of burrow types and size recorded.

Types of burrow	Burrow condition	No. of burrow recorded	Burrow size	
			Circumference (cm)	Depth (cm)
FD	Old	66	69.3 ± 5.7	62.8 ± 28.4
FD	New	95	69.8 ± 7.1	66.1 ± 30.1
LB	Active	05	73.8 ± 4.6	
LB	inactive	15	69.2 ± 8.7	252.6 ± 23.8

FD—Feeding burrow | LB—Living burrow (The depth of active living burrow was not measured).

(CITES 2016), with mixed forest containing various tree species dominated by *Shorea robusta*, *Schima wallichii*, *Castanopsis indica*, and *Alnus nepalensis* as the main habitat type which recorded majority of the pangolin burrows (74%) (Suwal et al. 2020).

In this study, relationship between canopy cover and burrow counts were analyzed to determine the influence of canopy cover over the number of burrows in an area. Results revealed that in WBL within canopy cover ranging from 26–50 %, burrows were high (*n* = 50), and only one burrow recorded within the within canopy cover of 51–75 %. While in CBL, 44 burrows were within canopy cover of 26–50%, and only one burrow within canopy cover of 51–75 %. As such, burrows were high (*n* = 94) within the canopy cover ranging from 26–50 %; and low (*n* = 2 burrow) within the canopy cover of 51–75 %. A negative correlation between the canopy cover and the number of pangolin burrow was shown, (*r* (48) = -.310, *p* = 0.016), indicating that burrows increase when crown cover decreases and vice-versa (*R2* = 0.33). The reason could be because more tree stumps and some dead trees were found in the open canopy cover that provides a good nesting area for termites during field survey. Similar results were reported by Bhandari & Chalise (2014) which could be due to the presence of their prey i.e. termites in open spaces. A study conducted by Hemachandra et al. (2014) also revealed that termites' occurrence was highest in dry than wet areas.

As for ground cover, the number of burrow count were high (*n* = 100) within the ground cover of 76–100 % and low (*n* = 8) within the ground cover 0–25%. Spearman's correlation shows positive relationship of burrow counts to ground cover *r* (48) = .241, *p* = .050, indicating that the increase in burrows with increase in ground cover and vice-versa. This suggests that the CP tend to avoid open ground and preferred dense ground cover layer for locomotion and feeding in order to avoid. Wu et al. (2003) also reported that CP used dense ground cover for protection of their burrow entrance

while Suwal et al. (2020) inferred that pangolins prefer areas with medium canopy cover (50-75%).

For elevation, evidence of CP was recorded between 1,026–2,100 m. The highest record of CP occurrence in the entire study area was recorded at elevation of 2100m. Within this elevation range, results showed that CP preferred elevation of μ = 1533m and SD = 267m. The number of CP burrow to elevation showed a negative relationship, (*r* (48) -.585, *p* 0.001), indicating that the species prefers lower altitude but are mostly in mid elevation during winter. Similar results were also reported in Nepal by Bhandari & Chalise (2014). This could be due to the decrease in the diversity of termites with increase in the elevation as reported by Hemachandra et al. (2014).

Slope utilization by CP were observed between 5–65 % (with μ = 34.56%, SD = 12.87%) slope with preference for gentle slopes. The Spearman's rho correlation showed strong negative association between slope and the number of occurrences of CP burrows (*r* = -.551, *p* = 0.001). In WBL, slope range of 25–45 % were the most preferred with 61 burrows recorded. Similarly, with CBL and AL, slope gradient of 25–45 % recorded highest number of burrows (n = 45, n = 27) respectively. In China, Wu et al. (2004) reported that the CP burrows were mostly recorded at slope between 30–60 % while Suwal et al. (2020) reported that pangolins were more observed between 30–50 % slope in Nepal. In the study area, it should be noted that soft clayey loam soil was dominant in the slope gradient from 24–45 % which may facilitate digging of burrows.

Additionally, a higher number of burrows were observed in the northeast aspect (*n* = 64) followed by northwest (*n* = 63) while minimum burrows were encountered in southwest (*n* = 4). There were, however, no burrows encountered in south and west aspect in both the forest types (Figure 3). Kruskal-Wallis test showed that a significant difference between the mean numbers of burrow and the aspect, (*H* (7) = 15.64, *p* = .016) with a mean rank score highest in northwest with 30.62
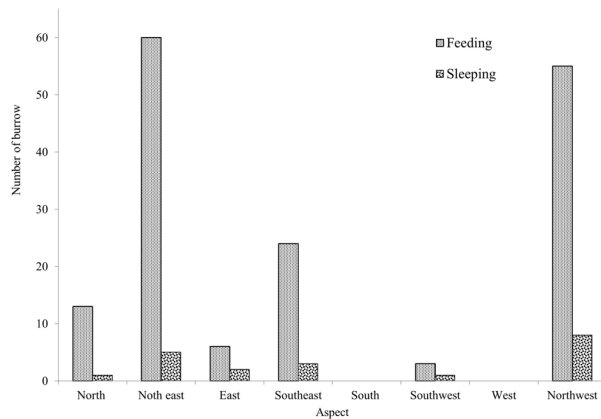
Figure 3. Number of pangolin burrows in different aspect.

Figure 4. Life form of tree layer.

Figure 5. Life forms of shrub layer.

and minimum mean rank score of 6 in the west. Most pangolin burrows encountered in the present study site were from the northeast and northwest. Similarly, this finding is in agreement with Bhandari & Chalise (2014), who reported that pangolin burrows were mostly found in northwest aspect in the Nagarjun Forest, Shivapuri Nagarjun National Park in Nepal. Also, according to Wu et al. (2004), the pangolin burrow entrance often faces the sun, probably to maintain the burrow temperature in winter.

For soil type, the highest number of burrows were in the clay loam soil (*n* = 78), followed by sandy loam (*n* = 53) and the least in the silty loam (*n* = 7). No burrows were recorded in sandy and loamy soils. This could be due to the presence of more termites in clay loam and sandy loam soil in the study area. The clay loam and sandy loam soils form soft layers, which may be generally preferred by the Chinese Pangolin due to the ease of burrowing in the soil as Wu et al. (2004) noted
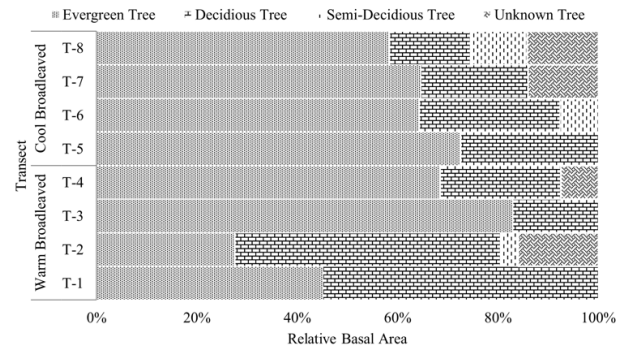
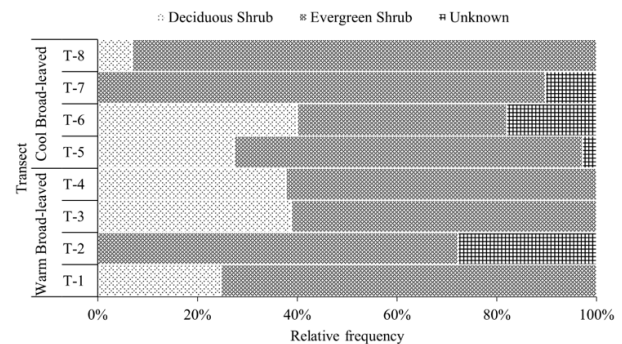that the species mainly prefer soil that is moist, rich and of a certain soft layer thickness to dig burrows.

As for vegetation, a total of 24 families and 42 tree species were recorded from 48 plots. Trees were classified into three major forms namely evergreen (22 species), deciduous (13 species), semi-deciduous tree (one species) and unidentified (five species). Vegetation in the potential sites of CP consisted of 60%

Table 2. Dominant and co-dominant tree species in the study area.

Species	Relative density	Relative dominance	Relative frequency	IVI
Schima wallichii	26.04	11.03	31.09	68.16
Castanopsis hytrix	17.08	16.14	21.72	54.94
Viburnum sp. (Asaray)	10.42	3.65	14.98	29.05
Beischmiedia roxburghiana	5.63	13.62	7.49	26.73
Nyssa javanica	5.21	12.43	7.49	25.13
Engelhardtia spicata	11.46	6.66	3.00	21.11
Acer thomsonii	6.04	5.21	8.24	19.49
Macaranga denticulata	9.17	7.04	1.50	17.70
Cinnamomum bejolghota	2.92	10.69	0.37	13.99
Euaria aquaminita	3.54	8.87	1.50	13.91
Caeserea glomerita	2.50	4.96	2.62	10.09
Mean	9.09 ± 6.79	9.12 ± 3.80	9.09 ± 9.31	27.3 ± 17.28
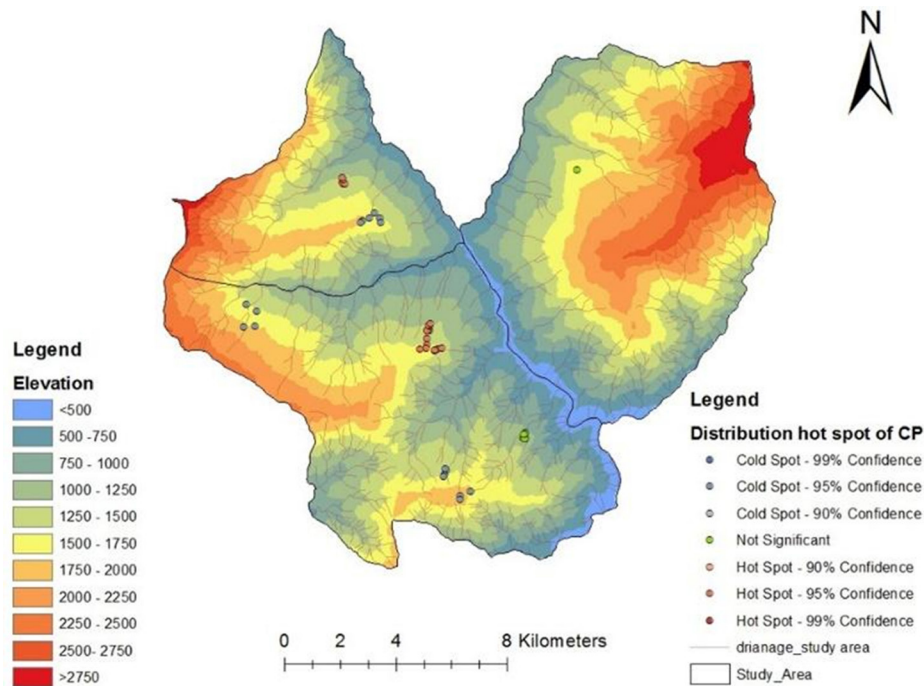
evergreen, 30.1% deciduous, 1.4% semi-deciduous and 6.4% unidentified tree species (Figure 4). Overall, the most dominant tree species recorded with maximum Importance Value Index (IVI) was *Schima wallichii* (IVI = 68.16) followed by *Castanopsis hytrix* (IVI = 54.94) and *Viburnum* species (IVI = 29.05), while least for *Cinnamomum bejolghota* (IVI= 13.99) (Table 2).

(Note: IVI determined Species dominance encountered in the study area. Higher the IVI, more dominant tree species in the area)

A total of 18 species from 14 families of shrubs were recorded and categorized into three forms namely deciduous shrub (nine species), evergreen (12 species) and unidentified shrubs (six species). Two dominant species (*Maesa chisia* and *Edgeworthia gardneri)* were recorded from WBL and *Daphne bholua* and *Daphne sureli* from CBL. *Maesa chisia* was the common dominant species in both forests. Furthermore, both forests were dominated by evergreen shrub species (Figure 5). Shanon-Wiener diversity index (H') for the CBL, where burrows were recorded showed the highest tree diversity (H'= 2.36) as compared to WBL (H'= 2.14). Similarly, shrub diversity was high (H'= 2.23) in CBL as compared to WBL (H'= 1.80). Species richness (SR = 7) for trees species and (SR = 31) for shrub species were observed comparatively lesser in broad-leaved forest, (SR = 8 for species in and SR = 29 for shrub species) than warm-tree cool broad-leaved forest.

Burrow Density of CP

Eight sampling sites were utilized to estimate burrow density of CP where only active living/sleeping burrows were considered (Begon 1979). Permanent plots in the belt transect were recorded repetitively after 30 days for three months from January 2017 to March 2017. A total area of 48,000 m² from a 48 sample plots were surveyed and recorded only five active living burrows. As such, overall burrow density of the study area was found to be 0.104 signs per hectare which is lower than Bhandari & Chalise (2014) with 0.833 signs per hectare in the Nagarjun Forest, Shivapuri Nagarjun National Park in Nepal. This could be as only active living burrows were recorded in this study.

Current distribution of the CP

Extensive search of indirect signs and direct sightings of CP along the eight transects-was then used to assess the distribution of the species in the three blocks under Dorokha Sub-District. All blocks recorded the presence of CP. In the Dophuchen block, CP signs were recorded from Dagap, Manidara, Basentey, Satakha, Laptsegaon, Sengdhen, Wangchuk, Jigme, Mithin, and Mithun Top villages, while in the Dumtoed block, the species' signs were sparse, being only in a few localities in Daragaon, Gairegaon, Khalinggaon, and Kuchey villages. The presence of CP, however, were observed only from Relukha village in the Denchukha block.

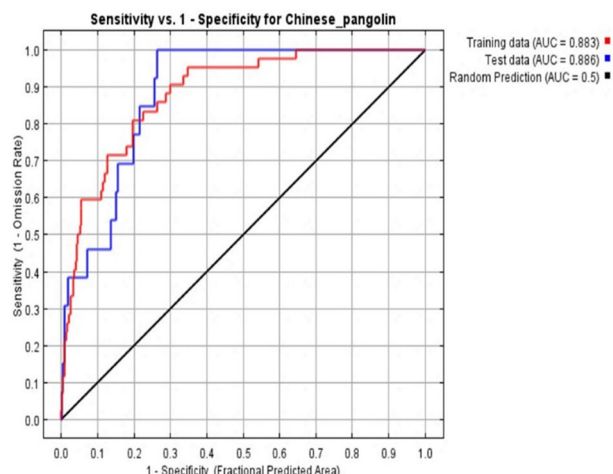Among these villages, CP presence was found

Figure 7. Model analysis of AUC curve of Chinese Pangolin.

Table 3. Percent of contribution by environmental variables to Chinese Pangolin distribution.

Environmental variables	Percent contribution
Elevation	34.3
Settlement	23.4
Aspect	16.5
Drainage	10.1
Land use	5.9
Mean temperature	4.9
Slope	4.3
Mean precipitation	0.6
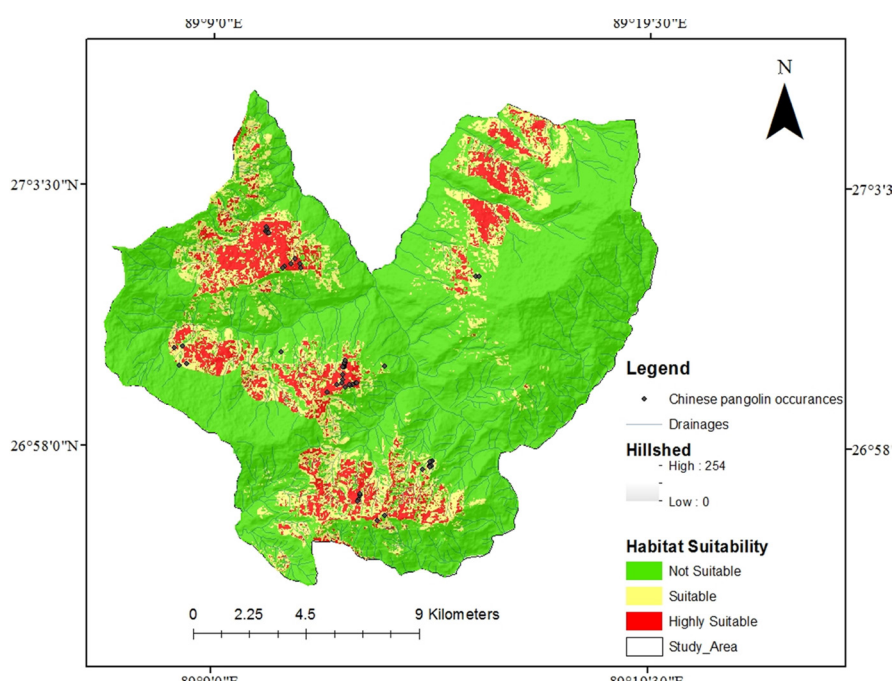
Figure 8. Habitat Suitability map of Chinese Pangolin in the study area.

comparatively more in Dogap, Manidara and Basentry villages under Dophuchen block, Daragaon village under Dumtoed block as indicated by the red dots (Figure 6). This could be due to the existence of more cardamom cultivation and soft soil. The species presence was more moderate in Laptsekha under Dophuchen and Relukha under Denchukha block as indicated by green dots (Figure 6). The presence of CP (indicated by the orange dots) in Sengdhen, Satakha, Mithun under Dophuchen and Gairegaon and Khalingtar villages under Dumtoed block, however, was very low which might be due to the high elevation in these areas.

The Maxent program predicted few patches of the study area as high probability of CP occurrence. The high probability areas are located in close proximity to human settlements and correspond to broad-leaved forest (performed with 0.883 for training data and 0.886 for test data (Figure 7). The Maxent result showed that currently 23.57km² of the study area is classified as highly suitable habitats (as indicated by red), 37.88km² of the study area as suitable habitat (yellow color) with the remaining study area of 194.98km² not suitable habitat for the CP (Figure 8). In this study, modelling was influenced by the variable "elevation" which contribute

Image 1. Chinese Pangolin sighting in the study area.

Image 2. Chinese Pangolin burrow.

Image 3. Pangolin habitat near settlement

Image 4. Overview of habitat of Chinese Pangolin.

Image 5. Chinese Pangolin sighting in agriculture land.

to 34.3% of the model gain followed by "settlement" with 23.4% contribution. This is due to more evidence of the presence of the species to settlements and mid elevation between 1,250–1,500 m. The least contributed variable was "mean precipitation" (0.6%) indicating that mean precipitation is not an important factor for the species distribution. Likewise, the variable "slope" contributed 4.3% (Table 3) as the presence of CP was recorded in almost all the slopes (5–65 %) in the study area although it prefers gentle slope (25–45 %).

CONCLUSION AND RECOMMENDATION

This study provides more in-depth information on the CP distribution and habitat preference in a mountainous country like Bhutan and should serve as a baseline for future monitoring. The information obtained from the research will also prove to be significant to the Chinese Pangolin conservation in Bhutan, such as habitat recovery and management, population management, population assessment and others. Although, CP population is declining globally, Bhutan holds potential as a conservation stronghold for pangolins due to its strict conservation laws namely Forest and Nature Conservation Rules 2017 and management practices.

CP was encountered in very low density in the study area and distributed in few villages of Dorokha Dungkhag with burrow density of 0.104/ha. Burrow distribution was highly influenced by the elevation, aspect and soil type while the highest elevation record of CP occurrence in the current study area was 2100 m. We also observed CP presence near human settlements, in Agriculture land and adjacent forest. Results of this study shows that 56.95% of the potential area of CP in the study areas is close to human settlement (Agricultural land), as CP prefer to choose termites nest for its greater biomass that

is mostly found in Cardamom cultivation area especially in winter. As a result, population of the species may be decreasing as they make easy targets for hunters. As such, detailed studies need to be conducted to envisage its ecological or social implications with an in-depth study focusing on distribution of pangolins in Bhutan to ensure that appropriate conservation measures are in place. At the same time, relevant authorities such as the Samtse Forest Division could implement programs targeted to the farmers residing in the potential habitat of CP on the legislation protecting pangolins, their ecological roles and benefits of CP conservation in order to change the attitude of local people towards pangolins.

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