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Cover: Common Keeled Skink *Eutropis carinata* in oil pastels, colour pencils, & micron pen adapted from photograph by H. Byju © Pooja Ramdas Patil.

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ARTICLE

Coexistence of Indian Pangolin *Manis crassicaudata* (Geoffroy, 1803) (Mammalia: Pholidota: Manidae) and Indian Crested Porcupine *Hystrix indica* (Kerr, 1792) (Mammalia: Rodentia: Hystricidae) in Purulia District, West Bengal, India

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Abstract: The Indian Pangolin *Manis crassicaudata* and the Indian Crested Porcupine *Hystrix indica* are subject to extensive poaching in Purulia District (West Bengal, India), diminishing their populations, and making the study difficult. Applying methodologies that include local sightings, field observations, camera trapping, and quadrate analysis, these species were observed to co-occur in rocky cavities in Ajodhya hills at several locations. Evidence for this included fresh pangolin tail drag marks, claw prints, footprints, scales, porcupine quills, teeth marks, and faecal matter in the same locations within the study area. Quadrate analysis showed that the trees housing the target prey species of the Indian Pangolin as well as the trees bearing fruits favoured by the Indian Crested Porcupine, occurred at maximum frequency within the Quadrate area. We hypothesise that pangolins and porcupines co-occupy rocky cavities for protection from poachers, who can easily break into more typical burrows and set traps in front of them. This may be an example of adaption to poaching, which demonstrates the necessity of conservation measures to alleviate severe anthropogenic pressure.

Keywords: Ajodhya hills, camera trapping, co-inhabitation, diurnal surveys, perception study, poaching, quadrate analysis, rocky cavity.

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Competing interests: The authors declare no competing interests.

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Author contributions: DS—Formal analysis, software, data curation, writing-original draft, writing-review & editing, visualization. SB—Conceptualization, Methodology, validation, resources, supervision, funding acquisition, writing-review & editing. SP—Investigation, resources, project administration, supervision.

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INTRODUCTION

Indian pangolins and porcupines have not been extensively studied due to their shyness, nocturnal habits, affinity for inhabiting inaccessible places, and difficulty of spotting them in the wild (Saltz & Alkon 1989; Karawita et al. 2018). Current studies of pangolin conservation come from South Africa (Heath & Coulson 1997; Shepherd et al. 2017). Our study concentrated on the Ajodhya Hills, Purulia, West Bengal, India where Indian Pangolins *Manis crassicaudata* and Indian Crested Porcupines *Hystrix indica* are known to be present as well as poached, with the goal of providing insights into how these species interact and adapt to excessive poaching.

The Indian Pangolin has been assessed as 'Endangered' according to the IUCN Red List of Threatened Species (Mahmood et al. 2019). It has also been listed in the Appendix I of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and a Schedule I species under the Wildlife (Protection) Amendment Act, 2022, to safeguard it from the extensive poaching.

The Indian Crested Porcupine has been accessed as 'Least Concern' on the IUCN Red List (Amori et al. 2021), and is protected under the Schedule I of the Wildlife (Protection) Amendment Act, 2022 to illegalize its poaching.

Description

As the species name *crassicaudata* suggests, the Indian Pangolin is characterized with a prehensile thick (crassus) tail (cauda), with adults weighing up to 16 kg and having a length of approximately 148 cm (Mahmood et al. 2019). Sharp keratinous scales cover the dorsal and lateral surfaces of its body, both dorsal & ventral surfaces of the tail, and over the limbs. It has 11–13 rows of overlapping scales round the mid body with a terminal scale on its ventral side of tail (Mohapatra & Panda 2014). It has curved claws in its forelimbs which are used to dig into termite mounds and ant nests, following which the ants and termites are licked up by its long, sticky saliva-coated tongue. When threatened, it either flees or curls up into a tight ball, depending entirely on its scales, for protection (Chao et al. 2019).

The Indian Crested Porcupine weighs approximately 11–18 kg (Prater 2005) and has a body length of 70–90 cm (Prater 2005). Its body is covered with two types of keratinous quills—a longer and slender type which masks the shorter and thicker ones underneath. When threatened, it raises its quills with the help of a muscle attached to the base of its quills and tries to scare away the threat. It has long claws for digging, sharp incisors, and a keen sense of smell.

Distribution

According to Mohapatra et al. (2015), the Indian Pangolin is found in southern Asia from northern and southeastern Pakistan throughout the Indian subcontinent south of the Himalaya, to northeastern India and Sri Lanka. In India, it is distributed across states like Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal and has also been reported to be present in Bangladesh, Pakistan, Nepal, and Sri Lanka.

The Indian Crested Porcupine is found in most countries of southwestern, southern and central Asia, including Afghanistan, Armenia, China, Georgia, India, Iran, Iraq, Israel, Lebanon, Nepal, Pakistan, Saudi Arabia, Sri Lanka, Turkey, and Yemen.

Habitat and Diet

The Indian Pangolin is mainly fossorial and is known to excavate burrows in the soil, as well as inhabit crevices of boulders (Mahmood et al. 2019). There are two types of burrows: the resting burrow, where it rests during the day, and the feeding burrow, which it digs to uncover prey (Karawita et al. 2018). The most preferred dietary choices of the Indian Pangolin are the red ants and the termites (Supplemental Images 1A, 1B, 1C, 1D), which are found within its habitat (Karawita et al. 2018; Mahmood et al. 2019).

The Indian Crested Porcupine is semi fossorial and digs burrows or lives in rocky caves. However, it is not an expert climber and spends most of its lifetime on or under the ground. It can be found in rocky hillsides, forests, grasslands, and even agricultural fields where it goes for eating potatoes (Saltz & Alkon 1989), fruits, tubers, roots, etc. Its habitat choice is dependent on the presence of abundant food resources (like fruit trees) and rocky cavities or proper substrate to make the digging of burrows practically possible (Saltz & Alkon 1989).

Behaviour

The Indian Pangolin sleeps in burrows during the daytime and forages at night (Karawita et al. 2018). A study conducted on Indian Pangolins in captivity at the Nandankanan Zoo, India, revealed that they show peak activity between 2000 h and 2100 h (Mahmood et al. 2019). It is also arboreal and can climb trees using its

forelimbs, hindlimbs, and the prehensile tail which acts as an 'extra limb' (Mahmood et al. 2019). It is myrmecophagous (Beca et al. 2022) and termitophagous (Chao et al. 2019) and known to prefer the ant species *Camponotus confucii*, *C. compressus*, and termite species *Odontotermis obesus*, as shown by a study conducted in the Potohar Plateau, Pakistan (Mahmood et al. 2013).

The Indian Crested Porcupine has been found to feed preferably on underground bulbs, such as potatoes (Saltz & Alkon 1989), and fallen fruits from trees and is considered a 'generalist herbivore'. It has been found to consume a greater variety of food items in the summer season, compared to that in the winter season; the reason can be attributed to the fact that it shows greater activity in summer than in winter (Corsini et al. 1995) thus exploring more area from the burrow for foraging in the summer, hence the diversification in its diet (Akram et al. 2017). Its activity radius was found to be greater in the late summer (when forest is already enriched with nutrient sources) than in the early summer (when nutrient sources become available initially) (Saltz & Alkon 1989). Therefore, it can be predicted that higher the concentration of food resources in an area or near the living burrow, the greater the preference of the porcupine to inhabit there, to get a variety of food sources. It is known to remain in proximity to its burrow during the brightly moonlit nights (to avoid predators) and its habitation is closely linked with the 'forage availability'. It leaves its burrow shortly before sunset and returns only at sunrise (Corsini et al. 1995).

MATERIALS AND METHODS

Study area

The current study was conducted in the Gajaburu Hills (Supplemental Image 2) near Mohultarn Village in the Sirkabad Beat, Arsha Range of the Purulia Division Forest Department, West Bengal, India. The global positioning system (GPS) coordinates of the place are 23.24^0 N, 86.22^0 E. Six sites were selected within the study area as the focal sites.

Study design

The study was conducted from November 2022–April 2023. These months were chosen for the study so that the behaviour of the target animals could be monitored in the duration of winter season, as well as partly in the summer season, for preventing any bias of the behaviour towards a particular season. The first requirement was identification of potential sampling sites, which was accomplished with the help of perception study of local people and rigorous field surveys in November 2022. Quadrate analysis was added as a part of the study to further validate if the chosen sampling sites could support the co-existence of the pangolin and the porcupine. The data was collected by taking photographs of animal prints and by collecting quills, faecal matter, and scales.

Community interviews and Perception study

Community interviews are one of the most cost-effective methods to determine pangolin and porcupine distribution in regions where their population has declined overtime and to further access their current population status. Most surveys that used this method, reported successful recognition of target species by the locals who were interviewed (Willcox et al. 2019). The locals in Purulia recognize the Indian Pangolin as 'Soorjomukhi' and they could easily identify and describe it. We interviewed local hunters and local people living in the Mohultarn village to study their perception, which helped us in identification of the priority sites for pangolin and porcupine burrow distribution and how to distinguish these burrows from those of other burrowing animals present in the associated habitats. However, for the validation of the statements made by the local people, we cross checked the information provided by the locals with the available scientific records and observations mentioned in the existing scientific literature.

Diurnal field surveys

The field surveys were conducted for a period of six months, from November 2022–April 2023. In November 2022, field surveys were undertaken once each week (four times). Following this, field surveys were conducted twice each month for the rest of the five months from December 2022–April 2023 (10 times). Each in-person field survey was limited to four to five hours (with recesses) at a time, to prevent manual error in data collection due to fatigue. The frequency of field surveys was reduced from four in November 2022 to two in the rest of the months because the initial time-consuming process of identifying the potential sampling sites within the study area was completed in November 2022. Accordingly, six potential sites were identified within the study area. In total, 14 field surveys were conducted during the whole study period.

The site selection criteria included the detection of recent claw marks, tail drag marks, footprints, faecal samples (dung), quills, bite marks, feeding signs (broken

ant nests and termite mounds), scratch marks, and burrows of our target animals (Indian Pangolin and Indian Crested Porcupine). To determine if the burrows had been occupied most recently, we checked for the absence of leaves and cobwebs (Willcox et al. 2019) and by looking for the presence of fresh soil or fresh activity signs of the pangolin and porcupine near the burrow entrance (Waseem et al. 2020).

In November 2022, the field surveys were conducted randomly (to prevent bias) on a day of each week, with a minimum of seven days gap before the next survey, to remove the effects of any human interference. During December 2022–April 2023, the surveys were focussed on collection of data from already identified sites, setting of camera traps and performing quadrate analysis. These surveys were undertaken with a gap of approximately 14 days between each survey. For example, if the first survey in December was performed on the Friday of the first week of December, the second survey in December was performed on the Friday of the third week of December. Following this, the next survey was conducted on the Friday of the first week in January 2023, and again on the Friday of the third week in January 2023.

The surveyors who comprised of seven trained individuals and two experienced local villagers (employed as para-biologists (Karawita et al. 2018) to guide us to the actual field sites (during the daytime)) were divided into three groups: Group A—two trained individuals and a local villager; Group B—two other trained individuals and the other local villager; Group C—three trained individuals. Each group was placed in-charge of two sampling sites (six in total).

Camera trapping

Once the potential habitats and feeding signs of the pangolin and the porcupine were detected, camera traps (Cuddeback X-Change™ Color model 1279) (Supplemental Image 3) were set at those selected sampling sites (six in number) targeting the entrance of resting burrows, feeding burrows, termite mounds, ant nests, edge of a rivulet, and in places where fresh bites and feeding signs were observed. Installation of camera traps was done separately and following a routine which was different with respect to the capturing of photographs of animal signs using the Nikon D3400 camera (Refer to 'Data collection and capturing photographs' of materials and methods section).

The six selected sampling sites where field surveys were conducted, were also chosen as the six camera trap stations. The exact GPS coordinates (taken using GPS Map Camera Application in Xiaomi Redmi Note 8) of these six stations were noted as follows:

Site 1: 23.23^0 N 86.27^0 E, Site 2: 23.20^0 N 86.28^0 E, Site 3: 23.22^0 N 86.26^0 E, Site 4: 23.25^0 N 86.24^0 E, Site 5: 23.24^0 N 86.27^0 E, Site 6: 23.21^0 N 86.28^0 E.

Twelve camera traps were required during the entire study period. During the first four field surveys in November 2022, no camera traps were set. The first set of six camera traps were installed (during the day) on the Friday of the first week of December 2022 at the six different sampling sites (coordinates mentioned above) in the study area. The six camera traps remained in the field for a period of 14 days, following which those were removed from the six sampling sites on the Friday of the third week of December 2022. Then, as the first set of six camera traps were removed, the second set of another six camera traps were re-installed at the six sampling sites on the Friday of the third week of December 2022. The second set remained installed for 14 days, after which they were removed on the Friday of the first week of January 2023, and again the initial first set of six camera traps were re-installed on the same day. This process of installation and removal of camera traps were followed till the Friday of the third week of April 2023, resulting in 132 days of camera trap data. The timings of camera trap installation, removal and re-installation were strictly maintained between 1200 and 1400.

Quadrate method

Quadrate method (25 × 25 m) was used for vegetation analysis at the six selected sites where camera traps were set, in the study area.

The collection of quadrate data was first performed in the first week of November 2022. Following this, three technical replicates (data provided as supplementary material) of the quadrate data were obtained on three separate days— Friday of the first week of December 2022, Friday of the first week of February 2023, and Friday of the first week of April 2023, with a gap of one month between the technical replicates. This was done to monitor any change (if at all) of the vegetation cover at the sampling sites in the study area, during the study. Collection of quadrate data was part of the workflow of the diurnal field surveys conducted at the frequency as mentioned in the "diurnal field surveys" section.

Two sampling sites were placed under one group of team members (consisting of three members in each team). Each sampling site also corresponded to a quadrate area (25 × 25 m). Therefore, there were six quadrate areas, with each group responsible for taking quadrate data from two sites. For each quadrate area, three biological replicates (of the species of trees) were

counted on the same day, by the three team mates independently and separately, to prevent the possibility of bias in counting due to influence of the result of counting obtained by one teammate over the others.

For the data collection of quadrate analysis, the type of trees and number of each type of tree was noted down, from six quadrate areas, considered in the six sites within the study area. Three technical replications of the data collection were done at each of the six sites, thus resulting in 18 datasets (refer to supplementary material) for each type of tree.

Data collection and capturing photographs

Data collection was done from six selected sites within the study area and included the capturing of photographs (Image 1A) (using Nikon D3400 digital camera) of rocky burrows, termite mounds, ant nests, feeding signs, fresh prints of body parts on ground, and trees within the quadrate areas. Also, faecal matter and detached body parts such as quills (of Indian Crested Porcupine) and scales (of Indian Pangolin) (Images 1B,C) were collected.

Data collection and capturing of photographs was conducted on all six sampling sites, during every diurnal field survey. Data was collected during one random day in each week in November 2022, with a gap of minimum seven days (four data collections in November); followed by data collection in the Friday of the first week of December 2022, then in the Friday of the third week of December 2022, then in the Friday of the first week of January 2023, followed by the Friday of the third week of January 2023, and so on, till April 2023. Therefore, data collections were done twice each month from December 2022–April 2023 (10 times), accounting for total 14 data collection rounds.

Data analysis

The statistical analysis of the data obtained through

Image 1. Indian Pangolin and its scales found in study area: A—Individual detected in one of the six sampling sites in our study area | B—ventral surface of a scale found detached from the body | C—dorsal surface of the scale found detached from the body. © Shwetadri Bhandari.

quadrate method was performed using Microsoft Excel and R version 4.3.0.

The Mean ± SEM values of the number of trees commonly occurring within the quadrates, were used for plotting the graph. The commonly occurring trees were further divided into two groups:

1) The Favoured group—trees favoured by Indian Pangolin and Indian Crested Porcupine within the quadrate areas, and

2) The Unfavoured group—trees unfavoured by Indian Pangolin and Indian Crested Porcupine, within the quadrate areas.

Ethical considerations

The project was undertaken and executed only after the provision of required permits for the fieldwork, by the Forest Department of West Bengal, Purulia Division (Approval letter number: 2552/26-1(WL); date of approval: 06/09/2022). The surveys were carried out by following all the instructions of the forest rangers. The two villagers (anonymised for the sake of research integrity) were involved in the surveys as para-biologists, only after informing them thoroughly about our survey goals, in their colloquial language, without using scientific jargons, and only when they voluntarily consented for contribution in the study. Absolute care was taken to maintain silence during the surveys and to leave the areas without any major changes after the surveys.

The data collection was non-invasive, involving perception study, surveys, camera trapping, quadrate analysis, and collection of faecal matter. Additionally, since the Indian Pangolin and the Indian Crested Porcupine are nocturnal and exhibit movements in their habitats at night, the in-person data collection and surveys were done during the day. Camera traps were hidden out of view of the animals and set in such a way, to prevent any interaction of the camera traps with any animals. Certain body parts like quills (of the Indian Crested Porcupine) and scales (of the Indian Pangolin) were collected only when those were left on the ground after their natural detachment from the animal bodies.

RESULTS

Signs of pangolin and porcupine presence

Rocky cavities were detected at multiple locations in the Gajaburu hills, where the evidence of the Indian Pangolin and the Indian Crested Porcupine sharing their living space were detected. However, we have depicted the evidence observed at only one rocky cavity (henceforth called 'focal rocky cavity') in the Results section because results captured by camera at this site had maximum clarity. At sites other than the six focal sites, the rocky cavities were at such an angle of the terrain, that although the evidence was visible, photographing those up close was not logistically possible, without hampering the evidence.

In Image 2A, the focal rocky cavity is clearly visible, with the fresh and recent tail drag marks, footprints, and claw prints (the magnified views of these have been shown in Images 2B,C, respectively of the Indian Pangolin, in the sandy soil layer at the entrance of the focal rocky cavity. Interestingly, further inwards from the sandy soil layer, towards the focal rocky cavity, the detached quills of the Indian Crested Porcupine (Image 2D) were also detected. Additionally, a boulder was found approximately 2–3 m from the focal rocky cavity, on which we spotted fresh dung (faecal sample) of the Indian Crested Porcupine. This indicates recent co-usage of the same rocky cavity by both the Indian Pangolin and the Indian Crested Porcupine.

Habitat suitability

A Karam *Neolamarckia cadamba* tree was detected (Image 3A) within 5 m of the focal rocky cavity, where co-existential evidence of the Indian Pangolin and Indian Crested Porcupine was detected. The Karam tree was observed with a termite mound growing on the lower part of its trunk and red ants were spotted all over its trunk and branches. Another huge and well-developed termite mound was detected (Image 3B) approximately 7 m from the focal rocky cavity and 3 m from the Karam tree. It shows that this site with termite mounds and presence of red ants in proximity to the rocky cavity, is the preferred habitat for the Indian Pangolin, due to the abundant food sources nearby.

Numerous fallen Bael fruits were found already cracked open, and their inner contents eaten by the Indian Crested Porcupine (Image 4A). We further spotted the teeth (incisor) marks of the Indian Crested Porcupine (Image 4B) on a Bael *Aegle marmelos* fruit. The left-side teeth marking (marked in red towards left edge in Image 4B) possibly shows the porcupine having tried to drag its incisors across the hard outer covering of the fruit, thus trying to pry it open. The right-side teeth marking (marked in red towards right edge in Image 4B) possibly shows the porcupine having tried to get a firm hold of the fruit with its teeth, while trying to fracture the hard covering of the Bael fruit, to feed on the meat inside it. Again, this feeding evidence was detected near our focal

Image 2. Signs of pangolin and porcupine presence: A—focal rocky cavity with position of tail drag marks, footprints (bigger red rectangle) and claw prints (red circle) of Indian Pangolin, and detached quills (smaller red rectangle) of the Indian Crested Porcupine, at the entrance | B—magnified view of the entrance of focal rocky cavity with tail drag marks (towards left) and footprints (towards right) of the Indian Pangolin | C—magnified view of the entrance of focal rocky cavity with claw prints (shown in red circle) of the Indian Pangolin | D—detached quills of the Indian Crested Porcupine collected from the entrance of the focal rocky cavity. © Debosmita Sikdar.

rocky cavity, indicating that our considered site also has nutrient sources for the Indian Crested Porcupine, which therefore has an affinity to stay in this habitat, which is further proved by the presence of fresh dung of the Indian Crested Porcupine on a boulder (Image 4C) at that place.

Quadrate analysis

The results of all six quadrates were combined in a single table (Table 1) and graph (Figure 1) to visualize the relationship between the types of trees most commonly spotted in the quadrates (plotted on the x-axis) versus the total number of each type of tree counted in the quadrates (plotted on the y-axis) considered, where the focal rocky cavities were present, as well as camera traps

were set. Among the eight types of commonly occurring trees, there were four types of trees which occurred most frequently in the quadrate areas namely: Tendu *Diospyros melanoxylon*, Bael *Aegle marmelos*, Karam *Neolamarckia cadamba*, and Sisu *Dalbergia sissoo*. These four trees were grouped under 'the Favoured group' (Refer to 'Data analysis' sub-section under 'Methods' section). The remaining four trees namely: White Siris *Albizia procera*, Indian Plum or Kul *Ziziphus mauritiana*, Banyan *Ficus benghalensis*, and Palash *Butea monosperma* are grouped under 'the Unfavoured group' (Refer to 'Data analysis' sub-section under 'Methods' section).

Trees such as *Dalbergia sissoo*, which provide humid conditions in their roots for supporting the formation of ant nests and termite mounds, are often found within the habitat of the Indian Pangolin (Mahmood et al. 2013). Also, the Karam tree that was found in our focal site, bore termite mounds and red ants on it. Therefore, the presence of Karam and Sisu tree in our quadrates (containing the focal rocky cavity), favours the presence of the Indian Pangolin in the area.

Additionally, we observed that the Indian Crested Porcupine had fed on Bael fruits. Also, the Tendu tree produces sweet fruits, which local people often collect for eating. Although, we have not found evidence of the Indian Crested Porcupine having fed on Tendu fruits, yet scientific literature suggests that it prefers eating fruits, bulbs, tubers, and roots of plants, even potatoes from agricultural fields (Saltz & Alkon 1989). Therefore, the presence of Bael and Tendu trees in the quadrates (containing the focal rocky cavity), favours the presence of the Indian Crested Porcupine in the area.

Thus, the trees which housed the target prey species of the Indian Pangolin (red ants and termites) and the trees bearing fruits favoured by the Indian Crested Porcupine, occurred at maximum frequency within the quadrate area, which already contained the focal rocky cavity. This overlapping of favoured food sources of the pangolin and porcupine in the same area, is an indication that both the species may co-inhabit in the area, and occupy the same living burrow, as indicated

Table 1. Results of the quadrate analysis. The trees - *Diospyros melanoxylon, Aegle marmelos, Neolamarckia cadamba,* and *Dalbergia sissoo* - occurred at maximum frequency within the quadrate areas.

	Types of trees most commonly spotted in the quadrates	No. of trees of each type counted in the quadrates (Mean±SEM)
1.	White Siris *Albizia procera*	12±0.28
2.	Indian Plum or Kul *Ziziphus mauritiana*	15±0.63
3.	Banyan *Ficus benghalensis*	2±0.25
4.	Palash *Butea monosperma*	9±0.44
5.	Tendu *Diospyros melanoxylon*	29±0.78
6.	Bael *Aegle marmelos*	21±0.86
7.	Karam *Neolamarckia cadamba*	26±1.27
8.	Sisu *Dalbergia sissoo*	23±0.70

Image 3. Habitat suitability signs for the Indian Pangolin: A—Karam tree with termite mounds on its trunk, found near the focal rocky cavity within the quadrate area | B—termite mound observed near the focal rocky cavity within the quadrate area. © Debosmita Sikdar.

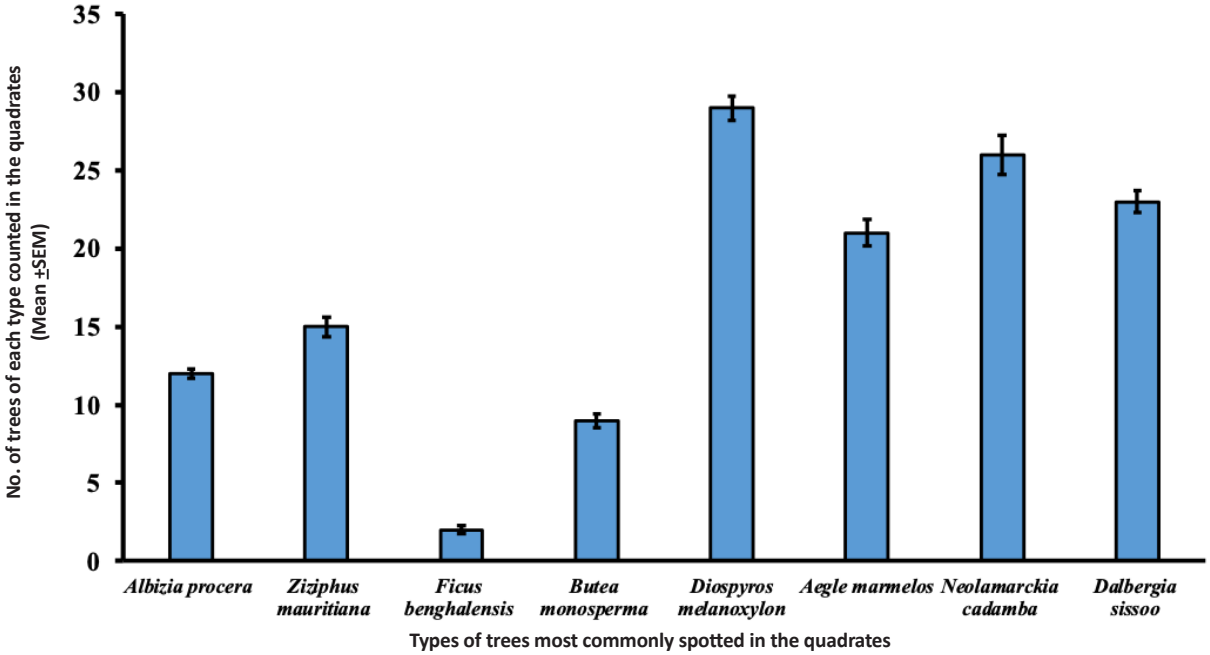

Figure 1. Graphical representation of result of quadrate analysis.
The two trees (*Neolamarckia cadamba* and *Dalbergia sissoo*) which housed the target prey species of the Indian Pangolin (red ants and termites) and the two trees (*Diospyros melanoxylon* and *Aegle marmelos*) which bear fruits favoured by the Indian Crested Porcupine, occurred at maximum frequency within the quadrate areas.

by the indirect evidence near the entrance of our focal rocky cavity.

Statistical analysis of quadrate data

The dataset for the Favoured group was analysed using R version 4.3.0 to check for normal distribution of the dataset, using the Shapiro-Wilk normality test. However, the original dataset did not show normal distribution (Shapiro-Wilk Normality test: W = 0.958, P = 0.016 as P <0.05; so, log transformation of the dataset was taken and then the dataset showed normal distribution (Shapiro-Wilk normality test: W = 0.972, P = 0.112) as P >0.05.

Similarly, the original dataset for the Unfavoured group did not show normal distribution (Shapiro-Wilk normality test: W = 0.938, P = 0.002) as P <0.05. Even the subsequent log transformations of the original dataset could not yield normal distribution of data (Shapiro-Wilk normality test: W = 0.796, P = 2.227e-08), and (Shapiro-Wilk normality test: W = 0.707, P = 1.902e-10) respectively, as P <0.05.

The datasets of the Favoured and Unfavoured groups were analysed using a non-parametric test called Wilcoxon signed-ranks test, by taking into consideration the original datasets of both groups. The null hypothesis was: There is no significant difference between number of trees of Favoured group and number of trees of Unfavoured groups in the quadrates considered at focal sites. The alternate hypothesis was: there is significant difference between number of trees of Favoured group and number of trees of Unfavoured groups in the quadrates considered at focal sites.

After running the analysis, the alternate hypothesis was accepted (Wilcoxon signed-ranks test: W = 100, P <2.200e-16) as P < 0.05. This indicates that at the quadrate areas, the trees which contain the food sources of both the Indian Pangolin and the Indian Crested Porcupine, are significantly different in number, with respect to those trees which do not contain food sources of both animals. Thus, the presence of trees of the Favoured group in an area facilitates the co-inhabitation of both animals and has significant potential for supporting the presence of both the Indian Pangolin and the Indian Crested Porcupine simultaneously, as evidenced by the data collected from our focal sites.

DISCUSSION

According to the report of the 2002 census of wild animals in southern West Bengal, conducted by the West Bengal Forest Department, only 42 pangolins were found in the Purulia district (Samanta et al. 2021). The possible reason for their scanty population is that the

Image 4. Existential evidence of Indian Crested Porcupine: A—*Aegle marmelos* fruits found near the focal rocky cavity, cracked open and inner contents fed by the Indian Crested Porcupine | B—*Aegle marmelos* fruit recovered near the focal rocky cavity with biting marks (made by incisors) of the Indian Crested Porcupine | C—dung of the Indian Crested Porcupine found on a boulder near the entrance of the focal rocky cavity. © Debosmita Sikdar.

Indian Pangolin is extensively hunted and poached for its meat (Hughes 2014), which is consumed locally and as a luxury food; and scales which are internationally traded (Mohapatra et al. 2015). The scales combined with other materials are used in traditional Chinese medicine, to promote blood circulation, stimulate lactation, reduce swelling, expel pus (Xu et al. 2016) and cure rheumatism (Hughes 2014).

The scales of an average adult Indian Pangolin weigh about 3.5 kg in total. According to a report, in 1996 the pangolin scales were sold for INR1000/kg in Mizoram, which increased to INR12,000– INR13,000/kg in 2013 (Mohapatra et al. 2015). According to another report from 2006–2007, the scales were sold for USD $132/kg at wholesale markets, and USD $160/kg at retail markets, which have increased four-fold at the wholesale markets and six-fold at the retail markets (Xu et al. 2016).

There was a report on pangolin spotting in the Ajodhya Hills, in the Purulia District, West Bengal on 12 August 2021 by a camera trap survey, and there were also reports of rescue of two Indian Pangolins by the forest department of Purulia from poachers at Bararola and Serengdi village adjacent to the Ajodhya Hills on 22 August 2021 and 28 August 2021, respectively (Samanta et al. 2021).

The techniques employed by the poachers for entrapping a pangolin include the digging up of muddy burrows or driving them out by smoking or flushing them out with water, pitfall trapping, and using hunting dogs. Then the captured pangolins are killed by boiling them in water or knocked unconscious by hitting with a club. The scales are then either peeled off the pangolin or it is entirely skinned (Mohapatra et al. 2015). Banerjee (2022) discusses about the traditional 'Shikar' or hunting ritual carried out in the Ajodhya Hills, Purulia on 'Baishakhi Purnima', the full moon day in summer, wherein the Santhal (local tribe) men wander in the forests and kill wild porcupine, pangolin, deer, monkey, wild boar, and bear.

The Indian Crested Porcupine is also subject to extensive poaching to obtain its meat, and quills, which are used for making traditional medicines. Lupo & Schmitt (2005) state the porcupines were hunted using spears. However, the porcupines are recently hunted using special traps called 'fibre purse' or 'bag trap', which is set in front of the burrow of the animal. These special traps are built in a specific way, consisting of fibres or ropes hanging down from a layer of rocks on the top. Then, the hunters frighten the porcupine and force it to move into the trap, wherein quills of the porcupine get entangled in the dangling fibres, and when trying to pull away and escape, the rocks fall on its delicate body, thus injuring and immobilising the porcupine, which gets subsequently poached

The Indian Pangolin and the Indian Crested Porcupine in Purulia, coexist in the same rocky cavity. From the perspective of the Indian Pangolin, it protects itself by staying in the rocky cavity occupied by the porcupine, by making it difficult for the poachers to break or dig open a hard rocky cavity, as opposed to a soft, muddy burrow. Additionally, by occupying pre-formed rocky cavities, the pangolin can save the energy that it would have spent in digging a burrow in the soil, thus, more energy is available for foraging, mating, and offspring rearing.

From the perspective of the Indian Crested Porcupine, it gains huge advantage of co-inhabiting with the Indian Pangolin by decreasing its probability of getting poached by 50%. When the porcupine co-exists with a pangolin, then considering that both Indian Pangolin and Indian Crested Porcupine have overlapping time period of peak activity at night, the probability that the porcupine exits the burrow at a specific time is one-half of the probability of exiting the burrow when it was the lone occupant of the burrow. Thus, the probability of the porcupine getting entrapped in the 'fibre purse', is reduced by half (50%) with respect to probability of being poached when it occupied the burrow alone.

A study from southwestern Sri Lanka, had reported the co-occupancy of the 'same habitats' by burrowing animals such as the Indian Pangolin, the Greater Bandicoot Molerat *Bandicota indica* and the Indian Crested Porcupine *Hystrix indica* (Karawita et al. 2018). The general trend being observed in case of the co-inhabitancies, is that these behaviours are exhibited mostly in the areas involving high human-wildlife interactions.

CONCLUSION

The present study undertaken at the Purulia District of West Bengal, India, depicts that the Indian Pangolin and the Indian Crested Porcupine may coexist and share the same habitat. The reason for such behaviour, can be attributed to help them in coping up with extreme anthropogenic intrusion in their niche. An immediate necessity for their conservation also arises to diminish their population decline, caused by extensive poaching.

Future Work

IUCN estimates predict that the global Indian Pangolin population is likely to decrease by over 50% in the next 20 years (Waseem et al. 2020). Moreover, among all the Asian Pangolins, the Indian Pangolin is the least studied in terms of their abundance, population status, burrow characteristics and habitat preference (Karawita et al. 2018). This lack of proper quantitative data about the Indian Pangolin in India, Nepal, and Bangladesh, hampers understanding of the behaviour and ecology of the species. Future research and thorough surveys on pangolin populations are needed to shed light on this aspect.

It is important to determine if the Indian Pangolin shows such behaviours in presence of any other animals, whether it co-inhabits with other animals during the breeding, offspring rearing seasons and study their behaviours in other types of habitats, especially in the tropical wet rainforests. The study of these activities are essential to formulate effective conservation strategies for the 'Endangered' Indian Pangolin.

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Quadrate Analysis Data

The Favoured Group

Name of tree	*Diospyros melanoxylon*	*Aegle marmelos*	*Neolamarckia cadamba*	*Dalbergia sissoo*
	33	25	32	21
No.	34	22	30	22
	32	23	29	23
	27	19	27	25
of	25	18	25	28
	27	19	25	26
	35	29	21	22
trees	32	27	23	23
	31	28	23	22
	28	21	35	28
of	26	21	33	27
	28	21	36	28
	31	18	22	23
each	30	17	19	23
	33	17	20	23
	26	20	22	19
type	25	20	21	19
	26	21	22	20
Mean	**29.389**	**21.444**	**25.833**	**23.444**
Standard deviation	**3.310**	**3.650**	**5.393**	**2.955**
SEM	**0.780**	**0.860**	**1.271**	**0.696**

Colour coding for Quadrate data collected at the six focal sites (in order):

- Three technical replicates from Focal site 1
- Three technical replicates from Focal site 2
- Three technical replicates from Focal site 3
- Three technical replicates from Focal site 4
- Three technical replicates from Focal site 5
- Three technical replicates from Focal site 6

The Unfavoured Group

Name of tree	*Albizia procera*	*Ziziphus mauritiana*	*Ficus benghalensis*	*Butea monosperma*
No. of trees of each type	12	15	2	10
	11	14	2	8
	12	15	1	9
	11	21	1	8
	12	19	1	8
	11	18	1	7
	13	12	3	7
	12	10	2	8
	10	13	2	7
	11	14	2	13
	13	13	3	11
	12	15	2	10
	12	13	0	8
	15	15	0	8
	12	14	0	8
	10	15	3	10
	13	16	3	12
	11	18	3	12
Mean	**11.833**	**15.000**	**1.722**	**9.111**
Standard deviation	**1.200**	**2.657**	**1.074**	**1.875**
SEM	**0.283**	**0.626**	**0.253**	**0.442**

Colour coding for Quadrate data collected at the six focal sites (in order):

- Three technical replicates from Focal site 1
- Three technical replicates from Focal site 2
- Three technical replicates from Focal site 3
- Three technical replicates from Focal site 4
- Three technical replicates from Focal site 5
- Three technical replicates from Focal site 6

R Code Sheet for Statistical Analysis of Quadrate data

```
R version 4.3.0

[Workspace loaded from ~/. RData]

> library(readxl)
> Pangolin_Porcupine <- read_excel ("Pangolin-Porcupine.xlsx",
+     sheet = "Favoured")
> View (Pangolin_Porcupine)
> shapiro.test (Pangolin_Porcupine$Number)

        Shapiro-Wilk normality test
data:  Pangolin_Porcupine$Number
W = 0.95757, p-value = 0.01615
> LOGFAV=log (Pangolin_Porcupine$Number)
> shapiro.test (LOGFAV)

        Shapiro-Wilk normality test
 data:  LOGFAV
W = 0.97228, p-value = 0.1125
```

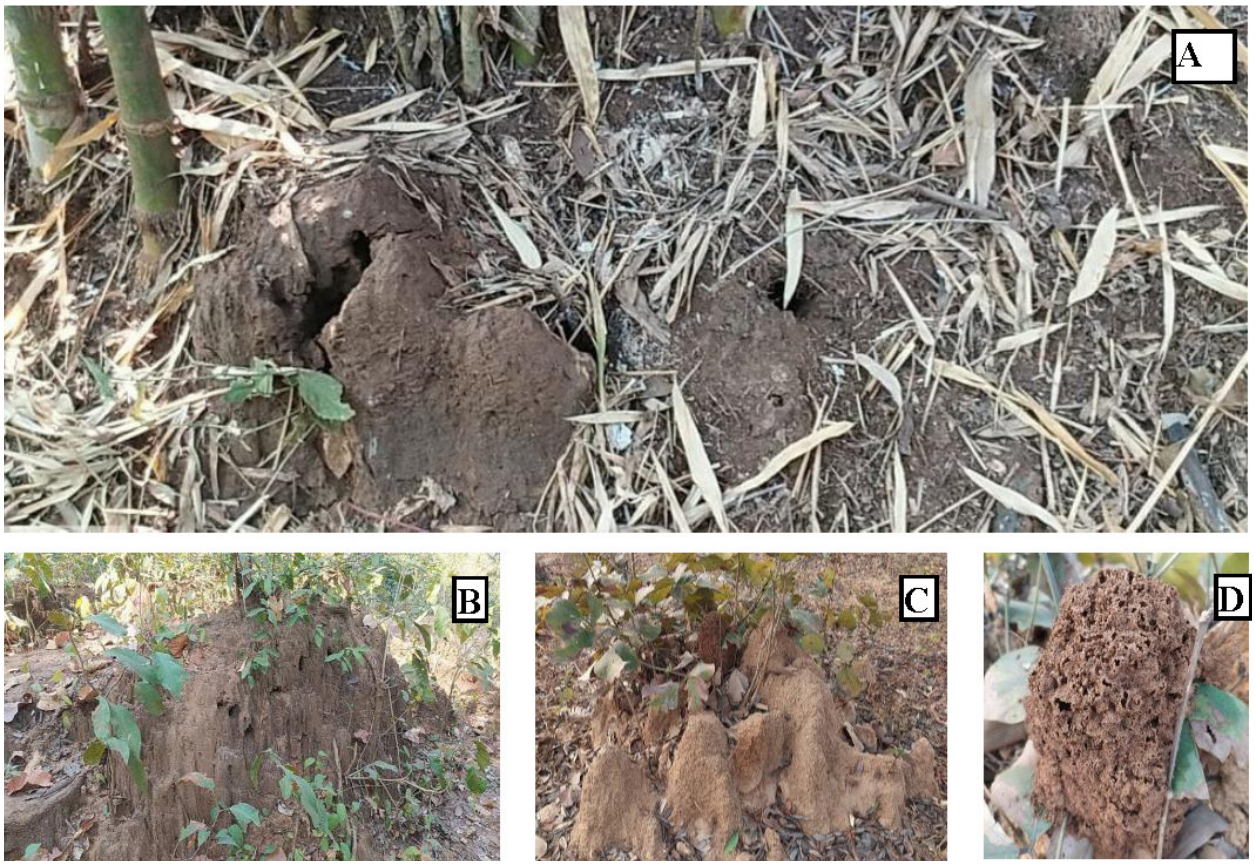
The Favoured group's dataset was log transformed to make the dataset parametric or normally distributed (Shapiro-Wilk normality test, P>0.05).

```
> library(readxl)
> Pangolin_Porcupine <- read_excel ("Pangolin-Porcupine.xlsx",
+     sheet = "Unfavoured")
> View (Pangolin_Porcupine)
> shapiro.test (Pangolin_Porcupine$Number)

        Shapiro-Wilk normality test

data:  Pangolin_Porcupine$Number
W = 0.93847, p-value = 0.001587
> LOGVAL=log (Pangolin_Porcupine$Number)

> shapiro.test (LOGVAL)

        Shapiro-Wilk normality test

data:  LOGVAL
W = 0.79605, p-value = 2.227e-08
 > LOGVAL1<-log (Pangolin_Porcupine$`log (Number)`+1)
> shapiro.test (LOGVAL1)

        Shapiro-Wilk normality test
 data:  LOGVAL1
W = 0.70663, p-value = 1.902e-10
```

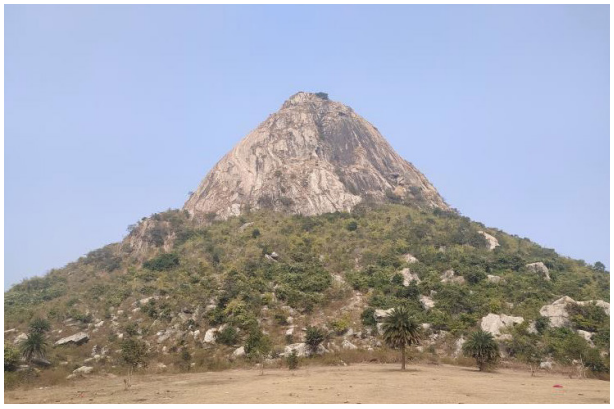
The Unfavoured group's dataset was non-parametric i.e., not normally distributed (Shapiro-Wilk normality test, P<0.05). Two types of log transformations were performed to normalize data distribution but couldn't be done.

```
> library(readxl)
> Pangolin_Porcupine <- read_excel ("Pangolin-Porcupine.xlsx",
+     sheet = "Combined")
> View (Pangolin_Porcupine)
> wilcox.test (Pangolin_Porcupine$Number)

        Wilcoxon signed rank test with continuity correction
data:  Pangolin_Porcupine$Number
V = 10011, p-value < 2.2e-16
alternative hypothesis: true location is not equal to 0.
```

Non-parametric test (Wilcoxon signed-ranks test, P<0.05) performed between the Favoured group and Unfavoured group, here named "Combined" group.



Supplemental Image 1 (A–D). Termite mounds found in study area. In addition to the six focal sites, termite mounds were found at various other locations within the study area, indicating the presence of the Indian Pangolin. © Debosmita Sikdar.



Supplemental Image 2. Picture of Study area. A view of the Gajaburu hills in Purulia District, West Bengal, India, where the Study was conducted. © Debosmita Sikdar.

Supplemental Image 3. Picture of Camera trap. The picture shows the type of Camera traps that were used in the study for monitoring the activities of the Indian Pangolin and the Indian Crested Porcupine. © Debosmita Sikdar.

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