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ORIGINAL ARTICLE

Population size and roost use of the greater false vampire bat *Lyroderma lyra* (Family: Megadermatidae) in a northern hill forest with updated distribution in Bangladesh

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ABSTRACT

Synanthropic roosting behavior of bats, i.e., roosting in human-made structures, provides valuable insight into environmental plasticity. Roosting adaptations are the key to survival and essential for setting conservation strategies, especially in landscapes that are undergoing rapid habitat modification. The greater false vampire bat (*Lyroderma lyra*) is a carnivorous species with a diet dominated by insects and occasionally including small vertebrates, which is frequently observed in both natural and human-modified habitats across South and Southeast Asia. However, its roosting ecology and fine-scale distribution remain poorly documented in Bangladesh. To address these gaps, we identified roosts and estimated population size at Madhutila Eco-Park (MEP), a human-modified hill forest in northern Bangladesh, and updated national distribution records of *L. lyra* based on direct observation and available references. Fieldwork was conducted between September and November 2024, and roosts were identified using a preliminary roost assessment survey combined with direct visual counts. Species distribution was updated by compiling published records and field observations. We documented one diurnal roost and four night roosts within MEP, all located in abandoned anthropogenic structures. The estimated population at the diurnal roost ranged from 394 to 443 individuals, based on detection probabilities of 0.8 and 0.9, providing a lower-bound range that accounts for potential under detection. We also identified five additional diurnal roosts across five protected areas, outside MEP, located in both natural and anthropogenic settings in Bangladesh. The findings offer documentation of *L. lyra* roosting ecology from MEP and an updated distribution in Bangladesh. We recommend prioritizing long-term monitoring to assess population trends and potential threats to bats roosting in the human-made structures and incorporating those synanthropic roosts into protected area management plans.

INTRODUCTION

Bats are the only mammals capable of true flight, widely distributed globally, occurring in all continents but largely absent within polar regions of Antarctica, Arctic and a few oceanic islands (Mickleburgh, Hutson and Racey, 2002). Around 1500 species of bat have been documented worldwide, with 153 reported from South Asia and 36 from Bangladesh (Hasan et al., 2025; Simmons and Cirranello, 2025; Srinivasulu, Srinivasulu and Srinivasulu, 2026). As nocturnal mammals, bats typically roost during the daytime in shady, dark places such as caves, tree holes, tree hollows and human-made structures (Kunz and Lumsden, 2003). The greater false vampire bat *Lyroderma lyra* (formerly known as *Megaderma lyra*) often uses human-made structures, including abandoned buildings, bridges, and road culverts, as roosting sites for shelter and reproduction, which are comparable microclimatic conditions to natural roosts, and may explain the species' synanthropic roosting behavior (Bates and Harrison, 1997; Voigt et al., 2016; Gual-Suárez and Medellín, 2021). This species falls under the Megadermatidae family, distributed in South and Southeast Asia, ranging from Afghanistan to Bangladesh (Feng et al., 2024). Its broad geographic range and ecological flexibility, evidenced by larger colony sizes (Bates and Harrison, 1997; Molur et al., 2002; Feng et al., 2024), a diverse feeding niche (Aitken, 1907; Gleadow, 1907; Mossea, 1931), and the use of both natural (e.g., caves, tree hollows) and anthropogenic structures for roost, may suggest *L. lyra* as a generalist species.

Lyroderma lyra is identified as a least concern (LC) species with unknown population trends both globally and locally (Srinivasulu and Srinivasulu, 2020; IUCN Bangladesh, 2015). Estimating population size and the distribution are fundamental to wildlife conservation as the data provide critical information for evaluating extinction risk and conservation measures (IUCN Standards and Petitions Committee, 2022). However, this remains challenging for many bat species to estimate population because they travel over larger areas, exhibit complex and often unpredictable roost distribution patterns, and frequently occupy concealed microhabitats even within established roosts (Ransome, 1989). Traditional methods for estimating bats from roosts include visual counts, emergence counts, recorded imagery, and mark-recapture techniques (Kunz et al., 2009; Jaffe, Carter and Corcoran, 2025). In addition, thermal imaging (Betke et al., 2008; Meade et al., 2025) and acoustic recordings (Kloepper et al., 2016; Milchram et al., 2020) are getting popular as digital methods. When most of the roosting bats are visible, direct visual count can be particularly effective (Kunz et al., 2009), as direct visual count can detect at least 92% of bats from diurnal roost, which can increase up to 99% of bats under mixed methods with certain conditions (multiple observers and multiple counts, visibility) and diurnal roost type (e. g., tree cavities) (Fleming et al., 2013). The visual count was effectively used in other studies around the world as well (Puechmaille and Petit, 2007; Moosman Jr et al., 2020). Bat roosts in ceilings of caves, mines, and buildings, where direct counts may be an acceptable method as long as prolonged disturbance can be avoided or minimized and the use of visual count methods has increased ability to estimate more accurate and reliable numbers of bats present (Kunz et al., 2009).

Bangladesh is a country with a high human population density, retaining only about 6% of its natural habitats (Khan, 2018; Azam and Rahman, 2022). With accelerating urbanization, many bats may rely more heavily on anthropogenic structures, yet the impacts of urban development on roost availability, foraging resources, and habitat conditions differ among regions and species, and are not always negative (Jung and Threlfall, 2016). Studying bats that predominantly roost in buildings is important not only for understanding the role of anthropogenic structures across different life stages of bats, but also for informing zoonotic disease surveillance and biodiversity conservation (Voigt et al., 2016; Winter, Mantilla-Contreras and Schmidt, 2020; Lunn et al., 2023).

Although *L. lyra* is listed as widely distributed in Bangladesh (IUCN Bangladesh, 2015), evidence-based fine-scale distribution data remain scarce. The most recent review by Hasan and Kingston, (2022) reported confirmed records of *L. lyra* from only three locations in the country and no previous records from northern Bangladesh. This limited spatially and ecologically explicit information hinders accurate assessments of its habitat use, conservation status, and exposure to local threats from land-use change or human disturbance. Therefore, understanding the distribution and population size of *L. Lyra* is important for its conservation planning. In this study, we aimed to identify the roosting sites, estimate the population size of *L. lyra* in human-modified landscapes of Madhutila Eco-Park forest range and update its distribution record in Bangladesh.

MATERIALS AND METHODS

Study Area

Madhutila Eco-Park (MEP) is a 3 km² deciduous forest within the Madhutila forest range (25°12´ N, 90°09´E), located in Sherpur District, Bangladesh, and bordering the Meghalaya region of India (IUCN Bangladesh, 2015; Islam et al., 2017). The area has an average elevation of 27 m above sea level, an average temperature of 27°C, and annual rainfall is approximately 2000–2500 mm. The topography is very rugged with a series of ridges running in a north-south direction (Aziz et al., 2016). A highway runs east-west through the study area and divides it into a *Shorea robusta* tree-dominated forest in the north and a southern area characterized by mixed and monoculture plantations and agricultural lands (Fig. 1). Within MEP, a artificial lake and several buildings have been developed for tourists within the forested landscape.

Species Identification

Two megadermatid species occur in Bangladesh, *Lyroderma lyra* and *Megaderma spasma. L. lyra* has an elongate posterior noseleaf with nearly parallel-sided flaps and a narrow oval intermediate noseleaf, whereas *M. spasma* has broader convex flaps and a distinctly heart-shaped intermediate noseleaf. These characters are readily visible in photographs, allowing reliable separation of the two species (Francis, 2019).

Roost identification

Roost surveys were conducted from September to November 2024 using the Preliminary Roost Assessment (PRA) method, which involved systematic visual inspections of abandoned buildings and trees, as well as interviews with local community members to locate potential bat roosts (Froidevaux et al., 2020). To identify roosts, we surveyed during the day (10:00-17:00) and at night (20:00-22:00) over two survey days each month. Each suspected roost was then revisited twice per month to confirm occupancy throughout the study period. We used a handheld GPS (Garmin e-Trex10) to record locations of the roost. The distance between the roost and nearest water sources was calculated using Google Earth Pro.

Population size estimation

Individuals were counted in each month (September - November 2024) during daytime from the only identified diurnal roost of MEP (Table 1, Supplementary Materials (SM) Table and Fig. 1), using the direct visual count method (Kunz, 2003; Kunz et al., 2009) to estimate the population size. Hand counters were used to count individuals under minimal lighting to reduce disturbance. Observers systematically scanned all walls and ceilings within the roost. To minimize observer bias and avoid double-counting, three observers counted simultaneously, each assigned to a specific section of the roost. No individual bats were observed moving between rooms during counts, thereby ensuring count accuracy. The diurnal roost of MEP consisted of three rooms; two had bamboo ceilings that provided concealed spaces and reduced visibility, whereas the third room had no ceiling

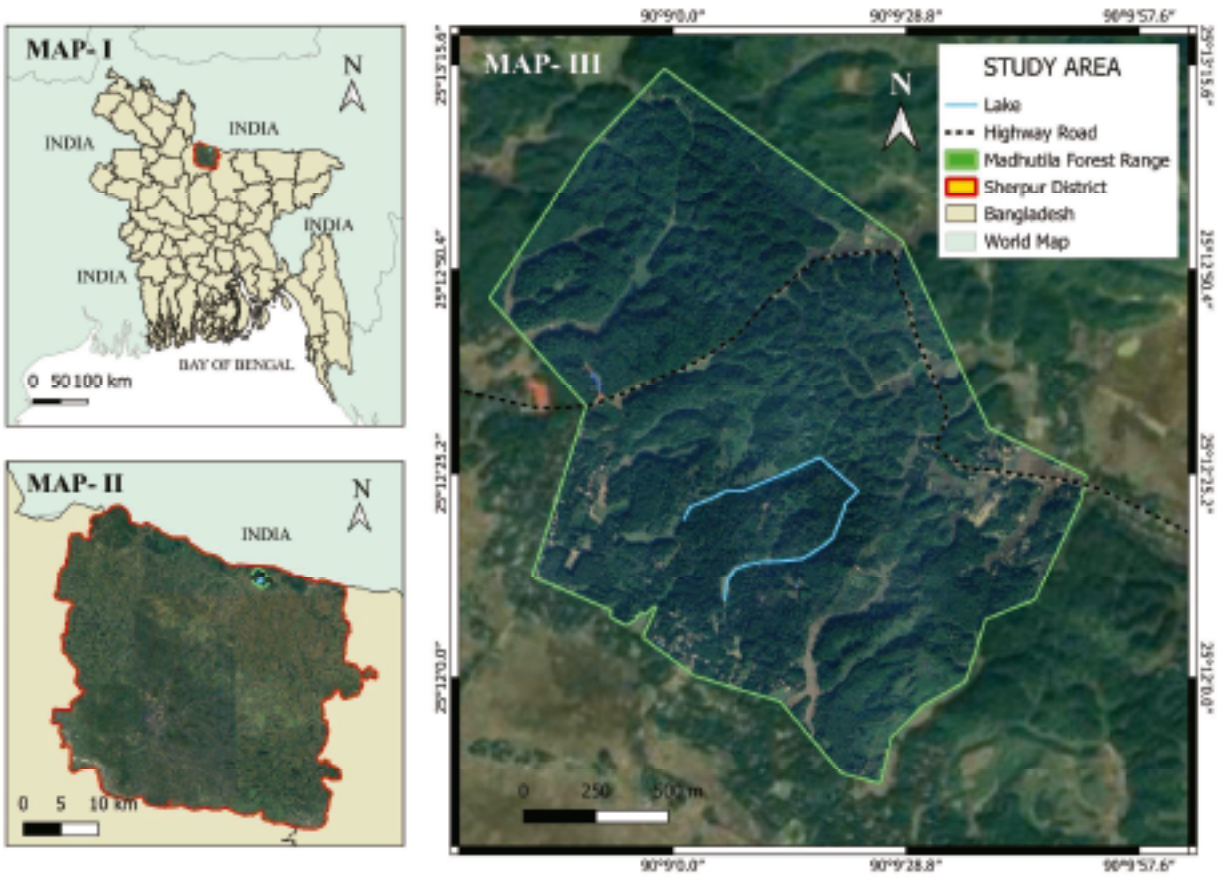


Fig. 1 - Location of the study area in Bangladesh and spatial extent of Madhutila Eco-Park. (Map I)- Map of Bangladesh with Sherpur District highlighted. (Map II)- Sherpur District showing the location of Madhutila Eco-Park. (Map III)- Boundary of the Madhutila Eco-Park within Madhutila Forest Range.

(Table 1 and SM Fig. 1). Because a proportion of bats could have remained hidden within ceiling gaps and crevices, direct counts were likely to underestimate the number of individuals present. We therefore adjusted raw counts using a detection probability range (β) of 0.8–0.9, following Kunz et al. (2009). This detection range was not derived empirically for this roost from independent detection trials, but was applied as a precautionary adjustment to account for moderate visual obstruction from the damaged ceiling, the use of minimal lighting during counts, and the possibility that some individuals remained hidden in crevices or ceiling gaps. Population size (N) was estimated using the formula: $N = C/\beta$, where C represents the average number of individuals counted per survey and β is the detection probability (Kunz et al., 2009).

Distribution record compilation

To update fine-scale distribution data for *L. lyra* in Bangladesh, we compiled all occurrence records reported after the review period covered by Hasan and Kingston, (2022), which summarized records available up to February 2022. The updated dataset comprised records from 2022 to 2025 obtained from published studies conducted in Bangladesh, field surveys by the authors, and personal communications from researchers with documented observations of the species. Only records supported by explicit evidence, such as capture by the authors, diagnostic photographs, or direct roost documentation, were retained. When the same record was reported by multiple sources for the same locality and sampling period, it was counted as one locality. Records with uncertain species identification or without supporting documentation were excluded. Verified and confirmed records were then mapped using QGIS (version 3.34.13) to produce an updated distribution map for the species.

RESULTS

Identified roosts of *Lyroderma lyra*

We identified a total of four night roosts and one diurnal roost in Madhutila Eco-Park. All identified roosts were located near an artificial lake (within approximately 500 m), which is a permanent water source inside the Eco-Park area (Table 1). Night roosts were distributed to the north of the diurnal roost within a 1.37 km radius inside the forest. The diurnal roost (DR), along with night roosts NR1 and NR2, were located in abandoned buildings (SM Table 1 and Fig. 1). The Diurnal Roost (DR) was located in an abandoned L-shaped house consisting of three rooms, two with bamboo ceilings and one without a ceiling, while NR3 and NR4 were situated within small culverts. NR3 was identified adjacent to a lake, and NR4 was located in a culvert under a highway (Fig. 2). NR4 is the farthest identified roost from both DR and the lake.

Estimated population size

The estimated population of *L. Lyra* in the diurnal roost ranged from 394-443 individuals (Table 2). No other species were detected in the diurnal roost during the counts. The lowest number of individuals was recorded in September (341 individuals), the highest in October (375 individuals) and the mean count across the three months was approximately 355 individuals (Table 2).

Table 1 - Characteristics of *Lyroderma lyra* roosts, colony sizes, and distance from night roosts (NR) to diurnal roost (DR) and to the nearest water source.

Roost	Roost Structure	Bat counted	Distance from diurnal roost (m)	Distance from nearest water source (m)
DR	Three rooms of an abandoned tin shade building	341-375	-	200
NR1	Single room of an abandoned tin shed building	3-5	388	100
NR2	Single room of an abandoned tin shed building	3-4	397	35
NR3	Culvert under a road	4-8	507	5
NR4	Culvert under a highway	3-5	1367	470

DR- Diurnal Roost; NR- Night Roost

Table 2 - Estimation of *Lyroderma lyra* population from Diurnal Roost

Month	Bat counted	Average bats counted	Estimated Total, N = (C/β)	
			80% (β= 0.8)	90% (β= 0.9)
September	341			
October	375	354.67	443*	394*
November	348			

*Decimal values were omitted and counts were rounded down to whole numbers.

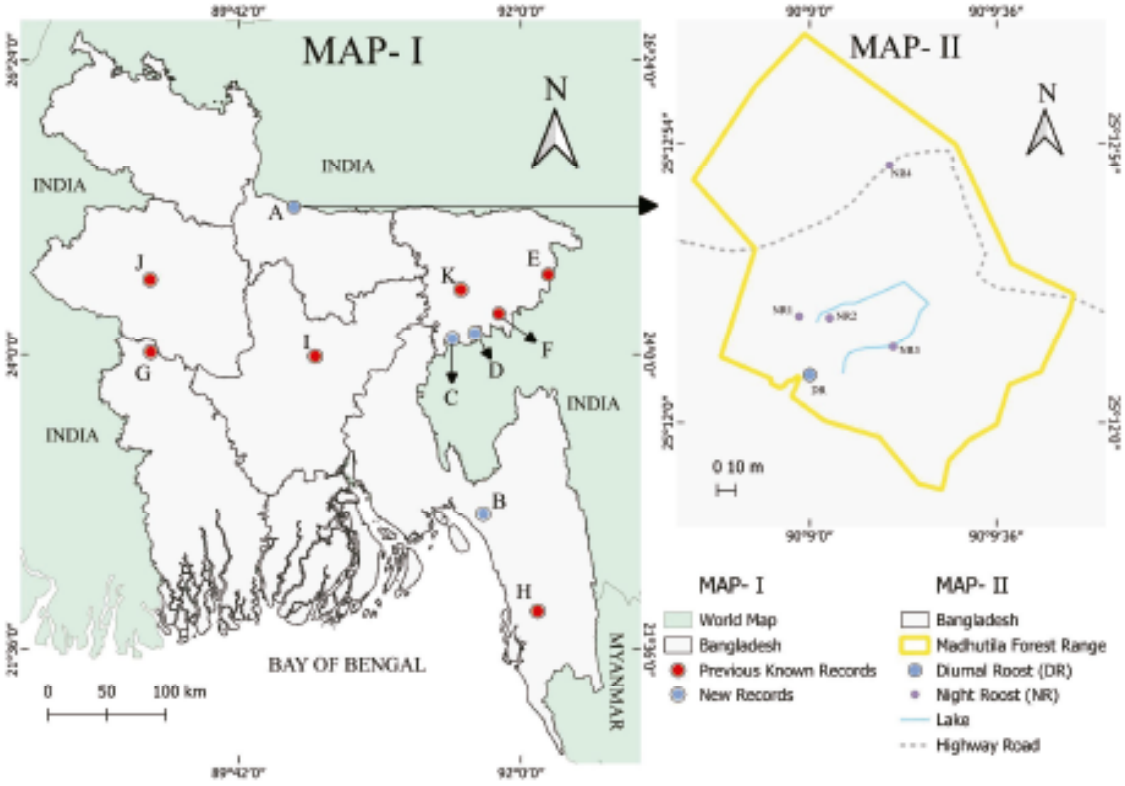


Fig. 2 - Distribution of *Lyroderma lyra* in Bangladesh and location of roosts in Madhutila Eco-Park. **(Map I)-** Updated distribution records of *L. lyra* across Bangladesh. Points A–D (blue) represent newly documented records, and points E–K (red) indicate previously documented records by published studies. **(Map II)-** Madhutila Eco-Park forest range showing the locations of the identified diurnal roost (DR) and night roosts (NR1–NR4). More information about these distribution records is available in Supplementary Table 1.

Distribution of *Lyroderma lyra* in Bangladesh

We compiled 11 confirmed distribution locations of *L. lyra* in Bangladesh (locations A–K; Fig. 2; SM Table 1). Four locations (A–D) are new locality records, whereas seven (E–K) were obtained from published studies. The record from Madhutila Eco-Park (MEP) forest range (location A) is the first confirmed occurrence of *L. lyra* in northern Bangladesh. Diurnal roosts were confirmed at 6 locations (A–F), including 1 in a natural structure (tree hollow, location B) and 5 in anthropogenic structures (locations A and C-F). The remaining 5 locations (G–K) represent occurrence records only.

DISCUSSION

This study investigated the population size of *L. lyra* at MEP and identified roosting sites, as well as providing an updated distribution of the species in Bangladesh more broadly. We found that a single diurnal roost in an anthropogenic structure supported an estimated 394–443 individuals. We also found four night roosts, all located in anthropogenic structures within 1.37 km of the diurnal roost, each occupied by 3–8 individuals (Table 1). All night roosts were consistently located within 500 meters of a permanent water source (Table 1). In addition, we generated an updated distribution map of *L. lyra* in Bangladesh. Our records show that *L. lyra* uses both natural and anthropogenic roosts in Bangladesh, but the roosts documented at MEP were all located in abandoned human-made structures (SM Table 1). This pattern suggests that, within this modified landscape, anthropogenic structures form an important component of the local roosting ecology of this species. At the same time, the occurrence of additional diurnal roosts in both natural and anthropogenic settings in the country supports the view that *L. lyra* is roost-flexible and capable of using anthropogenic structures where natural habitats have been extensively reduced and modified.

Our population estimation of 394-443 individuals from a single diurnal roost contributes to the limited available data on the population of *L. lyra* in Bangladesh as well as South Asia (Table 2). Our results are consistent with previous population estimates of *L. lyra* derived from single roost assessments in India (Sripathi et al., 2004). The colony size documented in this study falls within the range reported in earlier studies (Bates and Harrison, 1997; Molur et al., 2002), although an exceptionally large colony of approximately 2,000 individuals has also been documented in India (Bates and Harrison, 1997). However, long-term population monitoring at MEP may improve understanding of the population dynamics of *L. lyra* and help guide conservation strategies in the modified forests of northern Bangladesh.

Estimation of population size and the identification of

critical roosting habitats of bats, such as night roosts, are essential for understanding the ecology and conservation needs of bats, including those considered as common or generalist (Ormsbee, Kiser and Perlmeter, 2007; Korine et al., 2016; Russo and Dechmann, 2025). Occurrence of all night roosts within a short distance (~1.5 kilometer) from the diurnal roost suggests that 3–8 individuals observed at these roosts may have originated from the same diurnal roost, particularly because *L. lyra* is known to forage up to 4 km from its roost (Audet et al., 1991). However, further study using methods such as radio telemetry is needed to determine the extent of the foraging area and the ecological role of these night roosts within this human-modified landscape.

Lyroderma lyra preys on a variety of small vertebrates, including birds, rodents, frogs, and lizards, in addition to insects, using a perch hunting strategy to capture prey from the ground or water surfaces (Marimuthu, Habersetzer and Leippert, 1995; Schmidt, Hanke and Pillat, 2000; Schmidt, Yapa and Grunwald, 2011; Hasan, Mojumdar and Ahammed, 2025). All the night roosts documented in this study were located within 500 meters of a permanent water body. Although we did not formally test this association, the pattern suggests that proximity to water may influence night roost selection by *L. lyra*, potentially through increased prey availability near aquatic habitats. Similar spatial associations between roost sites and water sources have been reported for several bat species (Kalcounis-Rüppell, Psyllakis and Brigham, 2005; Perry, Thill and Leslie, 2008). Future studies that explicitly examine roost selection relative to water source while accounting for additional environmental and structural factors could help clarify the role of aquatic habitats in shaping the roosting ecology of *L. lyra* in human-modified landscapes.

All the documented roosts (both night and diurnal) from MEP were located in abandoned anthropogenic structures. Such structures confer multiple benefits to bats by providing refuge from predators, thermal and energetic advantages during critical life stages (e.g., hibernation and reproduction), and opportunities for social aggregation (Voigt et al., 2016). The consistent use of these anthropogenic structures suggests that *L. lyra* exhibits synanthropic roosting behavior in the study area. These anthropogenic roosts were surrounded by relatively undisturbed natural habitat inside the protected area. We also observed several abandoned structures within MEP located near areas of high human activity (e.g., shops, rest houses), where no direct or indirect evidence of bat occupancy was detected. Additionally, we documented natural (tree hollow) diurnal roosts in the forest at Hazarikhil Wildlife Sanctuary (SM Table 1), which indicates that although *L. lyra* is commonly roosting in human-made structures, likely due to favorable microclimatic conditions (Voigt et al., 2016), it still appears to rely on relatively undisturbed roosting environments and surrounding natural habitats for persistence. In addition to the benefits offered by anthropogenic structures, the limited availability of natural roosts at MEP, such as live or dead standing trees with hollow tree trunks, fallen logs, and caves, may further explain the reliance of *L. lyra* on human-made structures.

Our findings on population size, roost characteristics, and updated distribution of *L. lyra* in Bangladesh further suggest that this species functions as a generalist, occurring across a wide range of environmental settings, and using both natural and anthropogenic roosts, with human-made structures constituting an important local roost resource in modified landscapes. In Bangladesh, high population density and widespread conversion of natural landcover to agriculture, timber plantations, and settlements have left only about 5% of the country under formal protection (Rahman and Islam, 2021), likely increasing the reliance of bats on anthropogenic structures. Consistent with this pattern, although these remnant forests continue to support forest-dependent species (Hasan et al., 2025), more than 30% of the bat species in Bangladesh, including *Rousettus leschenaultii, Hipposideros larvatus, H. lankadiva, Megaderma spasma, Lyroderma lyra, Pipistrellus coromandra, P. pipistrellus, Scotophilus heathii, S. kuhlii, Taphozous melanopogon,* and *Saccolaimus saccolaimus*, regularly roost in human-made structures alongside natural forests (IUCN Bangladesh, 2015). These structures may function as stepping-stone roosts and partly compensate for the scarcity of natural roosts, yet they remain highly vulnerable to disturbance, repair, and intentional removal, often driven by misinformation and negative perceptions (Voigt et al., 2016; Caiza-Villegas, Ginn and van Hoven, 2024). Because loss of diurnal roosts is a well-established driver of bat population declines (Kunz, 1982; Mickleburgh, Hutson and Racey, 2002; Frick, Kingston and Flanders, 2020), bat species in Bangladesh that rely heavily on anthropogenic roosts, including *L. lyra*, may be particularly at risk in rapidly changing landscapes. Given this dependency and the increasing frequency of human–bat interactions, we recommend establishing long-term monitoring programs and incorporating anthropogenic roosts, such as abandoned buildings, temples, culverts, and tunnels, into protected area management and broader conservation planning. Equally important is the protection and restoration of natural forest remnants, which continue to provide essential roosting and foraging habitats. Safeguarding both natural and anthropogenic roost resources will be critical for reducing conflict and ensuring the long-term persistence of *L. lyra* populations in human-dominated landscapes.

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