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Cover: Oil painting of Humpback Whale *Megaptera novaeangliae*. © R. Mahesh.

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ARTICLE

Rapid camera-trap assessment of mammals in Tripura, India: new records and implications for conservation

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Abstract: This study presents first ever rapid camera-trapping assessment of mammals across protected areas of Tripura, northeastern India, located within the Indo-Burma biodiversity hotspot. Surveys were conducted between January and April 2024 in Sepahijala Wildlife Sanctuary, Clouded Leopard National Park, Trishna Wildlife Sanctuary, Bison National Park, and Gumti Wildlife Sanctuary, resulting in 469 trap nights. A total of 19 mammalian species belonging to 16 genera, 10 families, and four orders were documented. Trishna Wildlife Sanctuary recorded the highest species diversity, followed by Sepahijala and Gumti. This study features the first photographic evidence of the Ferret Badger, range extensions for the Malayan Porcupine and the Fishing Cat. These findings fill important distribution gaps and highlight the conservation significance of Tripura's fragmented forests and wetland mosaics. Despite their small size and increasing anthropogenic pressures, the protected areas of Tripura support a diverse mammalian assemblage. The study demonstrates the value of rapid, pragmatic field approaches for generating essential ecological information under resource constraints and underscores the need for continued monitoring and regional connectivity planning.

Keywords: Biodiversity monitoring, camera-trapping, habitat connectivity, Indo-Burma biodiversity hotspot, landscape fragmentation, pragmatism.

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Author contribution: OP, AJ and AP contributed to data collection. Study conception, study design, preparation, data collection and analysis were performed by OP & AJ. The first draft of the manuscript was written by OP and all authors contributed to refining & revising the manuscript.

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INTRODUCTION

Tropical regions of southern and southeastern Asia support some of the richest yet most threatened biodiversity on Earth (Woodruff 2010). Within this region, India harbours exceptional mammalian diversity across varied landscapes ranging from the Himalaya to the Indo-Burma and Western Ghats hotspots (Myers et al. 2000). Despite this richness, many landscapes remain poorly studied due to their remoteness, limited accessibility and research bias toward established protected areas (Datta et al. 2008; Jhala et al. 2020). These gaps limit our ability to generate spatially explicit and quantitative data on species occurrence and abundance, particularly in smaller or peripheral reserves that function as critical ecological corridors.

Tripura, located in the northeastern corner of India, forms an ecological bridge between the Indian subcontinent and southeastern Asia. The state lies within the Indo-Burma biodiversity hotspot and supports a mosaic of tropical evergreen, semi-evergreen and moist deciduous forests (Champion & Seth 1968; Deb 1981). Its geographic position between the hill forests of Bangladesh and Mizoram enables biological exchange between the Indian and southeastern Asian faunal realms (Datta et al. 2008). While previous studies have documented mammalian diversity in Tripura through checklists and regional accounts (Majumder et al. 2015; Majumdar & Datta 2018; Talukdar et al. 2021), these efforts have been descriptive and presence-based.

Existing knowledge of mammals in Tripura is therefore limited in three key ways: (i) a lack of standardised, effort-based surveys, (ii) absence of quantitative data on relative abundance and detection patterns, and (iii) minimal understanding of species distribution across multiple protected areas within a unified sampling framework. Most available studies rely on opportunistic records, localised surveys or species-specific investigations, such as those of Western Hoolock Gibbon *Hoolock hoolock* and Gaur *Bos gaurus* (Gupta et al. 2005; Dasgupta et al. 2008). While valuable, these studies do not provide comparable or landscape-level insights necessary for conservation planning.

In this context, camera-trapping offers a robust, non-invasive and standardised method for generating comparable data on species occurrence, detection, and relative abundance across sites. However, prior to this study, no landscape-scale, systematic camera-trapping assessment had been conducted across the protected areas of Tripura. This represents a critical knowledge gap, particularly given the increasing anthropogenic pressures on the state's forests.

Tripura's forest landscapes are undergoing rapid change due to shifting cultivation, illegal logging, expansion of rubber plantations and infrastructure development (Gupta 1998; Chatterjee 2008). These drivers contribute to internal fragmentation and alter habitat connectivity. In such dynamic and resource-constrained contexts, long-term ecological studies are often challenging. Rapid, exploratory biodiversity assessments when implemented using standardised protocols, provide an effective approach to generate baseline data and identify conservation priorities within limited time frames (Wearn & Glover-Kapfer 2017)

A pragmatic research approach is therefore essential, one that balances scientific rigor with logistical feasibility. Such approaches emphasize adaptive field strategies, stakeholder participation and collaboration with local forest departments to ensure both data quality and management relevance (Sutherland et al. 2004; Mishra et al. 2017; Palencia et al. 2022).

Against this backdrop, the present study was designed as an exploratory, landscape-scale camera-trapping assessment to address critical data deficiencies in Tripura. Specifically, the study aimed to: (i) document mammalian occurrence using standardized camera-trapping across protected areas, (ii) generate effort-based indices of relative abundance and detection, and (iii) establish a baseline dataset to support future monitoring and management interventions by the Tripura Forest Department.

This study represents the first systematic, multi-site camera-trapping exercise conducted across protected areas in Tripura, moving beyond opportunistic and checklist-based approaches to provide a quantitative and comparable understanding of mammalian communities. The rapid assessment was conducted between January and April 2024 as a collaborative initiative between the Vivek PARC Foundation, The Habitats Trust, and the Tripura Forest Department.

MATERIALS AND METHODS

Study area

The study was conducted across the protected areas of Tripura: Sepahijala Wildlife Sanctuary (SWS), Clouded Leopard National Park (CLNP), Trishna Wildlife Sanctuary (TWS), Bison National Park (BNP), Gumti Wildlife Sanctuary (GWS), and Rowa Wildlife Sanctuary (RWS). CLNP falls within SWS and is hereafter collectively referred to as SWS. Similarly, BNP, located within TWS, is referred to as TWS. Together they represent the principal habitats of the state, covering approximately 613 km². These areas include tropical evergreen, semi-evergreen and moist deciduous forest types interspersed with bamboo brakes and cultivation zones (Deb 1981) (Table 1, Figure 1).

Tripura has about 59.89% forest cover (Majumdar & Datta 2018). Historical accounts indicate that the forests of Tripura have long been subjected to anthropogenic pressures, particularly shifting cultivation, timber extraction, and plantation expansion (Gupta 1998). Climatically, the region experiences four distinct seasons, winter, summer, monsoon, and post-monsoon, with annual rainfall of 2,000–2,500 mm (Debnath et al. 2021). The present survey, conducted between January and April 2024, represents a winter to pre-monsoon sampling. This period was suitable for camera trapping as reduced water availability concentrates animal activity around water sources, enhancing detection probability. Additionally, soft substrates near water bodies facilitated the identification of animal signs such as pugmarks, aiding in optimal camera placement (Rovero & Zimmermann 2016).

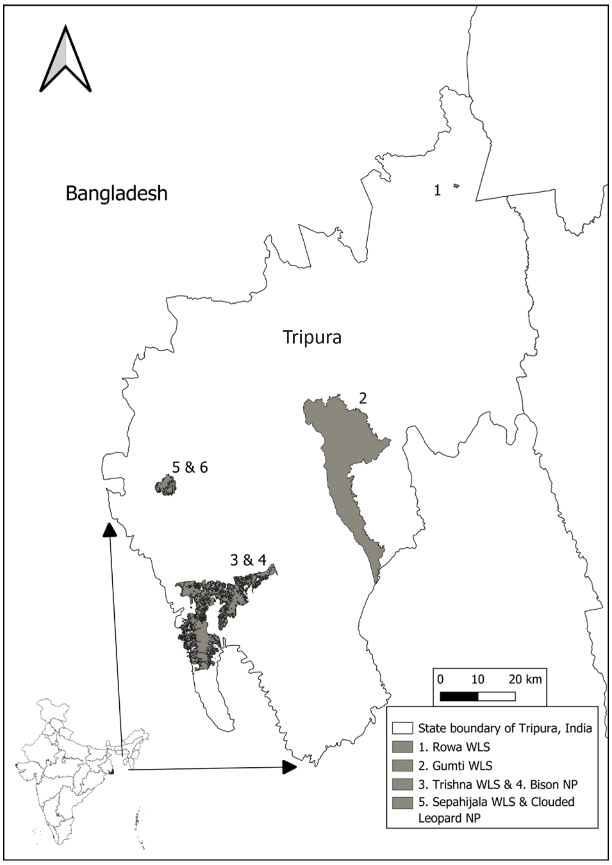

Figure 1. All the protected areas of Tripura along with the state boundary. WS—Wildlife Sanctuary | NP—National Park.

Sampling design

A grid-based camera-trap sampling framework was used following Rajaratnam et al. (2007) and Rovero & Zimmermann (2016). Grids of 2 km² were overlaid across each protected area. Camera traps were deployed in singles and pairs wherever feasible. In smaller reserves such as Rowa and Sepahijala, the grid layout was adjusted to accommodate limited area and access. Camera placement was guided by evidence of animal activity, such as pugmarks or scats, and grids with excessive human disturbance were avoided to minimize the bias and theft. Within TWS, 25 grids were selected for sampling, of which 14 were sampled, with all trap stations equipped with paired camera traps. In GWS, 48 grids were selected, of which 29 were sampled; camera traps were deployed in pairs at 15 stations and singly at 14 stations. In SWS, seven camera trap locations were selected, all with paired deployments. Similarly, in RWS, four camera trap locations were sampled, each with paired camera traps. Camera traps deployed singly were placed in areas with high human activity to reduce the risk of theft; this approach may have introduced detection bias, as a single camera covers a limited field of view compared to paired deployments.

The study followed a rapid assessment protocol emphasizing spatial coverage and standardized deployment over long-term replication. This design provides robust data on species presence and relative abundance but does not allow estimation of absolute densities or seasonal variation (O'Brien 2011).

Infrared and white-flash cameras (Cuddeback

Table 1. Details of the protected areas of Tripura.

Protected area	Size (km²)	Habitat type	Elevation range (in m)	Disturbance level
Sepahijala WS	18.5	Moist mixed deciduous forest	10–50	High
Trishna WS	194.71	Moist mixed deciduous forest	51–82	Moderate to high
Gumti WS	389.5	Tropical semievergreen forest	40–300	High
Rowa WS	0.8	Moist deciduous forest	70	Moderate to high

X-Change and Spartan Lumen models) were deployed for a maximum of 10 nights per location. Each site was geo-referenced, and details such as habitat type, elevation and proximity to human settlements were recorded. Cameras were positioned along trails or watercourses frequently used by wildlife. At certain locations, cameras were placed facing each other to document both flanks of patterned species (Johnson et al. 2009). Camera traps were mounted on trees or placed within small rock cavity-like structures at a height of approximately 30–45 cm above ground to target small-to medium-sized mammals. Additionally, two camera traps were opportunistically installed on trees at higher positions to sample arboreal mammals.

Camera traps were checked periodically by Tripura Forest Department staff and Banmitras. Cameras were concealed using natural vegetation and secured with locking cables.

Captured images were reviewed manually, and species identifications were verified independently by two observers (Images 1–17). Ambiguous images were labelled as "unidentified" and excluded from species-level analyses.

Detection bias and limitations

Camera detection probability varies among species due to body size, activity pattern and vegetation density. Smaller or arboreal mammals are generally under-detected (Burton et al. 2015). Consequently, relative abundance index (RAI) values are interpreted as indices of activity rather than true abundance. For species with fewer than 10 independent detections, results were treated qualitatively. Future monitoring could adopt occupancy or spatially explicit capture-recapture (SECR) models when sample sizes meet analytical thresholds (Efford & Fewster 2012; Wearn & Glover-Kapfer 2017).

Further, rarefaction curves were used to standardize species richness across sites with unequal sampling effort, enabling robust comparisons despite differences in trap-nights and detectability. They also help assess sampling adequacy by indicating whether additional effort is likely to record new species, making them particularly suitable for camera-trap studies (Gotelli & Colwell 2001; Magurran 2004).

Training, community engagement and ethics

Before field deployment, hands-on training sessions were organized for forest staff and Banmitras, focusing on equipment setup, troubleshooting and maintenance. Local communities around each protected area were informed about camera placement to minimize interference and promote awareness. No animals were handled or disturbed during the study, and all research was conducted under permits issued by the Tripura Forest Department.

Data management and quality control

All image files were systematically named using protected area and grid identifiers in the following format-'Name-of-PA_Forest-Range_Grid-ID' (for example, *GUM_GAN_CT1*). Metadata, including coordinates, habitat type, deployment date and personnel involved, were recorded in standardized field sheets. Images and metadata were stored in duplicate on external drives.

Data analysis

Relative abundance index (RAI):

RAI was used to estimate species activity across protected areas, serving as a cost-effective, non-invasive index widely applied in wildlife monitoring and management (O'Brien 2011).

RAI = (No. of independent detections/Total trap nights) * 100

Independent detections were defined as images of the same species separated by at least 30 min to avoid false replication (Rovero & Marshall 2009), and RAI values were calculated per protected area for comparative assessment of relative occurrence.

Diversity indices and hill numbers:

Biodiversity was quantified using two commonly applied indices: the Shannon-Wiener index (H') and the Simpson's index (D or 1–D).

$$H = -\sum_{j=1}^{S} p_i \ln p_i$$

where p_i is the proportion of detections of species *i* and *S* is the total number of species detected. A higher H' value indicates greater species diversity and evenness (Spellerberg & Fedor 2003).

Simpson's index (D) was calculated as

$$D = 1 - \sum_{i=1}^{N} (p_i)^2$$

where p_i is the same as above. Higher values of D indicate dominance by few species, whereas values of (1–D) closer to 1 represent higher overall diversity. These indices were calculated for each protected area to compare community structure and dominance patterns (He & Hu 2005).

To facilitate more intuitive and comparable interpretation of diversity across sites, the Shannon-Wiener (H') and Simpson (D) indices were converted to hill numbers (Hill 1973; Jost 2006). Traditional diversity indices are non-linear and expressed in units that are difficult to compare directly, whereas hill numbers transform these indices into the "effective number of species," representing the number of equally abundant species required to produce the observed diversity. This approach enables meaningful comparisons across sites with varying sampling effort and community structure, and is increasingly recommended as a standard in ecological studies (Jost 2006; Chao et al. 2014).

Shannon-Wiener (H′) and Simpson (D) indices were converted to Hill numbers using

$$^{1}D = e^{H'}$$

$$^{2}D = \frac{1}{D}$$

Rarefaction curve analysis

Independent camera-trap detections filtered using a 30-min temporal independence threshold were used to construct species-by-sampling-unit incidence matrices for each protected area, excluding cattle to avoid bias from domestic animals. Each grid cell (grid_id) was treated as a sampling unit and species presence-absence was calculated for per unit. Sample-based rarefaction curves were generated using the '*specaccum()*' function in the '*vegan*' package in R, applying the random method with 1,000 permutations to estimate mean richness and associated 95% confidence intervals (Oksanen et al. 2022), following established protocols for sample-based accumulation curves (Gotelli & Colwell 2001; Magurran 2004). Although coverage-based standardization is recommended when detection probabilities vary across sites (Chao & Jost 2012), sample-based rarefaction was used here to align with the dataset structure and sampling design.

Analytical approach

Given moderate detection rates, RAI and diversity indices were used as the primary comparative metrics. Occupancy or SECR models were not applied since individual recaptures per species were below the analytical threshold of 20 independent detections (Efford & Fewster 2012). All calculations were performed using Microsoft Excel and biodiversity indices were computed using R v4.3.2. Spatial visualization was conducted in QGIS 3.30.2.

RESULTS

A total of 19 mammalian species were documented from all the protected areas through a rapid camera-trapping survey conducted between January and April 2024 (Table 2). Rowa Wildlife Sanctuary was not included in the analysis due to insufficient data from camera traps. During field surveys, Barking Deer *Muntiacus vaginalis* was captured in a single camera trap, and direct sightings of Capped Langur *Trachypithecus pileatus*, Phayre's Leaf Monkey *Trachypithecus phayrei*, and Rhesus Macaque *Macaca mulatta* were recorded, indicating the continued presence of these species in the sanctuary. A cumulative sampling effort of 469 trap nights was achieved across all three protected areas, with the highest effort recorded in GWS (280 trap nights), followed by TWS (122) and SWS (77) (Table 3). Five cameras that malfunctioned or were lost were excluded from analyses.

The number of independent detections ranged from 46 in GWS to 150 in SWS (including 114 detections from TWS), collectively yielding 292 independent photographic captures. Despite variation in sampling effort, all the protected areas exhibited substantial mammalian activity, indicating diverse assemblages across the landscape.

Across all study sites, 19 species belonging to 10 families and four orders were recorded (Table 4). These included representatives of Carnivora, Primates, Artiodactyla, and Rodentia. Out of the 19 species, 17 were recorded in the camera traps while Capped Langur and Western Hoolock Gibbon *Hoolock hoolock* were sighted.

Key species detected were Rhesus Macaque, Pig-tailed Macaque *Macaca leonina*, Phayre's Leaf Monkey, Leopard Cat *Prionailurus bengalensis*, Common Palm Civet *Paradoxurus hermaphroditus*, Small Indian Civet *Viverricula indica*, Wild Pig *Sus scrofa*, and Barking Deer.

The photographic evidence of Fishing Cat *Prionailurus viverrinus* in TWS and Small-clawed Otter *Aonyx cinerea* in TWS provides significant records of wetland-dependent species within the Indo-Burma landscape.

Abundance Index (RAI)

The relative abundance index (RAI) revealed spatial variation in species activity across the three protected areas. In SWS, the Rhesus Macaque exhibited the highest RAI (69.12 ± 34.74), indicating strong primate activity within the sanctuary. Other frequently captured species were Large Indian Civet *Viverra zibetha* (25.00 ± 14.43), Pig-tailed Macaque (17.65 ± 8.66) and Common Palm Civet (14.71 ± 10.03). Herbivores such as Barking

Table 2. Summary of the camera-trapping effort undertaken in all the protected areas of Tripura. Note: Rowa Wildlife Sanctuary was not included in the analysis due to insufficient camera-trap data. Records from camera traps and opportunistic sightings were documented during field surveys.

Protected area	No. of camera-trap stations	Active trap nights	Period (2024)
Rowa WS	4	12	29 Jan– 04 Feb
Sepahijala WS	8	77	10 Feb–18 Feb
Trishna WS	15	112	19 Feb–08 Mar
Gumti WS	29	280	09 Mar–05 Apr
Total	**56**	**481 (469)**	-

Table 3. Camera-trap effort, number of species detected, number of independent captures and total trap nights across protected areas of Tripura.

Protected area	No. of species detected	No. of independent captures	Total trap nights
Sepahijala WS	9	107	77
Trishna WS	12	114	112
Gumti WS	8	71	280
Total	-	292	469

Deer (11.76 ± 6.42) and Wild Pig (10.29 ± 5.94) were also well represented.

In TWS, the Common Palm Civet (21.95 ± 10.03) and Pig-tailed Macaque (8.13 ± 8.66) were most abundant, while Gaur *Bos gaurus* (4.88 ± 2.82) and Small-clawed Otter *Aonyx cinerea* (3.25 ± 1.88) represented key large and semi-aquatic mammals, respectively. The photographic record along with numerous sightings of multiple troops of Phayre's Leaf Monkey reaffirmed the site's role as a crucial habitat for this threatened primate.

In GWS, overall detection rates were lower, with Crab-eating Mongoose *Urva urva* (16.37 ± 8.20) and Leopard Cat (2.49 ± 0.55) being the most frequently recorded. The presence of Leopard Cat and Masked Palm Civet *Paguma larvata* (0.36 ± 0.21) reflects habitat heterogeneity.

The dominance of adaptable species such as civets, macaques and small carnivores suggests that the mammalian community remains resilient under moderate anthropogenic pressure (Burton et al. 2015).

Species diversity

The Shannon-Wiener (H') and Simpson's diversity ndices (1–D) along with Hill numbers were calculated for each protected area (Table 5).

- Trishna Wildlife Sanctuary (H' = 1.984; 1–D = 0.8294) exhibited the highest diversity and lowest dominance (D = 0.1706), indicating a well-balanced species distribution.

- Sepahijala Wildlife Sanctuary (H' = 1.917; 1–D = 0.8194) showed moderate diversity, reflecting a stable community dominated by primates and civets.

- Gumti Wildlife Sanctuary (H' = 1.853; 1–D = 0.7843) displayed lower diversity and higher dominance (D = 0.2157), suggesting localized concentration of a few species such as Crab-eating Mongoose and Leopard Cat.

- Conversion of diversity indices to Hill numbers indicated that Trishna Wildlife Sanctuary exhibited the highest effective number of species (^1D = 7.27; ^2D = 5.86), followed by Sepahijala Wildlife Sanctuary, and Gumti Wildlife Sanctuary . The larger difference between ^1D and ^2D in GWS suggests greater dominance by a few species and lower community evenness, whereas TWS showed comparatively higher evenness and a more balanced species assemblage.

These results collectively indicate that Trishna supports the most even and balanced mammalian assemblage, followed by Sepahijala, while Gumti, though larger, is more ecologically heterogeneous.

Rarefaction curves

The rarefaction curve (Figure 2) for GWS shows a steady increase in species richness with increasing sampling units, with the curve beginning to approach an asymptote near the highest sampling intensity. This suggests that sampling captured most of the detectable species in this landscape, though a small number of undetected species may still remain. The gradually narrowing confidence interval indicates increasing precision at higher sampling effort. The curve's shape is consistent with well-sampled assemblages reported in other camera-trap studies where species detection stabilizes after sufficient spatial coverage (Kays et al. 2020).

The rarefaction curve (Figure 3) for SWS rises sharply during the initial sampling units, reaching approximately 8–9 species before showing signs of flattening. Due to the relatively low total number of sampling units (1–7), this apparent plateau may reflect limited sampling effort rather than true community saturation. Small sample sizes can give the illusion of convergence even when many species remain undetected (Gotelli & Colwell 2001). Thus, while the curve suggests moderate richness, additional sampling is likely necessary for a robust estimate.

The rarefaction curve (Figure 4) for TWS reaches the highest richness values among the three groups, with the

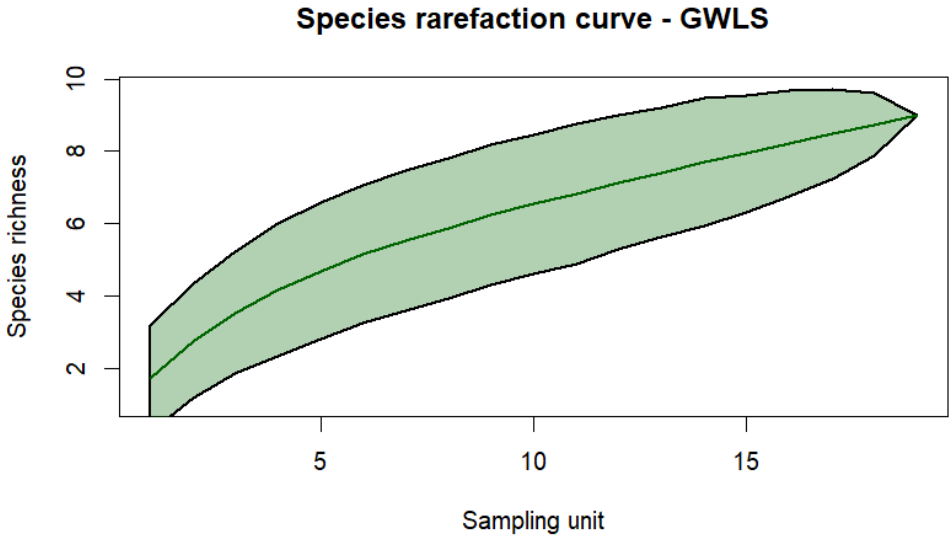

Figure 2. Species rarefaction curve for Gumti Wildlife Sanctuary.

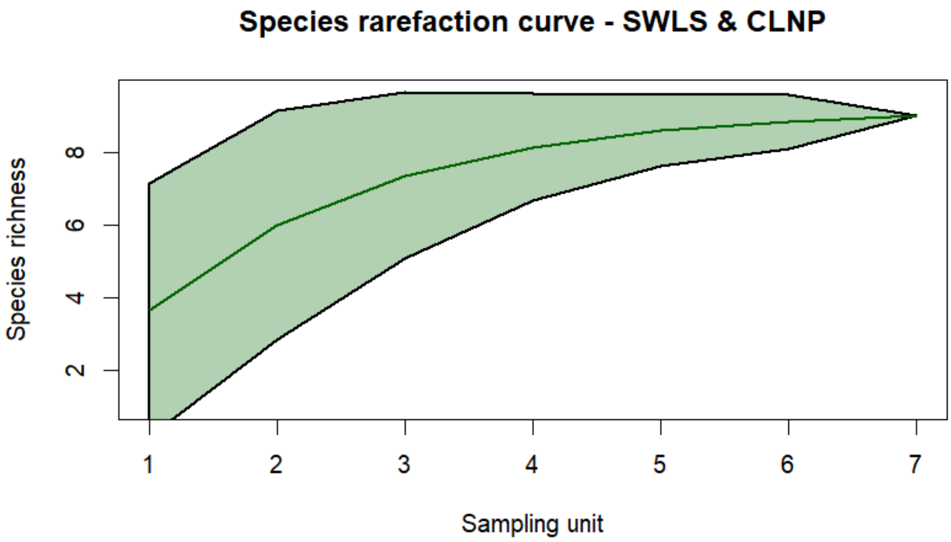

Figure 3. Species rarefaction curve for Sepahijala Wildlife Sanctuary & Clouded Leopard National Park.

upper confidence envelope exceeding 12 species. Unlike GWS, this curve continues to rise at higher sampling effort, indicating incomplete sampling and a higher likelihood of undiscovered species. This pattern aligns with studies showing that species-rich or structurally complex habitats require higher sampling intensity to capture full community composition. The combination of high richness and a non-asymptotic curve suggests TWS supports a relatively diverse mammalian assemblage and would benefit from expanded sampling.

Sample-based rarefaction curves provide a standardized comparison of species richness across protected areas in Tripura. GWS appears near-saturated, indicating adequate sampling. SWS shows moderate richness but requires additional sampling to confirm community estimates. TWS exhibits the highest richness and incomplete saturation, highlighting the need for increased sampling to fully document the species assemblage.

Noteworthy records

Several key species records obtained during the survey represent important contributions to the faunal inventory of Tripura:

1. This study provides the first camera-trap-based photographic record of the Ferret Badger *Melogale*

Table 4. Checklist of mammalian species recorded from the protected areas of Tripura with relative abundance index (RAI) values.

Common name	Scientific name	Order	Family	RAI SWS	RAI TWS	RAI GWS
Northern Red Muntjac	*Muntiacus vaginalis*	Artiodactyla	Cervidae	11.76 ± 6.42	1.42 ± 6.42	-
Wild Boar	*Sus scrofa*	Artiodactyla	Suidae	10.29 ± 5.94	-	-
Gaur	*Bos gaurus*	Artiodactyla	Bovidae	-	4.88 ± 2.82	-
Common Palm Civet	*Paradoxurus hermaphroditus*	Carnivora	Viverridae	14.71 ± 10.03	21.95 ± 10.03	2.14 ± 10.03
Large Indian Civet	*Viverra zibetha*	Carnivora	Viverridae	25.00 ± 14.43	-	-
Small Indian Civet	*Viverricula indica*	Carnivora	Viverridae	-	0.81 ± 0.41	0.36 ± 0.41
Masked Palm Civet	*Paguma larvata*	Carnivora	Viverridae	-	-	0.36 ± 0.21
Crab-eating Mongoose	*Urva urva*	Carnivora	Herpestidae	-	7.32 ± 8.20	16.37 ± 8.20
Ferret Badger	*Melogale* sp.	Carnivora	Mustelidae	-	-	1.78 ± 1.03
Asian Small-clawed Otter	*Aonyx cinerus*	Carnivora	Mustelidae	-	3.25 ± 1.88	-
Leopard Cat	*Prionailurus bengalensis*	Carnivora	Felidae	1.47 ± 0.55	1.63 ± 0.55	2.49 ± 0.55
Fishing Cat	*Prionailurus viverrinus*	Carnivora	Felidae	-	-	2.68 ± 2.09
Jungle Cat	*Felis chaus*	Carnivora	Felidae	-	0.81 ± 0.47	-
Malayan Porcupine	*Hystrix brachyura*	Rodentia	Hystricidae	7.35 ± 4.25	-	-
Phayre's Leaf Monkey	*Trachypithecus phayrei*	Primates	Cercopithecidae	-	0.81 ± 0.47	-
Capped Langur	*Trachypithecus pileatus*	Primates	Cercopithecidae	-	-	-
Rhesus Macaque	*Macaca mulatta*	Primates	Cercopithecidae	69.12 ± 34.74	40.65 ± 34.74	-
Northern Pig-tailed Macaque	*Macaca leonina*	Primates	Cercopithecidae	17.65 ± 8.66	8.13 ± 8.66	0.36 ± 8.66
Hoolock Gibbon	*Hoolock hoolock*	Primates	Hylobatidae	-	-	-

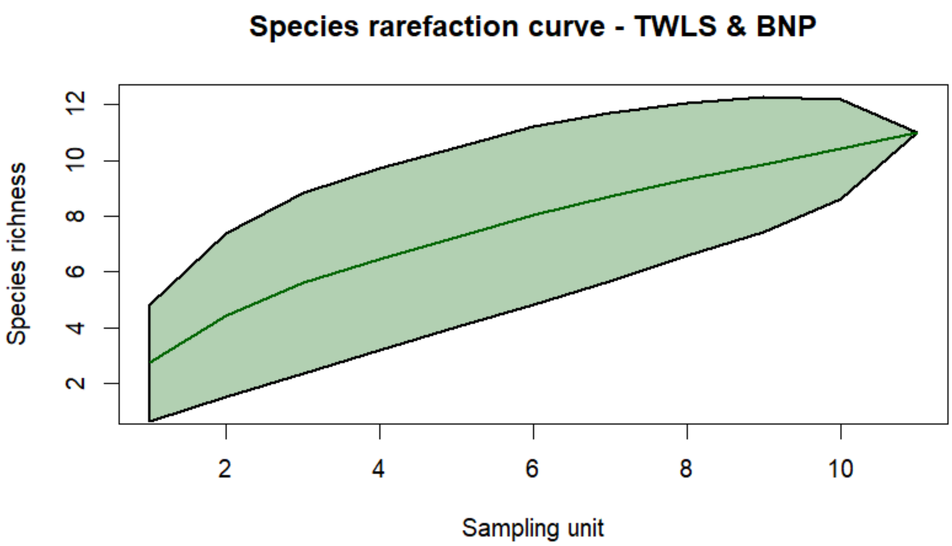

Figure 4. Species rarefaction curve for Trishna Wildlife Sanctuary & Bison National Park.

sp. from the state, reconfirming its presence in Tripura within the Indo-Burma biodiversity hotspot (Patil et al. 2025a).

2. Confirmed locality records were obtained for the Malayan Porcupine *Hystrix brachyura* and the Fishing Cat *Prionailurus viverrinus* from western and southern Tripura, respectively (Patil et al. 2025b). While both species are widely distributed across northeastern

Table 5. Simpson's (1–D) and Shannon-Wiener (H') diversity indices, along with hill numbers for mammals across protected areas of Tripura. Diversity indices and corresponding Hill numbers (q = 1 and q = 2) across SWS, TWS, & GWS representing the effective number of common and dominant species, respectively.

	SWS	TWS	GWS
Total individuals (N)	196	192	130
Simpson's dominance index (D)	0.1805861	0.1705934	0.2157424
Simpson's index of diversity (1-D)	0.8194139	0.8294066	0.7842576
Shannon's index (H')	1.917	1.984	1.853
Hill number ($^1D=e^{H'}$)	6.80	7.27	6.38
Hill number ($^2D=1/D$)	5.54	5.86	4.63

India, these represent the first systematic photographic records from the state, thereby strengthening their known occurrence and contributing to finer-scale range documentation.

3. A small subpopulation of Gaur *Bos gaurus* was documented in TWS, representing the species' continued presence in the state despite its absence from current IUCN Red List distribution map (Duckworth et al. 2016).

These photographic confirmations strengthen the evidence base for Tripura's mammalian diversity and update species distributions within the Indo-Burma transition zone.

Despite the smaller area and higher human population density, Tripura's protected areas continue to sustain a diverse mammalian community representative of the Indo-Burma transition zone.

DISCUSSION

Mammalian assemblage and species composition

The present assessment provides an updated account of the mammalian community within Tripura's protected areas and confirms the persistence of 19 species representing 16 genera, 10 families and four orders. The assemblage is dominated by small to medium-bodied carnivores and primates, with ungulates contributing to the herbivore guild, a pattern typical of fragmented tropical forest systems in the Indo-Burma biodiversity hotspot, where adaptable species persist under anthropogenic pressure (Datta et al. 2008; Bhatt et al. 2022).

Across sites, TWS exhibited the highest species diversity and evenness, whereas GWS displayed lower diversity but harboured several rare and specialized species. SWS, despite higher human influence, recorded high primate activity. Together, these patterns indicate that Tripura's protected areas function as complementary components of the regional mammalian diversity.

The co-occurrence of multiple primate species, including Phayre's Leaf Monkey, Rhesus Macaque, and Pig-tailed Macaque, further reflects microhabitat heterogeneity and ecological continuity of arboreal habitats.

New records and biogeographic implications

Several notable records expand the known distribution of mammals in Tripura. The Malayan Porcupine recorded in SWS represents a westward range extension (unpublished), while the Fishing Cat documented in TWS provides the first photographic confirmation from this region (Patil et al. 2025b). Both species are habitat specialists, associated with mixed bamboo-deciduous forests and wetland ecosystems, respectively, highlighting the importance of heterogeneous habitats and small wetlands as refugia within modified landscapes. Similarly, the first photographic evidence of Ferret Badger adjacent to a Jhum cultivation reconfirms its presence within the region. Its occurrence in such a disturbed habitat corroborates its known ecological adaptability and highlights the species' resilience in a dynamic landscape (Patil et al. 2025a).

The species assemblage broadly aligns with patterns reported from Manas National Park, Dampa Tiger Reserve, and community reserves in Meghalaya, where generalist species such as Leopard Cat and Common Palm Civet dominate (Sethy et al. 2021; Bhatt et al. 2022; Lyngdoh et al. 2023). The occurrence of wetland and forest-edge specialists such as Fishing Cat and Small-clawed Otter underscores Tripura's unique position at the intersection of Indo-Gangetic and Indo-Burmese biogeographic zones. Despite their relatively small size and isolation, these protected areas continue to function as important refuges and potential dispersal corridors.

Conservation and management Implications

The presence of a small, isolated subpopulation of Gaur in TWS further enhances the site's conservation importance. Despite its exclusion from the IUCN distribution map, repeated photographic and direct observations confirm its persistence (Duckworth et al. 2016). This population likely represents a relict group isolated from the larger populations in Mizoram and Bangladesh, raising concerns regarding long-term genetic viability. In contrast, Asiatic Wild Dogs

Cuon alpinus, historically present, appear to be locally extirpated, likely due to restricted transboundary movement caused by border fencing. Such barriers limit dispersal of wide-ranging species including Dholes, Asian Elephants, and Gaur, reflecting the complex interface between conservation and national security.

The findings of this study underscore several key implications for conservation management in Tripura:

1. Habitat heterogeneity and wetland protection: The detection of Fishing Cat, Small-clawed Otter and Malayan Porcupine highlights the importance of conserving diverse habitats, including riparian zones, bamboo thickets and degraded mixed forests. Management plans should incorporate small wetlands and community-managed water bodies within buffer areas.

2. Connectivity and landscape integration: The isolation of *Bos gaurus* and the extirpation of *Cuon alpinus* highlight the vulnerability of wide-ranging species requiring large home ranges. Continuous border fencing has likely restricted transboundary movement, isolating populations within Tripura and limiting functional connectivity with Bangladesh. Conservation efforts should therefore prioritize strengthening ecological linkages within the state, particularly between protected and adjoining non-protected forests, and maintaining connections with forested landscapes of Mizoram. Enhancing habitat quality and reducing anthropogenic pressures will be critical to sustain viable populations in an increasingly fragmented landscape. Under the current landscape configuration, opportunities for functional transboundary conservation with Bangladesh are limited, as continuous border fencing restricts wildlife movement and dispersal. Consequently, populations on either side are likely to function independently, reducing the effectiveness of traditional transboundary conservation approaches that rely on ecological connectivity.

3. Monitoring small carnivores and lesser-known species: The first photographic record of *Melogale* sp. underscores the importance of long-term monitoring of cryptic species. Expanding camera-trap networks both temporally and spatially will help capture rare occurrences and establish reliable population baselines. Together, these findings emphasize that Tripura's small but ecologically varied protected areas remain critical for regional mammal conservation and warrant sustained management attention and monitoring, although interpretations are conservative given the rapid assessment nature of the survey.

Pragmatism in research

Conducting wildlife research in smaller northeastern states poses logistical, temporal and infrastructural constraints. The current study adopted a pragmatic research approach, emphasizing achievable, methodologically sound outcomes within the available time and resources. Limited camera availability was addressed through a rotating deployment strategy, while sampling grids were selected based on animal sign evidence to maximize detection probability and spatial coverage.

These decisions directly contributed to key outcomes of the study. The optimized camera deployment enabled coverage across multiple protected areas within a short duration, resulting in the documentation of 19 species, including rare and previously unrecorded taxa such as Ferret Badger. The targeted placement of cameras in areas with animal signs improved detection success, facilitating the recording of habitat specialists such as Fishing Cat and Malayan Porcupine and allowing estimation of relative abundance across sites.

Pragmatism in conservation research prioritizes the generation of actionable data that can directly inform management decisions even when comprehensive long-term datasets are unavailable (Sutherland et al. 2004).

In this study, a combination of structured sampling and flexible field design ensured that results remain both reliable and management-relevant, particularly for guiding rapid conservation interventions and strengthening baseline data for future monitoring in Tripura.

CONCLUSION

This assessment provides the most recent and one of the first systematic accounts of Tripura's mammalian fauna to date. The documentation of new species records, range extensions, and isolated subpopulations contributes substantially to regional biodiversity knowledge. Despite limited area and increasing anthropogenic pressures, the protected areas of Tripura retain ecological significance as functional refuges within the Indo-Burma biodiversity hotspot. The study reinforces the need for continuous monitoring, landscape-level habitat management and the integration of pragmatic research strategies into conservation planning.

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Image 1. Asian Small-clawed Otter *Aonyx cinereus*.

Image 2. Common Palm Civet *Paradoxurus hermaphroditus*.

Image 3. Crab-eating Mongoose *Urva urva*.

Image 4. Ferret Badger *Melogale* sp.

Image 5. Fishing Cat *Prionailurus viverrinus*.

Image 6. Gaur *Bos gaurus*.

Image 7. Indian Muntjac *Muntiacus vaginalis*.

Image 8. Jungle Cat *Felis chaus*.

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Image 12. Masked Palm Civet *Paguma larvata*.

Image 13. Phayre's Leaf Monkey *Trachypithecus phayrei*.

Image 14. Pig-tailed Macaque *Macaca leonina*.

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Image 16. Small Indian Civet *Viverricula indica*.

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