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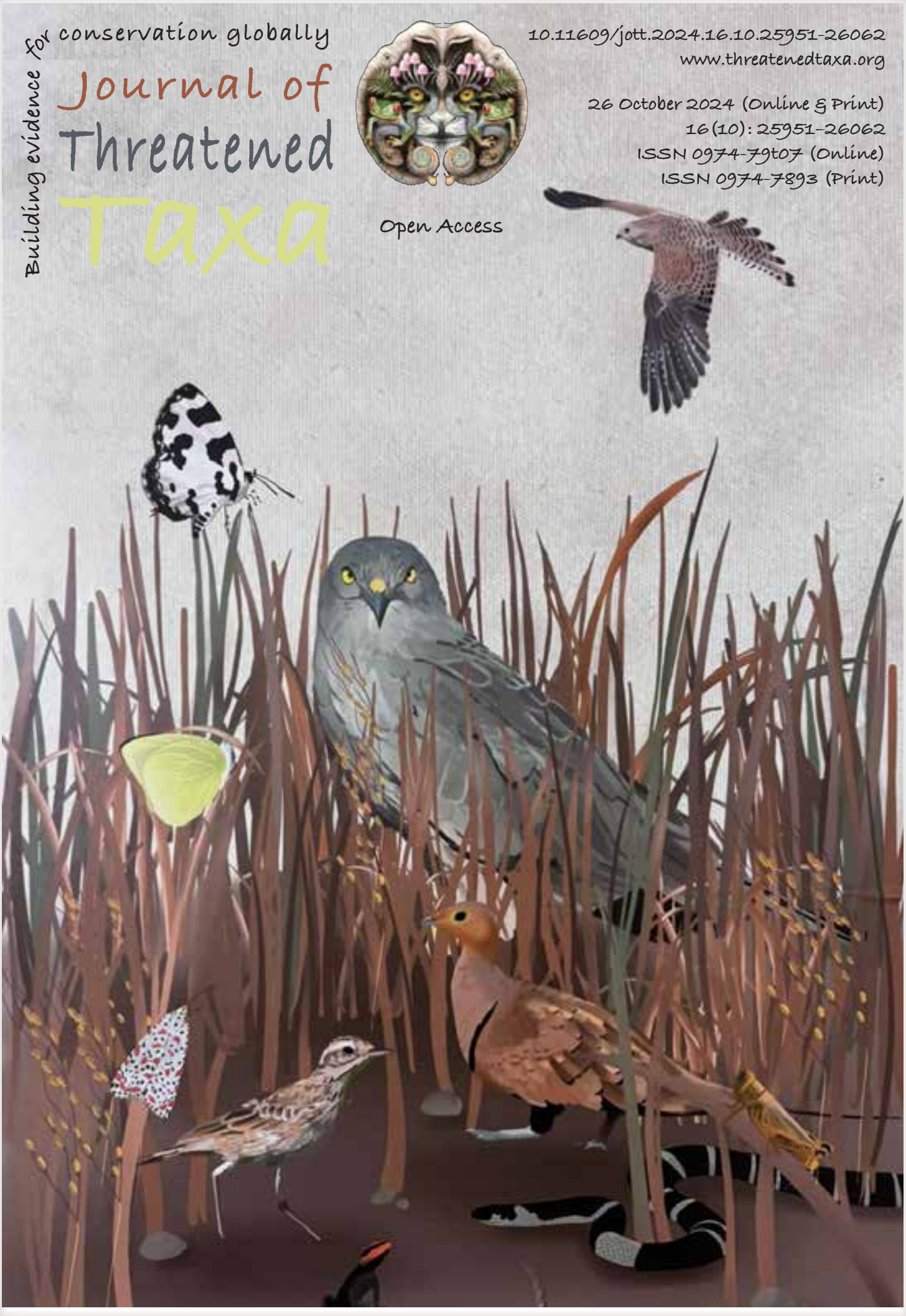

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Cover: A digital art of water birds of Noyyal River and its wetlands in Coimbatore District by Megha A. Kashyap.

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ARTICLE

Insights into human-wildlife interactions and community views on mangrove restoration in Kendrapada District, Odisha, India

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Abstract: This paper evaluates interactions between humans, Wild Boars, and crocodiles in mangrove ecosystems of the villages of Benakanda, Bhateni, and South Jambu in Mahakalapada Block in the Kendrapada District of the Indian state of Odisha, using questionnaire surveys. This is an area where mangrove restoration is currently in progress. Using a targeted sampling procedure, 280 respondents representing 14% of the population participated in the study. The results show that negative perceptions differ throughout villages, with a majority of respondents reporting interaction between humans and animals in Bhateni (91%) and South Jambu (98%). The most frequent animal reported to cause harm to crop and livelihoods is Wild Boar (44%). Communities understand the value of mangrove restoration despite facing obstacles brought on by interactions with wildlife. The vast majority of residents (87%) believe that restoration efforts were necessary, and many had taken part in these by themselves, or in conjunction with other communities.

Keywords: Crops, livelihoods, livestock, local communities, people perception, Saltwater Crocodile, Wild Boar.

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Author contributions: Study conception and design: Vijai Dharmamony, Muralidharan Manoharakrishnan, Janmejay Sethy and Murali Krishna Chatakonda, Data collection: Mohd Qayyum and Sadhwi Sindura, Analysis and interpretation of results: Vijai Dharmamony, Muralidharan Manoharakrishnan, Janmejay Sethy and Mohd Qayyum Draft manuscript preparation: Muralidharan Manoharakrishnan, Janmejay Sethy, Mohd Qayyum and Murali Krishna Chatakonda. All authors reviewed the manuscript and approved the final version of the manuscript.

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INTRODUCTION

Mangrove forests are unique ecosystems in tropical and subtropical coastal regions that contain salt-tolerant trees, shrubs and other vegetation. They help maintain coastal biodiversity and contribute to the planet's overall health. Mangroves are found in 118 countries and are distributed across southern & southeastern Asia, Africa, America, and Oceania. In India, 4,660 km^2 of diverse mangrove forests make up 0.14% of the country's total land area (Ragavan et al. 2019; Bryan-Brown 2020). These forests are concentrated in river deltas, estuaries, and sheltered coastal areas, where freshwater and tidal inflow create ideal conditions for mangrove growth. The forests provide essential resources for neighbouring communities, including food, fuel, medicine, and other traditional goods.

Indian mangroves have experienced significant loss, with a declining trend since 1995 (Kathiresan 2018). Previously viewed as wastelands, they are now protected for their ecological and environmental value (Badola & Hussain 2005; Hussain & Badola 2010). The "Green India Mission" and the National Action Plan on Climate Change (2008) prioritized mangrove conservation and restoration (MoEF&CC 2009). Human-wildlife interactions (HWI) have been considered one of the most challenging issues of wildlife conservation in the world (Holmern et al. 2007; Acharya et al. 2017; Bhatia et al. 2020; Stoldt et al. 2020; Zhang et al. 2020; Halley et al. 2021). Negative interactions between humans and wildlife arise with human expansion and intrusion into natural habitats (Nyhus & Tilson 2004; Graham et al. 2005), from the implementation of nature protection measures, and the rise of wild animal populations (Fall & Jackson 1998; Palmeira et al. 2008). Globally, there seems to be a rise in conflicts between agricultural interests and the preservation of wildlife (Redpath et al. 2013; Madden & McQuinn 2014).

Human activities gradually destroy the natural habitat of wildlife, which increases human-wildlife interactions globally (Nyhus 2005; Agarwal et al. 2016; Digun-Aweto et al. 2022). Economic losses impact livelihoods, leading to poverty, food insecurity, and conflicts between farmers and environmentalists, potentially causing the retaliatory killing of wild species (Katel et al. 2014). Human-wildlife interaction in India is a pressing issue, as the growing human population and habitat encroachment increasingly lead to negative interactions between people and wildlife, jeopardizing both human livelihoods and animal conservation efforts. Balancing the needs of local communities and the preservation of India's rich biodiversity is a complex challenge (Datta et al. 2012; Manral et al. 2016). In India, interactions between humans and wildlife, such as with the elephants and tigers, often result in crop damage, property destruction, and occasionally threats to human and animal lives, highlighting the challenges of coexistence and conservation efforts (Conover 2002; Decker et al. 2002; Madden 2004; Dickman 2010). When it comes to mangroves, the studies on human-tiger interactions and human-crocodile interactions are evident in their negativity and often appear in the literature (Vyas & Sengupta 2012; Khan et al. 2020; Dhar & Mandol 2023). Wild Boars can reside in a range of environments, including taigas, tropical forests, mountains, and marshes (Massei et al. 2011; Acevdo et al. 2014). Wild Boars threaten farmer livelihoods through crop depredation which is also aided by their rapid population growth, high fertility, and the absence of predators (Seward et al. 2004; Geisser & Reyer 2005; Liu et al. 2019; Csókás et al. 2020). The roles of natural ecosystems, such as mangroves, and hydrological variables, such as proximity to rivers, as well as various socio-economic factors determining economic well-being, are rarely taken into account (Das 2012). Bhitarkanika National Park is the second largest contiguous mangrove forest in India, with approximately 0.15 million mangrove-dependent populations residing in and around 307 villages within the protected area (Das et al 2022).

This study explores the relationship between mangrove conservation and wildlife interactions and the attitude of the community towards mangrove restoration in our study area, the Kendrapada District in Odisha State.

METHODS

Study Area

The study was conducted in Kendrapara District of the coastal Indian state of Odisha which lies between 20.3333–20.6167 °N and 86.2333–87.0167 °E. Bhateni, Benakanda, and South Jambu are three villages in Kendrapara District where the questionnaire surveys were conducted. Nestled close together, the three villages present a unique region of river and mangrove access. South Jambu is directly connected to the Dabka River and surrounded by lush mangroves. Bhateni is mostly enclosed by mangroves, with only a small area open to the river. In contrast, Benakanda is more exposed to the mangrove area (Figure 1).

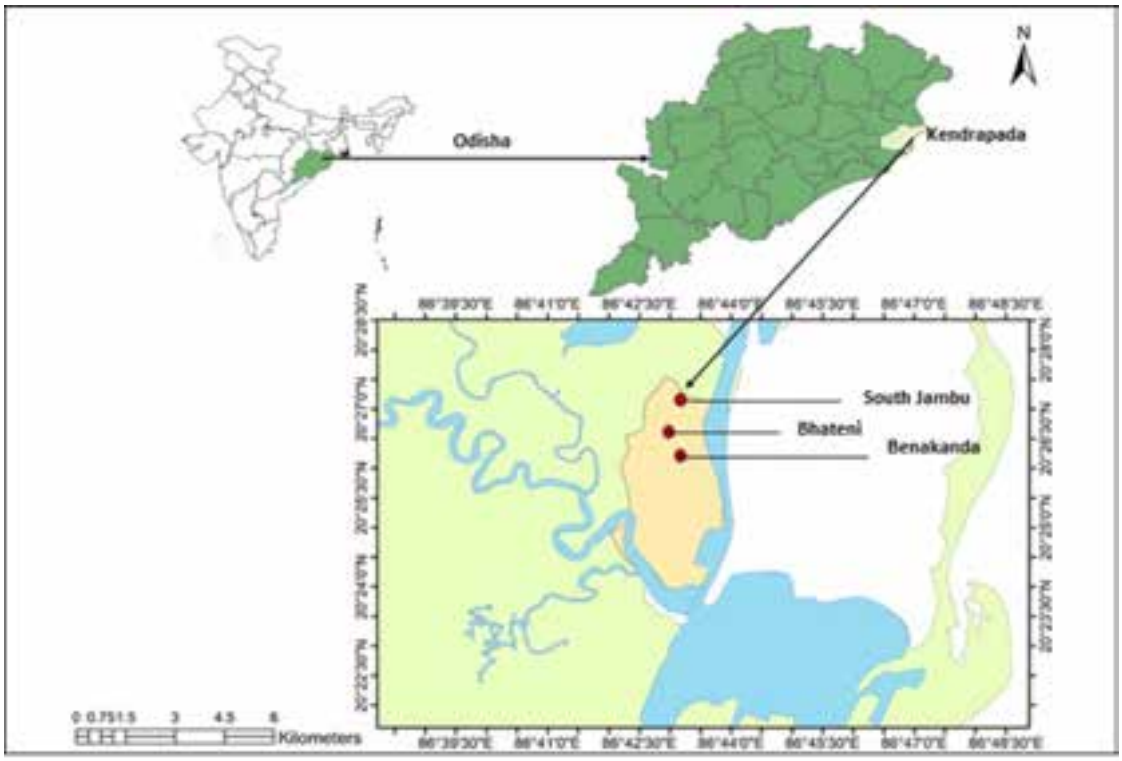

Figure 1. Map of the study area showing South Jambu, Benakanda and Bhateni.

In recent years, severe weather events such as cyclones and floods have increased in the Bhitarkanika landscape region (Kadaverugu et al. 2022). The two major river systems further make it vulnerable to cyclones, storm surges, and floods. The ingress of seawater is another threat that has also displaced many villages and threatened the livelihoods of the people in the landscape. The district has mangrove forests with varying widths of 100–10,000 m in places and narrow patches of Casuarina plantations near the sand dunes, but their presence is very limited (Das 2020).

Questionnaire survey

A survey was carried out in three villages where the mangrove restoration program by WWF India is in progress to gain further insight into the interactions between humans and wildlife in the mangrove forest as well as the opinions of the locals on the preservation of mangroves. In February and March of 2023, the survey was conducted over two months. Before the comprehensive questionnaire survey was carried out, interactive sessions and informal discussions were organised in the villages of Benakanda, Bhateni, and South Jambu. The questionnaire concerning the interaction between human-wildlife and mangrove restoration was developed after the pilot study (Appendix 1).

The interviews aimed to explore people's reliance on the mangrove ecosystem as a source of income as well as to understand the HWI in this region. All respondents freely participated in the questionnaire after providing informed verbal consent. For those participants who were less than 18 years of age, consent was taken from their parents/guardians before the commencement of the questionnaire. Prior to this, the study's purpose and their right to withdraw even in the middle of the interview, were clearly explained. This ensured ethical data collection through voluntary and informed participation. Open-ended questions were asked as they are more advantageous than closed-format questions when trying to understand the attitude of respondents (Newing 2010). We gathered information on which animals were most involved in the interaction (mostly negative) and whether these occurred seasonally. Additionally, we inquired about the types of crops that these animals feed on, the damages they cause, and whether the government provides any compensation or compassionate payment to address these negative interactions and pacify hostility.

We interviewed a total of 280 families, which represents 14% of the targeted population. These families included local representatives, leaders, fishermen, farmers, landowners, and daily wage labourers. The

purpose of the interviews was to determine the significance of mangroves in their lives, the occurrence of interactions between humans and wildlife, and the damages caused during these interactions. We worked with field staff from the forest and wildlife department of the state government, who acted as translators for the interviews conducted in Odia and Bengali. The data was analysed using Microsoft Excel.

RESULTS

The survey shows that 85% of the interviewed people reported experiencing HWI in the area.

Our study observed different gender distribution patterns in the three villages. In Benakanda, approximately 65.56% of the respondents were men. Similarly, in Bhateni, around 62.23% of the respondents were male, and 36.67% were female. In South Jambu, over 67% of the population was male, while females accounted for roughly 32% (Figure 2).

Age classification of the informants

The percentage of respondents was categorised by their generational group—Younger Generation (15–30 years), Mid Generation (31–60 years), and Old Generation (61–90 years)—across the three villages. This data helps in understanding the demographic distribution across these villages. This group constitutes the largest percentage of respondents in each village. South Jambu has the highest proportion at approximately 70%, followed by Benakanda (65%), and Bhateni (60%). The percentage of the younger generation is fairly consistent across the three villages, with each village having around 20% of its respondents in this category (Figure 3).

Species associated with human-wildlife interaction (Overall account)

Wild Boars were reported to account for the majority (43.6%) of interaction cases (where the crop is damaged), followed by jackals (21.3%), Saltwater Crocodiles (12.8%) (poultry and livestock lifting), and the remaining (22.3%) were comprised of wild cats, Spotted Deer, langurs, snakes, and birds. In Benakanda the maximum cases were observed with Wild Boars (49.39%), followed by Rhesus Macaques (22.22%), and crocodiles (12.36%), while jackals and wild cats accounted for less (4.94%) of interactions (Figure 4). Whereas in South Jambu it was maximum with Wild Boars (51.85%), followed by jackals (16.05%), Rhesus Macaques (14.20%), and crocodiles (10.49%). In Bhateni, the maximum number of cases were of jackals (38.56%), followed by Wild Boars (24.84%), wild cats (16.99%), and crocodiles (13.08%). Based on the respondents we observed varying human-wildlife interactions in different areas of the study site (Image 1,2).

Seasonal variation

The majority of interactions were reported during the cropping season, which runs from June to December. The areas with the highest reported interactions were Benakanda (71.11%), followed by Bhateni (61.2%), and South Jambu (59%). Wild Boars are the main cause of damage to paddy and tuber crops during this time, and they also pose a risk of injuries to humans (Figure 5). This issue is particularly prominent in South Jambu and Benakanda. In contrast, the risk of interactions remains consistent throughout Bhateni, as a large area of the village borders the mangrove forest. During the non-cropping season, the highest number of cases were reported in South Jambu (41%), followed by Bhateni (38.8%), and Benakanda (28.89%) (Figure 5).

Damage caused

The percentage of crop damage is highest in South Jambu at 48.0%, followed by Benakanda at 28% and Bhateni at 24%. In Benakanda, 36% of the population suffered injuries. In Bhateni, 53% of the cattle have been lost, which is higher compared to the other two villages (Figure 6). The “No loss” category represents the proportion of the population or property that has not suffered any loss. In South Jambu, 16% of the population or property hasn’t experienced any loss due to human-wildlife interactions. These give insights into the impact of certain factors on each village’s agriculture, population, and livestock. It helps in understanding the vulnerability and resilience of each community in the face of these challenges.

Human-wildlife interactions were claimed by the villagers for crop damage, livestock losses, and injuries. The most agricultural damage was observed in South Jambu, the area closest to the mangroves. The greatest number of livestock losses (cattle and goat) were reported in Bhateni, a region with vast fields that are home to Jackals and wild cats. Most injuries were reported in South Jambu and Benakanda (Image 2).

Mangrove restoration

In both the individual and community categories, Bhateni and Benakanda show higher percentages of restoration compared to South Jambu. South Jambu has the highest percentage in the “Restoring with

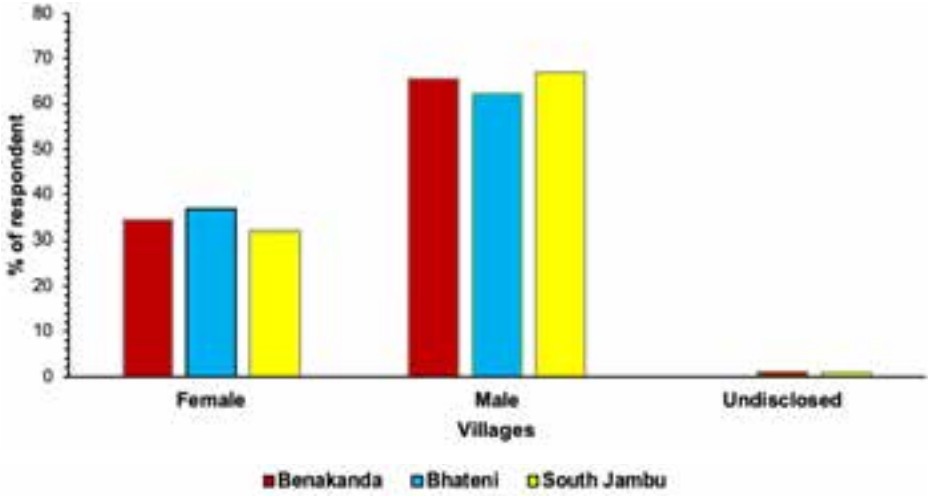

Figure 2. Gender-wise respondents in different villages.

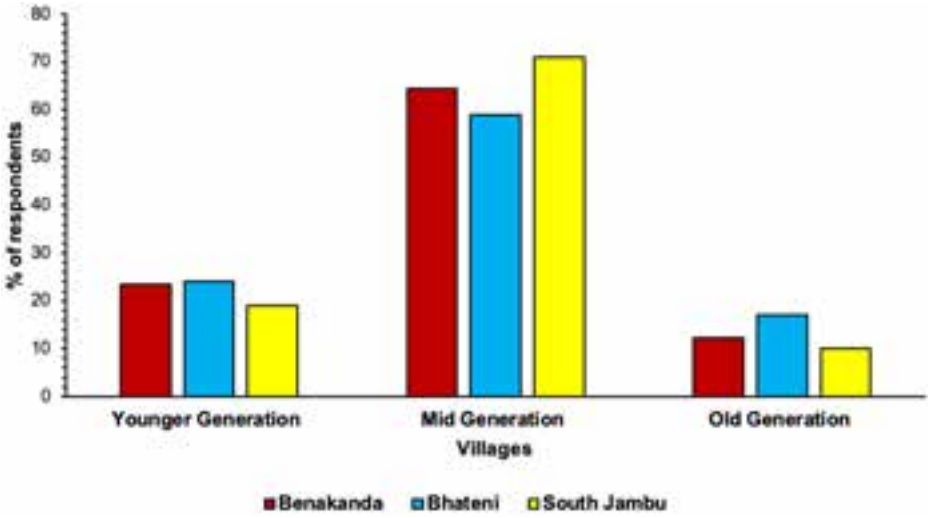

Figure 3. Age-wise respondents in different villages.

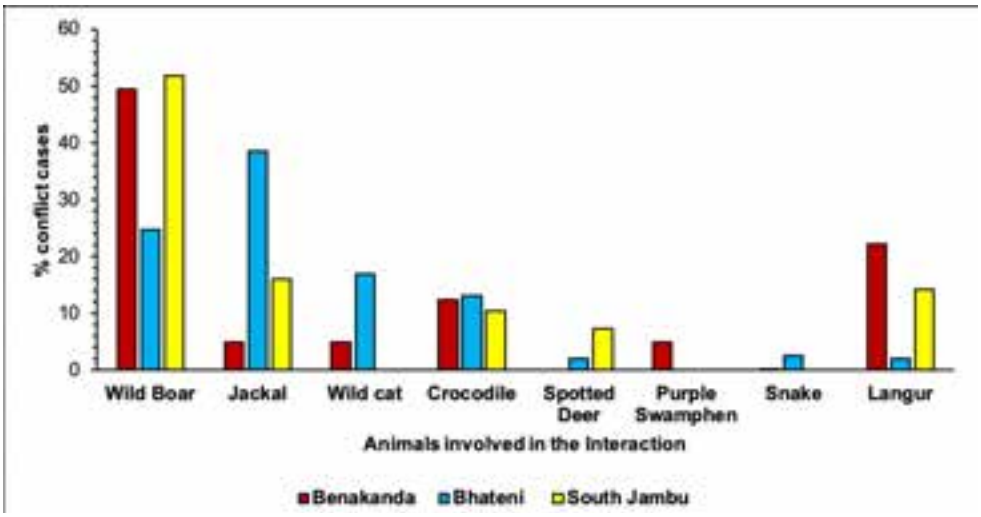

Figure 4. Different animals cause interactions in the respective villages.

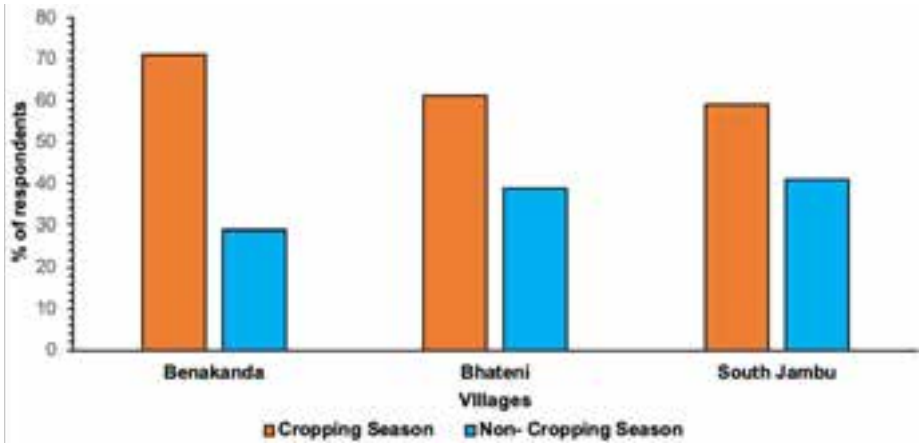

Figure 5. Season-wise human-wildlife interaction in the study area.

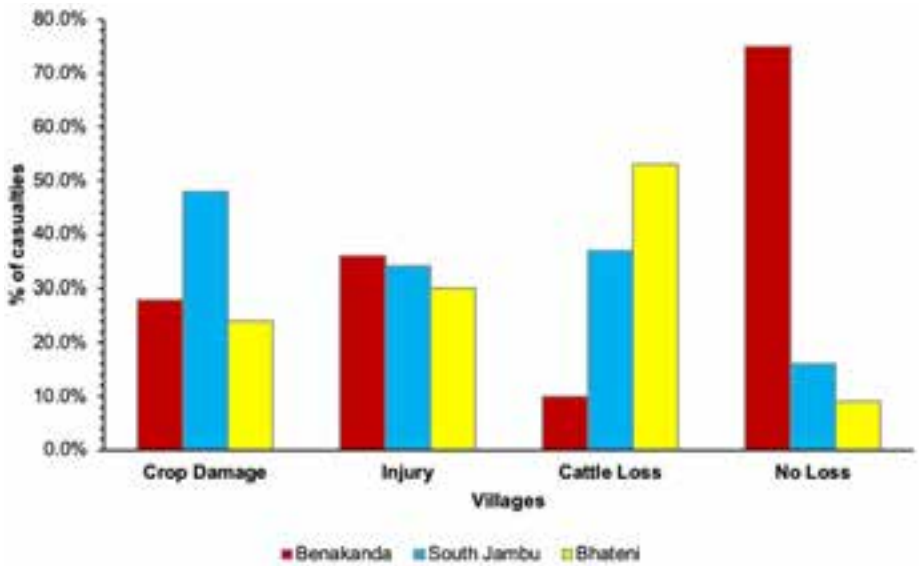

Figure 6. Human-wildlife interaction patterns in different villages.

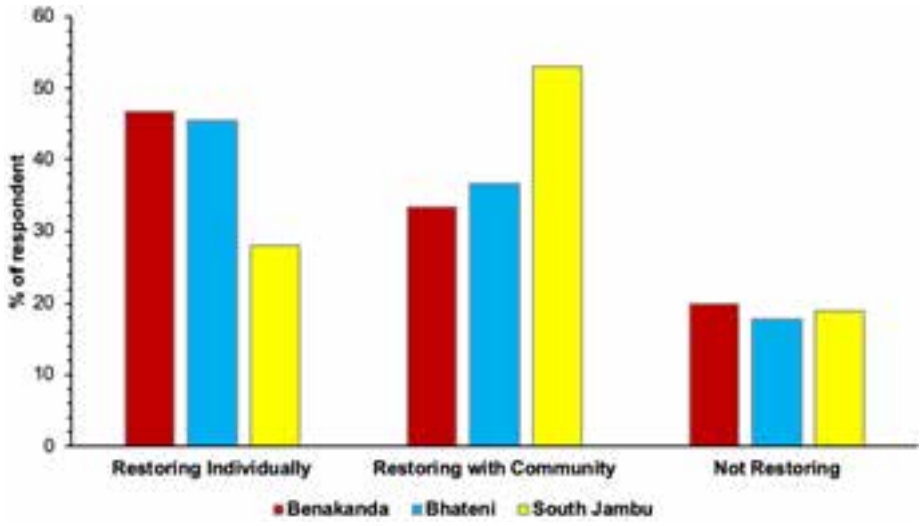

Figure 7. Restoration perception of local communities in different villages.

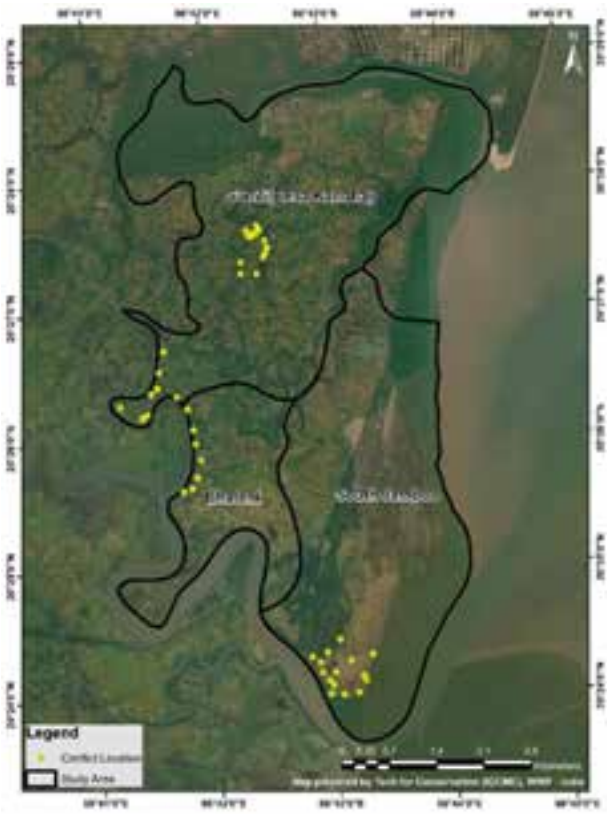

Image 1. Human-wildlife interaction locations.

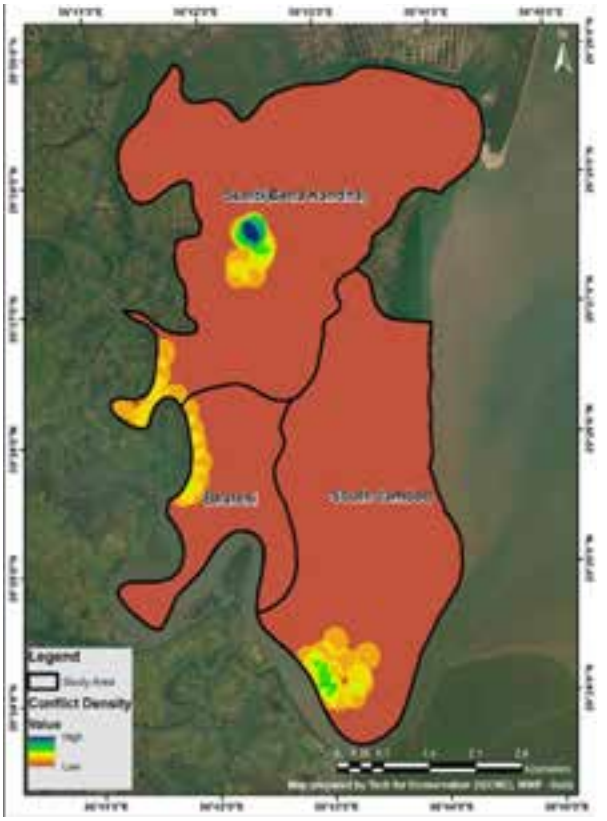

Image 2. Human-wildlife interaction density.

Community" category, indicating that community efforts are more prevalent there compared to individual initiatives. Bhateni and Benakanda seem to have a more balanced approach to individual and community-based restoration than South Jambu. For individual restoration, the percentages are Benakanda (46.67%), Bhateni (45.5%), and South Jambu (28%). In South Jambu, 53% of the community supports the restoration of mangroves. In Bhateni and Benakanda, the percentages are 36.66% and 33.33%, respectively. The majority of villagers agree that mangrove restoration is essential. However, while some prefer to work alone, others prefer to involve the community in the restoration work. Some remaining residents have shown no interest in restoring mangroves due to fears of potential HWI (Figure 7).

Awareness of Government schemes

Knowledge and awareness of government schemes related to HWI and compensation or compassionate grants provided in case of injury or damage were also assessed. The majority of respondents (92%) were unaware of any government schemes in their area, while only a small percentage (1.2%) had little knowledge, and a few (6.8%) had no idea about any government schemes (Figure 8).

DISCUSSION

This study provides information on human-wildlife interactions in the study area involving primarily crocodiles, wild cats, and Wild Boar. A majority of those interviewed emphasized the importance of human-boar interactions. Our research evaluated instances of interactions between humans and wildlife species such as Wild Boars in the mangrove ecosystem. These interactions likely arose due to habitat loss, competition for resources, and potential threats to livelihoods. This negative interaction is consistent with global observations (Mathur et al. 2015), which attest to the widespread appreciation of Wild Boar crop predators (Tisdell 1980; Bengsen et al. 2014). This negative interaction reflects their behavioural plasticity and increasing dependency on agricultural produce (Herrero et al. 2003).

Wild Boars were reported as being responsible for negative interactions in all villages. These interactions occur mostly during the cropping season when the boars feed on paddy fields and tuber crops during the

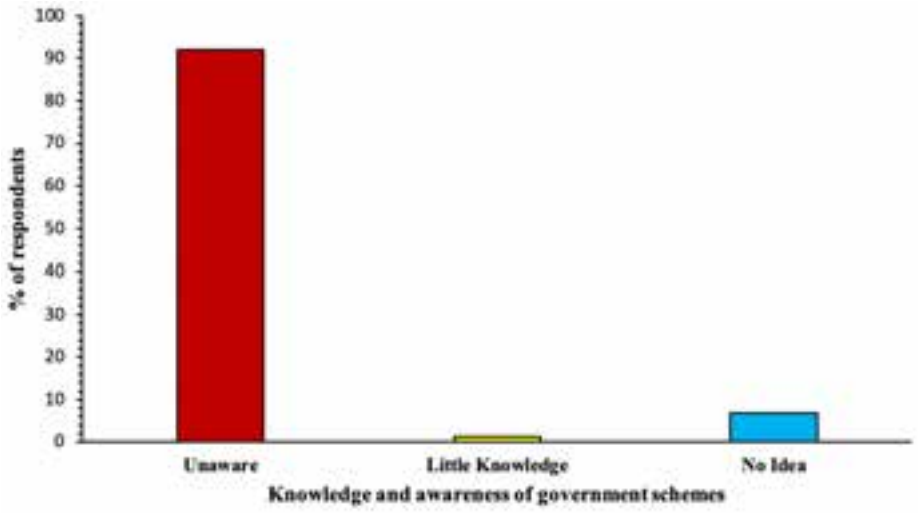

Figure 8. Knowledge and awareness of government schemes for human-wildlife interaction.

off-season. They are reported to come in large groups at night to eat the crops, and sometimes even sleep in the agricultural fields. When the farmers check on their crops, the boars cause injuries to anyone in their path while trying to escape from the farmers. Fencing done by the government, and the lack of fencing in some areas, increase the chances for animals to cause harm. Additionally, venturing into the forest in search of fodder and firewood puts people at risk of encountering animals. Unlike the majority of other wildlife, rising anthropogenic pressure has offered Wild Boars opportunities to expand their populations. Accordingly, the circumstances for interactions also increased in human-wildlife interface areas (Milda et al. 2023).

Wild Boars threaten farmers' livelihoods through crop depredation, which is aided by rapid boar population growth, high fecundity, and the absence of predators (Seward et al. 2004; Geisser & Reyer 2005; Liu et al. 2019; Csókás et al. 2020). Their entry into homes can be dangerous and has resulted in injuries and even loss of life. To protect themselves, farmers resort to various measures, such as building fences around their fields and homes. However, these measures are not always effective in stopping Wild Boars.

In previous seasons, farmers have also focused more on growing flowers than vegetables. A study conducted by Chauhan et al. (2009) advised changing crop patterns near forests by planting different income-generating crops instead of highly vulnerable crops. To resolve the interactions between people and Wild Boars, they experimented with traditional methods, such as using human hair to deter Wild Boars. However, this proved ineffective after a few days as the Wild Boars became accustomed. Similar techniques were observed by Rao et al. (2008) who found that many farmers in the Telangana State were using such farming strategies and development pathways of small-holder farming systems namely, (i) crop without livestock (CWL), (ii) crop with small ruminants (CSR), and (iii) crop with dairy (CD), in the context of climate change to reduce the damage caused by Wild Boars by 40–50 %. This study revealed that while many strategies have been attempted to address the interactions, they do not last long as they become ineffective after a few days.

The impact of Wild Boars on the livelihoods of people in rural areas is evident also in a study conducted in China, where on average, each household experienced a loss of 10,480 RMB (the Chinese renminbi) per year (Wang et al. 2023). While Wild Boars have been destroying crops and causing physical harm, jackals and wild cats have been causing a loss to cattle and poultry, despite fencing. Khan et al. (2020) report the long tradition of crocodile-human interactions. Crocodiles are associated with deities in several local communities across the nation. However, Project Crocodile's restoration attempts have been thwarted by increasing human encroachment and intolerance of crocodiles, mostly resulting in a reduction in crocodile habitat (Das & Jana 2018). This has led to a decline in the amount of available habitat for crocodiles leading to conflicts (Khan et al. 2020). This study did not report saltwater crocodiles causing any casualty of life in the region. However, the fishermen and villagers living near the forest often mentioned that they must be careful all the time because of the crocodile presence in the area and their entry into the fishponds, cattle sheds, and poultry, predating on fish and livestock like hens,

ducks, and rarely cattle. Fencing around their houses and ponds has given them a positive result.

It was observed that the local community holds mangroves with great reverence as they consider the mangrove trees as sacred trees. Furthermore, they are appreciative of the benefits of fodder, fuelwood, fruits and fish provided by the mangrove habitats. The community is closely connected to the mangroves and actively participates in their restoration by planting more trees in the vicinity of their homes and within the community. This has resulted in a low rate of exploitation in the area. The community receives various services from the mangroves such as firewood, crabs, and fishes (provisioning services), climate change regulation (regulating services), and protection from soil erosion (supporting services). Villagers lack the information on schemes available to them when damage is caused due to HWI. This knowledge gap hinders their ability to seek government assistance. However, there's a positive side: the majority of villagers recognize the importance of mangroves and are enthusiastic about their restoration. With proper guidance from the government or NGOs, they can play a crucial role in protecting these vital ecosystems, rather than contributing to their destruction. WWF-India has also initiated a conservation initiative on a plot of land in collaboration with the community, where they have established a nursery (employing local people) and are raising mangrove species to restore 22 ha of lost mangroves in community land alongside the Gobari River, spread across the three selected villages. On average, these resources contribute to over 14.5% of households' total income, with this proportion rising to over 30% for poorer households living near the forests (Badola & Hussain 2003). Given that these households typically have lower levels of education, employment, and income, their reliance on the mangrove resources is even greater.

Thus, the current study provides necessary base information for planning future restoration programs and investigating aspects that might cause hindrances. `

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Appendix 1. Questionnaire survey format for human-wildlife interaction.

CONTACT DETAILS

Name: **Age:**

Address: **Education:**

Gender: **Members:**

Sno	Questions
1.	What are ecosystem services that mangrove provides?
2.	Does the mangrove ecosystem provide a source of fresh water to you?
3.	Is there any noticeable change in the quality of water during the hightide and low tide?
4.	Do the mangroves have any cultural importance/ Values/ Purpose due to its natural character and traditional uses?
5.	Are there any traditional practices done by the community to conserve/protect the mangroves?
6.	Is mangrove ecosystem can provide sufficient income to support the family
7.	Does the community invite other parties to plant mangroves around the coastal area?
8.	Which animal appears the most often in Human-Wildlife interaction? What do you do to mitigate it?
9.	Do they have any particular season?
10.	Are there any particular crops they feed on?
11.	Types of Damages caused by them? (Economic Damage, Loss of Life, Injury)
12.	Does the government provide any compensation policy to mitigate the Human-Wildlife interaction?
13.	How can you describe your relationship with the animal?

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ARTICLE

A checklist of avian fauna of Suang Reserve Forest, Nagaon, Assam, India with notes on some species of interest

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Abstract: This study presents the first avian checklist from the Suang Reserve Forest of Nagaon, Assam, India. The study conducted between 2018 and 2023 documented 228 bird species belonging to 18 orders and 64 families of which four are globally threatened according to the IUCN Red List. Passeriformes was the most dominant order, with 128 species. Among non-passerines, Piciformes exhibited the highest richness (15 species), followed by Cuculiformes and Accipitriformes (13 species each). The family Muscicapidae had the greatest species diversity (21 species), followed by Accipitridae (13 species), Phylloscopidae (11 species), and Picidae (11 species). We also documented 38 winter visitors and seven summer migrants in the reserve forest. Noteworthy findings included rare sightings of the White-cheeked Partridge and Grey Peacock-Pheasant, and unusual sightings of Wreathed Hornbill and Pacific Golden Plover. The results showed the healthy condition of the forest and its high biodiversity value, despite the study limitations due to inaccessible terrain. We recommend extensive documentation of avifauna and other biodiversity for this region for future conservation planning.

Keywords: Accipitriformes, biodiversity, birds, conservation, documentation, IUCN, migrants, Passeriformes, Piciformes, threatened.

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Author contributions: Conceptualization: NB and CB; Data collection: CB, NB, RD, RJD and CBh; Methodology: CB and NB; Software: CB and CBh; Writing-original draft: NB, CB and CBh; Writing- review and editing: NB, CB and CBh. The final draft of the manuscript was read and approved by all the authors.

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INTRODUCTION

Birds are an essential part of the ecosystem and provide varied services that support life that depends on them (Michel et al. 2020). They carry out a variety of functions such as pest control, pollination, seed dispersal, and nutrient cycling (Ceia et al. 2023). Monitoring bird populations can yield valuable information about the health of an ecosystem (Fraixedas et al. 2020). The Indian subcontinent recorded 317 bird species, which is over 12.5% of the world's bird species (Praveen & Jayapal 2022). The confluence of the Indo-Malayan, Indo-Chinese, and Indian biogeographical areas, the northeastern region of India provides a diverse range of habitats that support a wide variety of avian species (Chatterjee et al. 2016). The state of Assam in northeastern India has a notably diverse bird population. Substantial contributions have been made to study the diversity, distribution, and ecology of birds in Assam in recent years (Barua & Sharma 2005; Choudhury 2006; Das & Deori 2010; Ahmed & Dey 2014 ; Chakdar et al. 2019; Kakati et al. 2022; Rahmani et al. 2023). Therefore, extensive surveys are very much needed to uncover all such unexplored regions. The Suang Reserve Forest in Nagaon district of Assam is one such undocumented region. It is a dense forest with undiscovered biodiversity. This moist deciduous forest features evergreen vegetation creating a unique habitat, complemented by its hilly terrain, hill streams, and nearby tea gardens. However, in terms of biodiversity documentation, no literature is available. Thus, the current study presents the first avian checklist documentation of the region and establishes baseline data for future studies and conservation efforts.

Study Area

Suang Reserve Forest (26.2832^{0}N, 92.8619^{0}E & 26.3552^{0}N, 92.9475^{0}E) is located near the Karbi Hills of Nagaon District in central Assam, under Nagaon Forest Division. The reserve forest, characterized by a dense forest cover covers an area of 2,645 ha (Figure 1). The predominant forest type is primarily moist deciduous or moist deciduous-mixed type. However, characteristics of tropical semi-evergreen forests are also observed in the study area. The reserve forest is surrounded on the north by Lungsung tea garden, on the south by Chapong pahar, on the east by Chapanala tea garden, and on the west by Balijuri and Jiajuri tea gardens. A prominent hill stream called Champawati also runs through it. The study area experiences a hot sub-tropical humid climate and is characterized by four distinct seasons, with summer (25.3–33 °C) and winter (11.2–25.2 °C) temperatures.

During the survey, prominent flora recorded included plantations of *Tectona grandis* and *Shorea robusta* as well as a variety of wild flora like *Artocarpus chama, Mangifera indica, Dysoxylum gotadhora, Artocarpus lakoocha, Spondias pinnata, Ficus religiosa, Ficus benghalensis*, and *Ficus racemosa*. Notably, prominent mammalian fauna spotted during our surveys included *Macaca mulatta, Macaca assamensis, Nycticebus bengalensis, Hoolock hoolock, Elephas maximus, Axis porcinus,* and *Muntiacus muntjac.*

MATERIAL AND METHODS

Field surveys were conducted for five years from January 2018 to January 2023 covering all four seasons (Pre-monsoon: March to May, Monsoon: June to September, Retreating Monsoon: October to November, and Winter: December to February). However, the tracks around the hill-stream were deliberately avoided in winter to avoid public interference.

The surveys were conducted during morning hours (0600–1000 h) and afternoon hours (1430–1530 h) by a team of two or three observers, following the point count method (Bibby et al. 2000), and at each point, GPS data was collected. The distance between two consecutive points was ~50 m. At each point, the observers recorded the number of bird species for 15 minutes. After arriving at each point of the count, a five-minute settling period was allowed for birds to resume normal behaviour. In the case of the birds that could not be seen but heard, counts were also made for those whose location was obvious from their songs/calls. Songs and calls were also recorded for later identification if necessary. Additionally, all other observations are entered as opportunistic sightings while moving from one point to another. Avian fauna was documented through direct observation using binoculars Nikon Prostaff (8 × 42 mm) and digital cameras (Nikon P900 and Nikon D500 with Nikkor 200–500 mm lens) for photographs. GPS data were collected using Garmin eTrex-10 and calls were recorded using a Zoom H1 handheld recorder. Birds were identified using a field guidebook (Grimmett et al. 2011).

The bird calls recorded were analysed later with the help of Raven Pro (1.6.5), using the machine learning model "BirdNET_GLOBAL_6K_V2.4" (Kahl et al. 2021). After that, the results were cross-checked at http://www.xeno-canto.org/ online database.

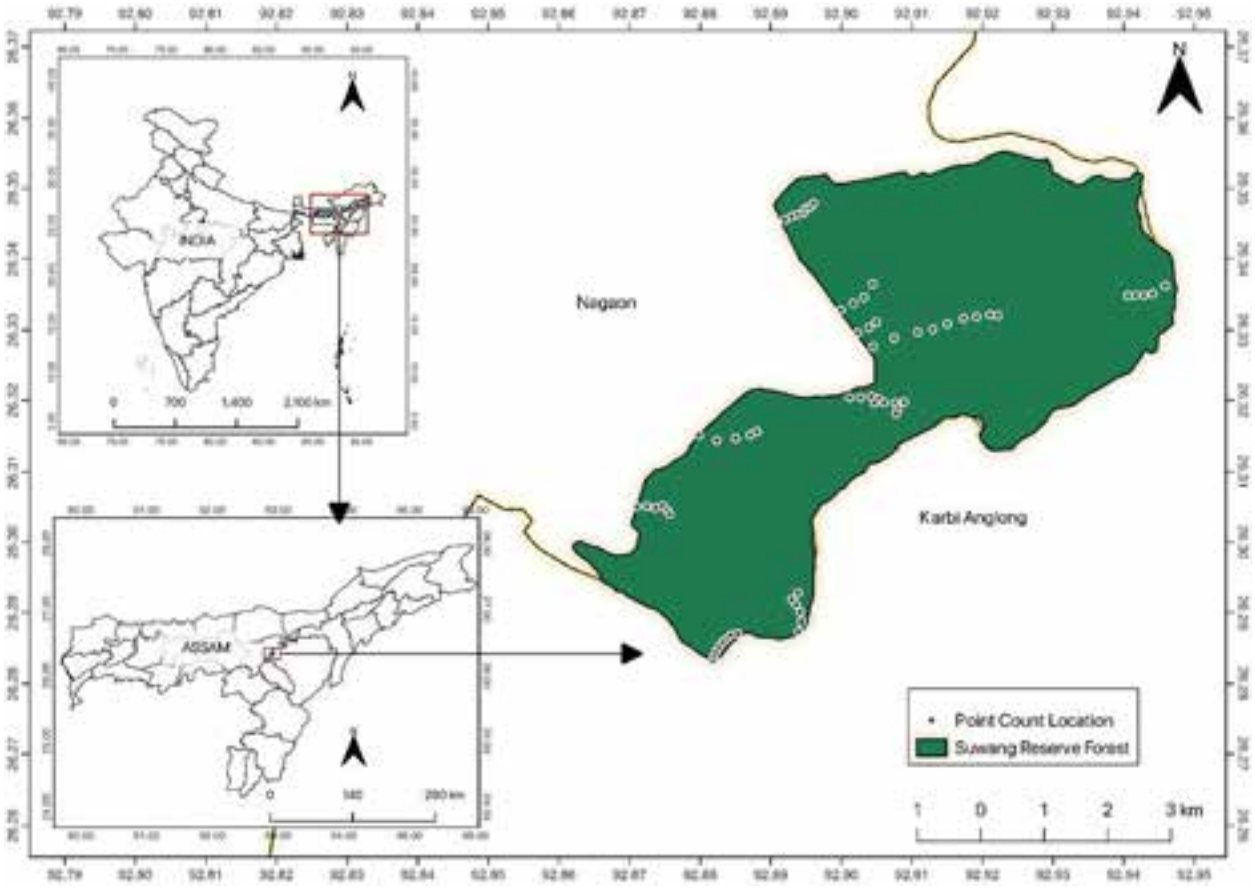

Figure 1. Location map of Suang Reserve Forest in Assam, India, showing point count locations within the reserve.

The threatened status of the birds was assessed as per the IUCN Red List status (IUCN 2023). The migratory status of the birds is given as per 'Birds of the World (2022)' (Billerman et al. 2022). Local names of the birds were compiled from available literature on birds in Assamese (Gogoi 2006; Dutta 2011).

RESULTS

The present study documented 228 species of birds belonging to 18 orders and 64 families. Order Passeriformes was the most dominant one with 128 species. Among the non-passerines, maximum richness was represented by the order Piciformes with 15 species followed by Cuculiformes with 13 species, and Accipitriformes with 13 species (Figure 2). The family Muscicapidae shows the highest species richness (21 species), followed by Accipitridae (13 species), Phylloscopidae (11 species), and Picidae (11 species). Among the 228 bird species recorded, 183 (80%) are resident birds. Winter Visitors (WV) account for 38 species (17%) of the total bird population, and seven species are Summer Migrants (SM). Eight (4 Vulnerable and 4 Near Threatened) species were threatened on the IUCN Red List of Threatened Species (IUCN 2023).

We recorded four species of Pheasants from this region out of which White-cheeked Partridge *Arborophila atrogularis* and Grey Peacock-Pheasant *Polyplectron bicalcaratum* are rare records. Also, some unusual sightings from the study area are Wreathed Hornbill *Rhyticeros undulatus* and Pacific Golden Plover *Pluvialis fulva*.

A detailed account of some interesting species like Grey Peacock-Pheasant, White-cheeked Partridge, Great Slaty Woodpecker *Mulleripicus pulverulentus*, Wreathed Hornbill, Great Hornbill *Buceros bicornis*, Red-headed Trogon *Harpactes erythrocephalus*, Bristled Grassbird *Schoenicola striatus*, Jackobin Cuckoo *Clamator jacobinus*, Malayan Night Heron *Gorsachius melanolophus*, Forest Wagtail *Dendronanthus indicus*, Pacific Golden Plover, Long-tailed Broadbill *Psarisomus dalhousiae* and Black-breasted Weaver *Ploceus benghalensis* is additionally provided with IUCN Red List status.

Table 1. Checklist of birds in Suang Reserve Forest.

	Common name	Scientific name	Local name	IUCN Red List	Migration status
Order: ANSERIFORMES Family: ANATIDAE					
	Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield, 1821)	Xoru Sorali Hah	LC	R
Order: ACCIPITRIFORMES Family: ACCIPITRIDAE					
	Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)	Kola deuka xen	LC	R
	Black Kite	*Milvus migrans* (Boddaert, 1783)	Chiloni	LC	WV
	Oriental Honey-buzzard	*Pernis ptilorhynchus* (Temminck, 1821)	Moukhap	LC	R
	Black Baza	*Aviceda leuphotes* (Dumont, 1820)	Kola tikoni xen	LC	R
	Crested Serpent-Eagle	*Spilornis cheela* (Latham, 1790)	Sap-Kota	LC	R
	Booted Eagle	*Hieraaetus pennatus* (Gmelin, 1788)	Eagle	LC	WV
	Changeable Hawk Eagle	*Nisaetus cirrhatus* (Gmelin, JF, 1788)	Deu-Eagle	LC	R
	Rufous-bellied Eagle	*Lophotriorchis kienerii* (de Sparre, 1835)	Mamor Petia Eagle	NT	R
	Peregrine Falcon	*Falco peregrinus* (Tunstall, 1771)	Pahari Xen	LC	R
	Pied Harrier	*Circus melanoleucos* (Pennant, 1769)	Pokhora Xen	LC	WV
	Eurasian Marsh Harrier	*Circus aeruginosus* (Linnaeus, 1758)	Masua-Xen	LC	WV
	Shikra	*Accipiter badius* (Gmelin, JF, 1788)	Bori Xen	LC	R
	Eurasian Sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)	Tuni-khua Chiloni	LC	WV
Order: APODIFORMES Family: APODIDAE					
	Asian Palm Swift	*Cypsiurus balasiensis* (J.E. Gray, 1829)	Tal Botahi	LC	R
Order: BUCEROTIFORMES Family: BUCEROTIDAE					
	Wreathed Hornbill	*Rhyticeros undulatus* (Shaw, 1812)	Chaya Dhonesh	VU	R
	Great Hornbill	*Buceros bicornis* (Linnaeus, 1758)	Raj Dhonesh	VU	R
Family: UPUPIDAE					
	Eurasian Hoopoe	*Upupa epops* (Linnaeus, 1758)	Kakoi-Xira	LC	R
Order: CHARADRIIFORMES Family: CHARADRIIDAE					
	Pacific Golden-Plover	*Pluvialis fulva* (Gmelin, JF, 1789)	Xunali-loriyoli	LC	WV
	Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)	Dol-Ghura	LC	WV
	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	Bali-Ghura	LC	R
	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)	Dol-Punga	LC	R
	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	Balituka	LC	WV
	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	Bali-khusora	LC	WV
Family: LARIDAE					
	Whiskered Tern	*Chlidonias hybrida* (Pallas, 1811)	Gonga-Chiloni	LC	R
Family: TURNICIDAE					
	Barred Buttonquail	*Turnix suscitator* (Gmelin, JF, 1789)	Bota-Sorai	LC	R
Order: CICONIIFORMES Family: CICONIIDAE					
	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	Samuk-bhonga	LC	R
	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	Bortokola	NT	R
Order: COLUMBIFORMES Family: COLUMBIDAE					
	Rock Pigeon	*Columba livia* (Gmelin, JF, 1789)	Paro-Sorai	LC	R
	Red Collared-Dove	*Streptopelia tranquebarica* (Hermann, 1804)	Harua Kopou	LC	R

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	Eurasian Collared-Dove	*Streptopelia decaocto* (Frivaldszky, 1838)	Sweto Kopou	LC	R
	Spotted Dove	*Spilopelia chinensis* (Scopoli, 1786)	Til Kopou	LC	R
	Oriental Turtle-Dove	*Streptopelia orientalis* (Latham, 1790)	Xon-Kopou	LC	R
	Asian Emerald Dove	*Chalcophaps indica* (Linnaeus, 1758)	Sil-Kopou	LC	R
	Yellow-footed Green-Pigeon	*Treron Phoenicopterus* (Latham, 1790)	Haitha	LC	R
	Thick-billed Green-Pigeon	*Treron curvirostra* (Gmelin, JF, 1789)	Bor-Haitha	LC	R
	Wedge-tailed Green-Pigeon	*Treron sphenurus* (Vigors, 1832)	Solokha-nejia Haitha	LC	R
Order: CORACIIFORMES Family: ALCEDINIDAE					
	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	Masruka	LC	R
	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	Boga-bukua Masruka	LC	R
Family: CORACIIDAE					
	Indochinese Roller	*Coracias affinis* (Horsfield, 1840)	Kau-Sorai	LC	R
	Dollarbird	*Eurystomus orientalis* (Linnaeus, 1766)	Nila Kau Sorai	LC	R
Family: MEROPIDAE					
	Blue-bearded Bee-eater	*Nyctyornis athertoni* (Jardine & Selby, 1828)	Nila-pakhi moukhua	LC	R
	Asian Green Bee-eater	*Merops orientalis* (Latham, 1801)	Jiya-Khati	LC	R
	Blue-tailed Bee-eater	*Merops philippinus* (Linnaeus, 1767)	Nila-neji Jiya Khati	LC	R
Order: CUCULIFORMES Family: CUCULIDAE					
	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	Bor-Kukuha	LC	R
	Lesser Coucal	*Centropus bengalensis* (Gmelin, JF, 1788)	Ulu-kukuha	LC	R
	Green-billed Malkoha	*Phaenicophaeus tristis* (Lesson, 1830)	Bomura	LC	R
	Chestnut-winged Cuckoo	*Clamator coromandus* (Linnaeus, 1766)	Badam Pakhiya Kuli	LC	SM
	Jacobin Cuckoo	*Clamator jacobinus* (Boddaert, 1783)	Piu kaha	LC	SM
	Asian Koel	*Eudynamys scolopaceus* (Linnaeus, 1758)	Kuli	LC	R
	Square-tailed Drongo-Cuckoo	*Surniculus lugubris* (Horsfield, 1821)	Fesu-Kuli	LC	SM
	Common Hawk-Cuckoo	*Hierococcyx varius* (Vahl, 1797)	Xen-kuli	LC	R
	Indian Cuckoo	*Cuculus Micropterus* (Gould, 1838)	Keteki	LC	SM
	Common Cuckoo	*Cuculus canorus* (Linnaeus, 1758)	Bilati keteki	LC	SM
	Large Hawk-Cuckoo	*Hierococcyx sparverioides* (Vigors, 1832)	Bor Xenkuli	LC	SM
	Asian Emerald Cuckoo	*Chrysococcyx maculatus* (Gmelin, JF, 1788)	Rongosua kuli	LC	SM
	Plaintive Cuckoo	*Cacomantis merulinus* (Scopoli, 1786)	Mamor-Petia Kuli	LC	R
Order: GALLIFORMES Family: PHASIANIDAE					
	White-cheeked Partridge	*Arborophila atrogularis* (Blyth, 1849)	Gal-Boga Hoikoli	LC	R
	Common Hill Partridge	*Arborophila torqueola* (Valenciennes, 1825)	Koira	LC	R
	Red Junglefowl	*Gallus gallus* (Linnaeus, 1758)	Bon-Kukura	LC	R
	Grey Peacock-Pheasant	*Polyplectron bicalcaratum* (Linnaeus, 1758)	Deu-Dorik	LC	R
	Kalij Pheasant	*Lophura leucomelanos* (Latham, 1790)	Dorik	LC	R
Order: GRUIFORMES Family: RALLIDAE					
	Slaty-breasted Rail	*Lewinia striata* (Linnaeus, 1766)	Jikor	LC	R
	Eurasian Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	Kura-Dhekor	LC	R
	Grey-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801)	Kam-Sorai	LC	R
	Watercock	*Gallicrex cinerea* (Gmelin, JF, 1789)	Pani-kukura	LC	R
	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	Dauk	LC	R

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	Brown Crake	*Zapornia akool* (Sykes, 1832)	Muga-Jikor	LC	R
Order: PASSERIFORMES Family: ACROCEPHALIDAE					
	Thick-billed Warbler	*Arundinax aedon* (Pallas, 1776)		LC	WV
	Paddyfield Warbler	*Acrocephalus agricola* (Jerdon, 1845)		LC	WV
	Clamorous Reed Warbler	*Acrocephalus stentoreus* (Hemprich & Ehrenberg, 1833)		LC	WV
Family: AEGITHINIDAE					
	Common Iora	*Aegithina tiphia* (Linnaeus, 1758)	Bihuyoti Sorai	LC	R
Family: ALAUDIDAE					
	Bengal Bushlark	*Mirafra assamica* (Horsfield, 1840)	Rongosua bhardwaj	LC	R
Family: ARTAMIDAE					
	Ashy Woodswallow	*Artamus fuscus* (Vieillot, 1817)	Botahi sorai	LC	R
Family: CAMPEPHAGIDAE					
	Grey-chinned Minivet	*Pericrocotus solaris* (Blyth, 1846)	Rupohi	LC	R
	Short-billed Minivet	*Pericrocotus brevirostris* (Vigors, 1831)	Suti thutiya rupohi	LC	R
	Long-tailed Minivet	*Pericrocotus ethologus* (Bangs & Phillips, JC, 1914)	Dighol-nejia Rupohi	LC	R
	Scarlet Minivet	*Pericrocotus speciosus* (Latham, 1790)	Rupohi	LC	R
	Large Cuckooshrike	*Coracina macei* (Lesson, 1831)	Kuli Erakhaiti	LC	R
	Black-winged Cuckooshrike	*Lalage melaschistos* (Hodgson, 1836)		LC	R
FAMILY: CETTIIDAE					
	Yellow-bellied Warbler	*Abroscopus superciliaris* (Blyth, 1859)	Tiposi	LC	R
Family: CHLOROPSEIDAE					
	Blue-winged Leafbird	*Chloropsis moluccensis* (Gray, JE, 1831)	Patsorai	LC	R
	Golden-fronted Leafbird	*Chloropsis aurifrons* (Temminck, 1829)	Xun kopali Patsorai	LC	R
Family: CISTICOLIDAE					
	Grey-bellied Tesia	*Tesia cyaniventer* (Hodgson, 1837)	Tesia	LC	R
	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)	Patxia sorai	LC	R
	Dark-necked Tailorbird	*Orthotomus atrogularis* (Temminck, 1836)	Patxia sorai	LC	R
	Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)	Tiktik sorai	LC	R
	Rufescent Prinia	*Prinia rufescens* (Blyth, 1847)		LC	R
Family: CORVIDAE					
	Common Green-Magpie	*Cissa chinensis* (Boddaert, 1783)	Xeujiya kuklunga	LC	R
	Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)	Sekseki	LC	R
	House Crow	*Corvus splendens* (Vieillot, 1817)	Pati Kauri	LC	R
	Large-billed Crow	*Corvus macrorhynchos* (Wagler, 1827)	Dhura kauri	LC	R
Family: DICAEIDAE					
	Yellow-vented Flowerpecker	*Dicaeum chrysorrheum* (Temminck, 1829)	Fultuka	LC	R
	Plain Flowerpecker	*Dicaeum minullum* (R. Swinhoe, 1870)	Fultuka	LC	R
	Scarlet-backed Flowerpecker	*Dicaeum cruentatum* (Linnaeus, 1758)	Fultuka	LC	R
Family: DICRURIDAE					
	Black Drongo	*Dicrurus macrocercus* (Vieillot, 1817)	Fesu	LC	R
	Bronzed Drongo	*Dicrurus aeneus* (Vieillot, 1817)	Motiya Fesu	LC	R
	Lesser Racket-tailed Drongo	*Dicrurus remifer* (Temminck, 1823)	Xoru Bhrimraaj	LC	R
	Hair-crested Drongo	*Dicrurus hottentottus* (Linnaeus, 1766)	Kexoraaj	LC	R

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	Greater Racket-tailed Drongo	*Dicrurus paradiseus* (Linnaeus, 1766)	Bor Bhrimraaj	LC	R
Family: EMBERIZIDAE					
	Chestnut-eared Bunting	*Emberiza fucata* (Pallas, 1776)		LC	WV
Family: ESTRILDIDAE					
	Scaly-breasted Munia	*Lonchura punctulata* (Linnaeus, 1758)	Futuki tuni	LC	R
	White-rumped Munia	*Lonchura striata* (Linnaeus, 1766)	Tuni sorai	LC	R
	Chestnut Munia	*Lonchura atricapilla* (Vieillot, 1807)	Kola tuni	LC	R
Family: EURYLAIMIDAE					
	Long-tailed Broadbill	*Psarisomus dalhousiae* (Jameson, 1835)		LC	R
Family: HIRUNDINIDAE					
	Asian Plain Martin	*Riparia chinensis* (J. E. Gray, 1830)	Teltupi	LC	R
	Bank Swallow	*Riparia riparia* (Linnaeus, 1758)	Teltupi	LC	R
	Barn Swallow	*Hirundo rustica* (Linnaeus, 1758)	Teltupi	LC	WV
Family: IRENIDAE					
	Asian Fairy-bluebird	*Irena puella* (Latham, 1790)	Nilpori	LC	R
Family: LANIIDAE					
	Brown Shrike	*Lanius cristatus* (Linnaeus, 1758)	Muga Era khaiti	LC	WV
	Long-tailed Shrike	*Lanius schach* (Linnaeus, 1758)	Dighol-nejia bagh sorai	LC	WV
	Grey-backed Shrike	*Lanius tephronotus* (Vigors, 1831)	Bagh sorai	LC	WV
Family: LEIOTHRICHIDAE					
	Lesser Necklaced Laughingthrush	*Garrulax monileger* (Hodgson, 1836)	Hahiyoti	LC	R
	Greater Necklaced Laughingthrush	*Pterorhinus pectoralis* (Gould, 1836)	Boiragi Hahiyoti	LC	R
Family: LOCUSTELLIDAE					
	Striated Grassbird	*Megalurus palustris* (Horsfield, 1821)		LC	R
	Bristled Grassbird	*Schoenicola striatus* (Jerdon, 1841)		VU	R
Family: MONARCHIDAE					
	Black-naped Monarch	*Hypothymis azurea* (Boddaert, 1783)	Rajkumar	LC	R
Family: MOTACILLIDAE					
	Forest Wagtail	*Dendronanthus indicus* (Gmelin, JF, 1789)	Balimahi	LC	WV
	Grey Wagtail	*Motacilla cinerea* (Tunstall, 1771)	Balimahi	LC	WV
	Citrine Wagtail	*Motacilla citreola* (Pallas, 1776)	Halodhimuriya Balimahi	LC	WV
	White Wagtail	*Motacilla alba* (Linnaeus, 1758)	Boga Balimahi	LC	WV
	Paddyfield Pipit	*Anthus rufulus* (Vieillot, 1818)	Matimahi	LC	R
	Rosy Pipit	*Anthus roseatus* (Blyth, 1847)	Gulapi Matimahi	LC	WV
	Olive-backed Pipit	*Anthus hodgsoni* (Richmond, 1907)	Matimahi	LC	WV
Family: MUSCICAPIDAE					
	Oriental Magpie-Robin	*Copsychus saularis* (Linnaeus, 1758)	Dohikotora	LC	R
	White-rumped Shama	*Copsychus malabaricus* (Scopoli, 1786)	Shama	LC	R
	Pale-chinned Flycatcher	*Cyornis poliogenys* (Brooks, 1880)	Makhiyoti	LC	R
	Small Niltava	*Niltava macgrigoriae* (Burton, 1836)	Xoru Nilmoni	LC	R
	Verditer Flycatcher	*Eumyias thalassinus* (Swainson, 1838)	Nilmoti	LC	R
	Lesser Shortwing	*Brachypteryx leucophris* (Temminck, 1828)		LC	R
	Bluethroat	*Luscinia svecica* (Linnaeus, 1758)	Nilakantho	LC	WV

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	Blue Whistling-Thrush	*Myophonus caeruleus* (Scopoli, 1786)	Nilomoti	LC	R
	Asian Brown Flycatcher	*Muscicapa dauurica* (Pallas, 1811)		LC	R
	Black-backed Forktail	*Enicurus immaculatus* (Hodgson, 1836)	Ketepa tip	LC	R
	Siberian Rubythroat	*Calliope calliope* (Pallas, 1776)	Tez tip	LC	WV
	Chinese Rubythroat	*Calliope tschebaiewi* (Przhevalsky, 1876)	Tez tip	LC	WV
	White-tailed Robin	*Myiomela leucura* (Hodgson, 1845)		LC	R
	Snowy-browed Flycatcher	*Ficedula hyperythra* (Blyth, 1843)	Makhiyoti	LC	R
	Taiga Flycatcher	*Ficedula albicilla* (Pallas, 1811)	Nasoni	LC	WV
	Slaty-backed Flycatcher	*Ficedula erithacus* (Blyth, 1861)	Makhiyoti	LC	WV
	Siberian Stonechat	*Saxicola maurus* (Pallas, 1773)	Hilkotora	LC	WV
	Grey Bushchat	*Saxicola ferreus* (Gray, JE & Gray, GR, 1847)		LC	R
	Black Redstart	*Phoenicurus ochruros* (Gmelin, S.G., 1774)	Kola somoka	LC	WV
	White-capped Redstart	*Phoenicurus leucocephalus* (Vigors, 1831)	Boga rongili	LC	R
	Plumbeous Water Redstart	*Phoenicurus fuliginosus* (Vigors, 183)		LC	R
Family: NECTARINIIDAE					
	Ruby-cheeked Sunbird	*Chalcoparia singalensis* (Gmelin, JF, 1789)	Moupiya	LC	R
	Crimson Sunbird	*Aethopyga siparaja* (Raffles, 1822)	Ronga Moupiya	LC	R
	Purple sunbird	*Cinnyris asiaticus* (Latham, 1790)	Bengunia Moupiya	LC	R
	Little Spiderhunter	*Arachnothera longirostra* (Latham, 1790)	Xoru Mokorakhua	LC	R
	Streaked Spiderhunter	*Arachnothera magna* (Hodgson, 1836)	Mokorakhua	LC	R
Family: ORIOLIDAE					
	Black-hooded Oriole	*Oriolus xanthornus* (Linnaeus, 1758)	Xokhiyoti	LC	R
	Maroon Oriole	*Oriolus traillii* (Vigors, 1832)		LC	R
Family: PARIDAE					
	Cinereous Tit	*Parus cinereus* (Vieillot, 1818)	Bhodorkoli	LC	R
	Sultan Tit	*Melanochlora sultanea* (Hodgson, 1837)	Mukutpindha	LC	R
Family: PASSERIDAE					
	House Sparrow	*Passer domesticus* (Linnaeus, 1758)	Gharsirika	LC	R
	Eurasian Tree Sparrow	*Passer montanus* (Linnaeus, 1758)	Bonsirika	LC	R
Family: PELLORNEIDAE					
	Puff-throated Babbler	*Pellorneum ruficeps* (Swainson, 1832)	Khupoti	LC	R
	Buff-breasted Babbler	*Pellorneum tickelli* (Blyth, 1859)		LC	R
	Abbott's Babbler	*Malacocincla abbotti* (Blyth, 1845)		LC	R
Family: PHYLLOSCOPIDAE					
	Yellow-browed Warbler	*Phylloscopus inornatus* (Blyth, 1842)	Tiposi	LC	WV
	Hume's Warbler	*Phylloscopus humei* (Brooks, 1878)	Tiposi	LC	WV
	Tickell's Leaf Warbler	*Phylloscopus affinis* (Tickell, 1833)	Tiposi	LC	WV
	Dusky Warbler	*Phylloscopus fuscatus* (Blyth, 1842)	Tiposi	LC	WV
	White-spectacled Warbler	*Phylloscopus intermedius* (La Touche, 1898)	Tiposi	LC	R
	Green-crowned Warbler	*Phylloscopus burkii* (Burton, 1836)	Tiposi	LC	WV
	Whistler's Warbler	*Phylloscopus whistleri* (Ticehurst, 1925)	Tiposi	LC	R
	Greenish Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	Tiposi	LC	WV
	Yellow-vented Warbler	*Phylloscopus cantator* (Tickell, 1833)	Sotsoti	LC	R
	Blyth's Leaf Warbler	*Phylloscopus reguloides* (Blyth, 1842)	Tiposi	LC	WV
	Grey-cheeked Warbler	*Phylloscopus poliogenys* (Blyth, 1847)	Tiposi	LC	R

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Family: PITTIDAE					
	Blue-naped Pitta	*Hydrornis nipalensis* (Hodgson, 1837)	Nila Pithia Bahtoli	LC	R
	Hooded Pitta	*Pitta sordida* (Statius Müller, 1776)	Kiriti Pindha Bahtoli	LC	SM
Family: PLOCEIDAE					
	Streaked Weaver	*Ploceus manyar* (Horsfield, 1821)	Tukura Sorai	LC	R
	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)	Tukura Sorai	LC	R
	Black-breasted Weaver	*Ploceus benghalensis* (Linnaeus, 1758)	Tukura sorai	LC	R
Family: PNOEPYGIDAE					
	Pygmy Cupwing	*Pnoepyga pusilla* (Hodgson, 1845)		LC	R
Family: PYCNONOTIDAE					
	Black-crested Bulbul	*Rubigula flaviventris* (Tickell, 1833)	Kola muriya Bulbuli	LC	R
	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	Bulbuli	LC	R
	Red-whiskered Bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)	Tikoni Bulbuli	LC	R
	White-throated Bulbul	*Alophoixus flaveolus* (Gould, 1836)	Gol boga Bulbuli	LC	R
	Ashy Bulbul	*Hemixos flavala* (Blyth, 1845)	Kojola Fesuluka	LC	R
Family: SITTIDAE					
	Chestnut-bellied Nuthatch	*Sitta cinnamoventris* (Blyth, 1842)	Dalbogua	LC	R
Family: STENOSTIRIDAE					
	Grey-headed Canary-Flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)	Bari-nasoni	LC	WV
	Yellow-bellied Fantail	*Chelidorhynx hypoxanthus* (Blyth, 1843)	Nasoni	LC	R
Family: STURNIDAE					
	Common Hill Myna	*Gracula religiosa* (Linnaeus, 1758)	Moina Sorai	LC	R
	Indian Pied Starling	*Gracupica contra* (Linnaeus, 1758)	Kankurika	LC	R
	Chestnut-tailed Starling	*Sturnia malabarica* (Gmelin, 1789)	Kath Xalika	LC	R
	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	Ghar Xalika	LC	R
	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)	Sutia-Xalika	LC	R
	Great Myna	*Acridotheres grandis* (Moore, F, 1858)	Bor Xalika	LC	R
Family: TIMALIIDAE					
	Pin-striped Tit-Babbler	*Mixornis gularis* (Horsfield, 1822)		LC	R
Family: TURDIDAE					
	Orange-headed Thrush	*Geokichla citrina* (Latham, 1790)	Komola-muriya Matikotora	LC	R
Family: VANGIDAE					
	Large Woodshrike	*Tephrodornis virgatus* (Temminck, 1824)	Bor kathariya	LC	R
	Bar-winged Flycatcher-shrike	*Hemipus picatus* (Sykes, 1832)		LC	R
Family: VIREONIDAE					
	White-bellied Erpornis	*Erpornis zantholeuca* (Blyth, 1844)	Horu khupati	LC	R
Family: ZOSTEROPIDAE					
	Indian White-eye	*Zosterops palpebrosus* (Temminck, 1824)	Patmugi	LC	R
Order: PELECANIFORMES Family: ARDEIDAE					
	Cinnamon Bittern	*Ixobrychus cinnamomeus* (Gmelin, 1789)	Itaguria	LC	R
	Purple Heron	*Ardea purpurea* (Linnaeus, 1766)	Ajan	LC	R
	Intermediate Egret	*Ardea intermedia* (Wagler, 1829)	Maju Bog	LC	R
	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	Bamun Bogoli	LC	R

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	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	Gu-Bog	LC	R
	Indian Pond-Heron	*Ardeola grayii* (Sykes, 1832)	Kona musori	LC	R
	Malayan Night Heron	*Gorsachius melanolophus* (Raffles, 1822)	Potiyori	LC	R
Order: PICIFORMES Family: PICIDAE					
	Speckled Piculet	*Picumnus innominatus* (Burton, 1836)		LC	R
	White-browed Piculet	*Sasia ochracea* (Hodgson, 1837)		LC	R
	Grey-capped Pygmy Woodpecker	*Yungipicus canicapillus* (Blyth, 1845)	Xoru Barhoituka	LC	R
	Fulvous-breasted Woodpecker	*Dendrocopos macei* (Vieillot, 1818)	Pokhora Kathruka	LC	R
	Greater Flame-back	*Chrysocolaptes guttacristatus* (Tickell, 1833)	Rongamuriya Barhoituka	LC	R
	Rufous Woodpecker	*Micropternus brachyurus* (Vieillot, 1818)	Barhoituka	LC	R
	Great Slaty Woodpecker	*Mulleripicus pulverulentus* (Temminck, 1826)	Bor saya barhoituka	VU	R
	Black-rumped Flameback	*Dinopium benghalense* (Linnaeus, 1758)	Xun barhoituka	LC	R
	Lesser Yellownape	*Picus chlorolophus* (Vieillot, 1818)	Xoru halodhiya Barhoituka	LC	R
	Grey-headed Woodpecker	*Picus canus* (Gmelin, JF, 1788)	Barhoituka	LC	R
	Greater Yellownape	*Chrysophlegma flavinucha* (Gould, 1834)	Bor halodhiya Barhoituka	LC	R
Family: MEGALAIMIDAE					
	Coppersmith Barbet	*Psilopogon haemacephalus* (Statius Müller, 1776)	Hetuluka	LC	R
	Blue-eared Barbet	*Psilopogon cyanotis* (Blyth, 1847)	Nila Pakhia hetuluka	LC	R
	Lineated Barbet	*Psilopogon lineatus* (Vieillot, 1816)	Kojola hetuluka	LC	R
	Blue-throated Barbet	*Psilopogon asiaticus* (Latham, 1790)	Nilakantho Heteluka	LC	R
	Great Barbet	*Psilopogon virens* (Boddaert, 1783)	Jomdakini	LC	R
Order: PSITTACIFORMES Family: PSITTACULIDAE					
	Red-breasted Parakeet	*Psittacula alexandri* (Linnaeus, 1758)	Golpura bhatou	NT	R
	Rose-ringed Parakeet	*Psittacula krameri* (Scopoli, 1769)	Golmonika	LC	R
Order: STRIGIFORMES Family: STRIGIDAE					
	Asian Barred Owlet	*Glaucidium cuculoides* (Vigors, 1830)	Kuruli fesa	LC	R
	Collared Owlet	*Taenioptynx brodiei* (Burton, 1836)	Fesa	LC	R
	Spotted Owlet	*Athene brama* (Temminck, 1821)	Futuki Fesa	LC	R
	Spot-bellied Eagle-owl	*Ketupa nipalensis* (Hodgson, 1836)	Dudhkusi hudu	LC	R
Order: SULIFORMES Family: ANHINGIDAE					
	Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)	Moniyori	NT	R
Family: PHALACROCORACIDAE					
	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	Pani Kauri	LC	R
Order: TROGONIFORMES Family: TROGONIDAE					
	Red-headed Trogon	*Harpactes erythrocephalus* (Gould, 1834)	Kathoni Buwari	LC	R

LC—Least Concern | NT—Near Threatened | VU—Vulnerable | R—Resident | WV—Winter Visitor | SM—Summer Migrant.

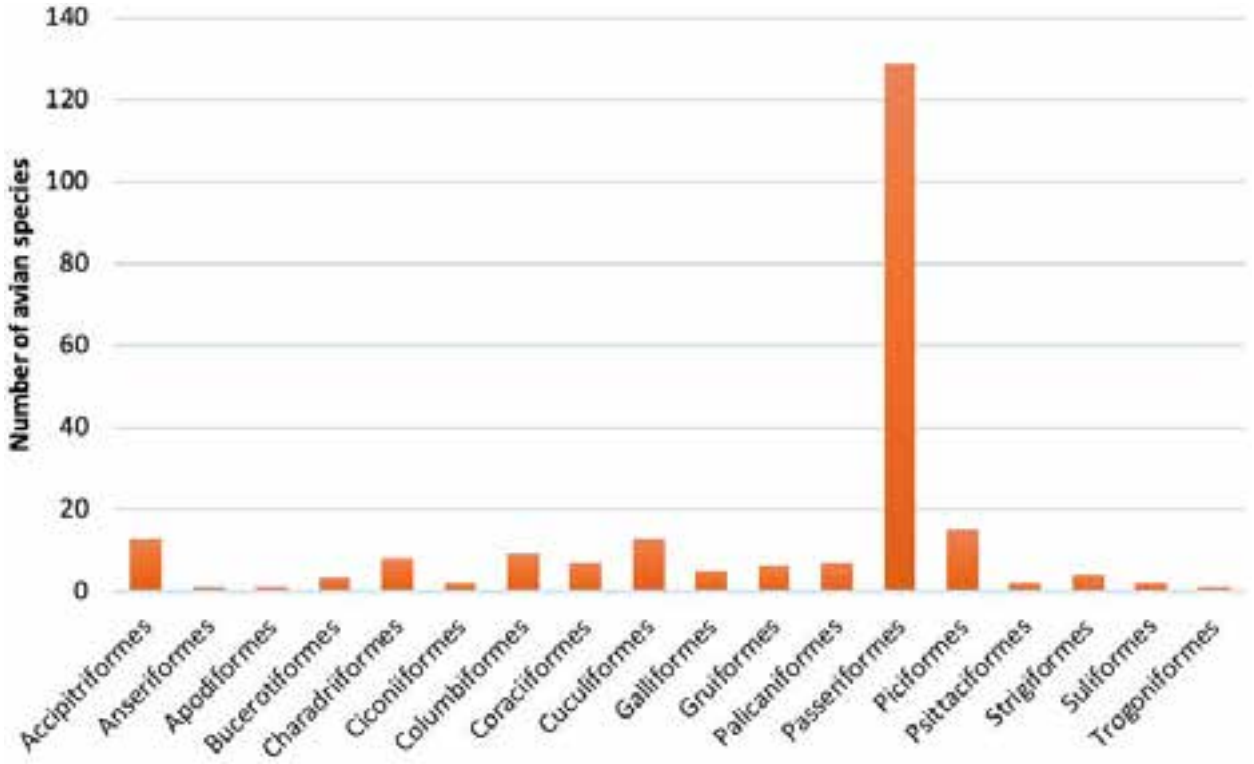

Figure 2. Order-wise species richness of avian fauna in Suang Reserve Forest.

DISCUSSION

This is the first study of avian fauna from the Suang RF in Nagaon. We recorded 228 species of birds. The findings are similar to observations from Behali Wildlife Sanctuary with 283 species belonging to 18 orders and 64 families (Kakati et al. 2022) of Assam with similar habitats. A higher species richness of order Passeriformes with 127 species, suggests that the study area consists of heterogenous habitat types (Hilaluddin & Sharma 2008).

The sampling in this area initially started as bird watching, which was only for three months during the first year of the study as part of forest trekking and casual bird-watching activities. However, after recognizing the potential richness of birds in the forest, we decided to have a more structured approach and integrated proper scientific methodologies for appropriate documentation and data curation. The fact that there are eight species of globally threatened birds; four Vulnerable: Wreathed Hornbill, Great Hornbill, Bristled Grassbird & Great Slaty Woodpecker, and four Near Threatened: Oriental Darter *Anhinga melanogaster*, Red-breasted Parakeet *Psittacula alexandri*, Lesser Adjutant *Leptoptilos javanicus*, and Rufous-bellied Eagle *Lophotriorchis kienerii*, suggests that the area needs maximum protection to preserve these bird species. Frugivorous forest birds, like the Wreathed Hornbills and Great Hornbills were observed in eight easily accessible locations in the study area. These findings reveal that the forest is in pristine condition and habitat quality suggesting that the region has a high biodiversity value (Saikia & Rabha 2006). The record of Grey Peacock-Pheasant is the first photographic documentation, from middle Assam, suggesting that the study area is unexplored and needs extensive documentation (Bora & Bora 2023). The study's limitation arises from the steep hilly terrain, so certain study areas were inaccessible and could not be explored. The felling of trees by local inhabitants was the only threat to the habitat we observed during the study period. We recommend that a comprehensive and proper scientific study be conducted on the biodiversity, including the avian community of the reserve forest, as no documentation was done earlier in this forest. This helps in future conservation planning of the reserve forest.

Notes on species of interest

Wreathed Hornbill *Aceros undulatus* (IUCN Red List status: Vulnerable)

Observed commonly in the hilly tracks of the study area (26.3191°N, 92.9427°E). Often observed in pairs. Mostly seen perched on fig trees (*Ficus religiosa, Ficus benghalensis, Ficus racemosa*) near the Champawati hill-stream that runs through the forest. Once nine individuals were seen together in flight.

Great Hornbill *Buceros bicornis* (IUCN Red List status: Vulnerable)

Great Hornbill pairs are frequently seen perched on large trees on the hilly slope or in flight in the trek towards the Champawati waterfall (26.3196°N, 92.9427°E).

Bristled Grassbird *Schoenicola striatus* (IUCN Red List status: Vulnerable)

It is a common resident from the grasslands of Kaziranga (Barua & Sharma 1999). During our survey, one individual was observed in a grassland (26.3389°N, 92.8256°E), adjacent to the reserve forest.

Great Slaty Woodpecker *Mulleripicus pulverulentus* (IUCN Red List status: Vulnerable)

Largest woodpecker found in the Indian subcontinent. Observed rarely in the study area, only twice during the study period in flight (26.3320°N, 92.9221°E). It is identified based on obvious visual cues. However, no photograph could be captured in any of the encounters.

Rufous-bellied Eagle *Lophotriorchis kienerii* (IUCN Red List status: Near Threatened)

An uncommon raptor for the study area. Only one individual was photographed (26.3197°N, 92.9088°E) in November 2023, during flight.

Malayan Night Heron *Gorsachius melanolophus* (IUCN Red List status: Least Concern)

A rare species for the study area. Several sighting reports are from Kaziranga National Park. (Barua & Sharma 1999; Rahmani 2018). In the reserve forest, we encountered a bird near bushes (26.3197°N, 92.9088°E-). It was an elusive bird and was observed only once in July 2018.

White-cheeked Partridge *Arborophila atrogularis* (IUCN Red List status: Least Concern)

A little-known resident of the Assam Valley and southern Assam hills with a relatively small and declining population (BirdLife International 2023). The White-Cheeked Partridge is confined to moist undergrowth and bamboo jungle in evergreen forests (Rasmussen & Anderton 2012). It is found in Panbari, Kukurakata, and Bagser reserve forests of Kaziranga, and the nearby foothills of North Karbi Anglong WLS. (Rahmani et al. 2023). In the study area, the species' call is often heard from several locations (26.3306°N, 92.9142°E). The bird was encountered once near a dense bamboo undergrowth (26.3204°N, 92.9024°E), and only a record shot of the bird could be captured.

Forest Wagtail *Dendronanthus indicus* (IUCN Red List status: Least Concern)

It is a winter visitor to the study area. One male individual was observed near the hill stream (26.3204°N, 92.9024°E), foraging between the rocks in December 2018.

Grey Peacock-Pheasant *Polyplectron bicalcaratum* (IUCN Red List status: Least Concern)

Due to its illusive behaviour the bird was mostly heard than seen. During the breeding season, the territory call of the male bird is frequently heard from several locations (26.3189°N, 92.9079°E; 26.3204°N, 92.9038°E), which indicates the presence of a population of Grey Peacock Pheasant in the study area. We also reported the first photographic documentation of the bird from the central region of Assam from the study area (Bora & Bora 2023). Earlier it has been reported from Dihing-Patkai National Park (Bhuyan et al. 2024), and Behali Wildlife Sanctuary of Assam (Kakati et al. 2022).

Red-headed Trogon *Harpactes erythrocephalus* (IUCN Red List status: Least Concern)

One male bird was seen only in June 2017. The bird was perched on a shrub (26.3297°N, 92.9108°E) but was disturbed by our presence and flew away before capturing any picture.

Jackobian Cuckoo *Clamator jacobinus* (IUCN Red List status: Least Concern)

A rare summer visitor to the study area. Only one individual was observed in the same grassland where the bristled grassbird was observed. The bird was perched on a small tree near a waterbody in the grassland (26.3283°N, 92.9018°E).

Pacific Golden-Plover *Pluvialis fulva* (IUCN Red List status: Least Concern)

A common winter visitor to Assam. However interestingly, deviating from the typical seasonal behaviour of the species, one individual was observed with its breeding plumage during summer in July 2023. The bird was seen in a paddy field (26.3268°N, 92.8542°E) adjacent to the reserve forest along with Red Wattled Lapwings.

Long-tailed Broadbill *Psarisomus dalhousiae* (IUCN Red List status: Least Concern)

Two individuals were spotted on two occasions in the summer of 2018. They were perched on tall tree branches on both occasions (26.3297°N, 92.9110°E). They were spotted with their distinct calls. Photographs

were taken during these encounters. No individuals of this species were encountered in subsequent surveys.

Black-breasted Weaver *Ploceus benghalensis* (IUCN Red List status: Least Concern)

Several nesting pairs of the bird were observed from the adjacent grassland (26.3345°N, 92.8404°E) of the reserve forest during the years 2017–2018. However, in recent years, the species has become less frequently seen, most likely due to the negative effects of overgrazing and excessive hay collection in the area.

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Image 1. White-cheeked Patridge.

Image 2. Slaty-breasted Rail.

Image 3. Rufous-bellied Eagle.

Image 4. Pale-chinned Blue Flycatcher.

Image 5. Grey Bushchat.

Image 6. Common Green-Magpie.

Image 7. Chestnut-winged Cuckoo.

Image 8. Black Baza.

Image 9. Bar-winged Flycatcher-shrike.

Image 10. Grey Peacock-Pheasant.

Image 11. Dollerbird.

Image 12. Abbott's Babbler.

Image 13. Clamorous Reed Warbler.

Image 14. Large Hawk-Cuckoo.

Image 15. Emerald Cuckoo.

Image 16. Black-breasted Weaver.

Image 17. Blue-eared Barbet.

Image 18. Eurasian Sparrow Hawk.

Image 19. Oriental Honey-buzzard.

Image 20. White-tailed Robin.

Image 21. Green-crowned Warbler.

Image 22. Grey-bellied Tesia.

Image 23. Malayan Night Heron.

Image 24. Yellow-browed Warbler.

Image 25. Asian Barred Owlet.

Image 26. Sultan Tit.

Image 27. Greater Racket-tailed Drongo.

Image 28. Greater Coucal.

Image 30. Kalij Pheasant.

Image 31. Grey-headed Canary-Flycatcher.

Image 32. Lesser Whistling-Duck.

Image 33. Plaintive Cuckoo.

Image 34. Shikra.

Image 35. Peregrine Falcon.

Image 36. Bristled Grassbird.

Image 37. Long-tailed Broadbill.

Image 38. Great Hornbill.

Image 39. Wreathed Hornbill.

Image 40. Pacific Golden-Plover

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ARTICLE

Age structure of carp and catfish catch as a tool to assess ecological health of fished stocks from the Ganga River system with special reference to Mahseer *Tor tor* (Hamilton, 1822)

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Abstract: In the 20th centuary, the economically important carp species *Labeo rohita, Tor tor,* & *Labeo calbasu* and the catfishes *Rita rita* & *Bagarius bagarius* contributed substantially to the total fish catch from the Ganga River system in India. Samples were recorded between December 2003 and June 2004 from fish landing centers in the Ken, Paisuni, and Tons rivers for *L. rohita, T. tor* and *L. calbasu*. *Rita rita* and *B. bagarius* were sampled between September 2001 and September 2003 in the Ganga River system. The data were used to evaluate the growth and age structures of fish populations. Age classes varied 0+–5+ for *L. rohita* in the Ken & Paisuni rivers and 0+–8+ in the Tons River. For *T. tor*, the age classes varied 1+–6+ in the Ken & Paisuni rivers and 1+–8+ in the Tons. Age classes of *L. calbasu* varied 1+–6+ in the Ken River, 1+–5+ in the Paisuni River, and 1+–7+ in the Tons. In the Ganga River, age classes of *R. rita* & *B. bagarius* varied 0+–7+ and 0+–6+, respectively. The *L. rohita,* age pyramid showed a tendency for bell shape in Ken River, base tends to be broader through bell shape in Paisuni River, and bell-shaped age pyramid was slightly distorted in Tons River. In case of *T. tor*, tendency for bell shape in Ken River and bell-shaped age pyramid in Paisun River & Tons River were obtained. In case of *L. calbasu*, heavy bottom shaped age pyramid was recorded in Ken and Paisuni rivers, while base tends to be broader in the Tons River. Bell shaped age pyramid was recorded for *B. bagarius* in the Ganga River while heavy bottom shape for *R. rita* in the Ganga River. Overall, *T. tor* is facing heavy fishing pressure and also targeted fish species by fishermen from the Ganga River system.

Keywords: Age composition, age of fish, age pyramid, catch, exploitation, fishing pressure, growth ring, operculum, Rohu, scale.

Hindi: भारत में 20वीं सदी में आर्थिक रूप से महत्वपूर्ण कार्प प्रजातियाँ लेबियो रोहिता, टॉर टॉर व लेबियो कलबासु, और कैटफ़िश रीटा रीटा एवं बागेरियस बागेरियस ने गंगा नदी प्रणाली से कुल फिश कैच में महत्वपूर्ण योगदान दिया है। इस अध्यन हेतु रीता रीता और बागेरियस बागेरियस का सैंपल सितंबर 2001 और सितंबर 2003 के बीच गंगा नदी प्रणाली में लिया गया था। दिसंबर 2003 और जून 2004 के बीच केन, पैसुनी और टोंस नदियों और फिश लैंडिंग केंद्रों से लेबियो रोहिता, टॉर टॉर व लेबियो कलबासु के लिए सैंपल प्राप्त किये गये। फिश पापुलेशन की वृद्धि और ऐज स्ट्रकचर मूल्यांकन के लिए सैंपल का उपयोग किया गया । केन और पैसुनी नदियों में लेबियो रोहिता के लिए ऐज क्लास 0 - 5+ और टोंस में 0 - 8+ थे। केन और पैसुनी नदियों में लेबियो रोहिता के लिए ऐज क्लास 0 - 5 और टोंस नदी में 0 -8+ है। टॉर टॉर के लिए ऐज क्लास केन और पैसुनी नदियों में 1- 6+ और टोंस में 1-8+ के बीच था। गंगा नदी में, रीटा रीटा और बागेरियस बागेरियस की ऐज क्लास क्रमशः 0 -7+, 0 - 6+ से भिन्न पाई गयी है । लेबियो रोहिता के ऐज पिरामिड ने केन नदी में घंटी के आकार की प्रवृत्ति दिखाई, पैसुनी और टोंस नदी में घंटी के आकार का ऐज पिरामिड थोड़ा बदल गया था। टॉर टॉर के मामले में केन नदी में घंटी के आकार की प्रवृत्ति और पैसुनी नदी एवं टोंस नदी में घंटी के आकार का ऐज पिरामिड पाया गया । लेबियो कालबासु के मामले में भारी तली के आकार का ऐज पिरामिड केन और पैसुनी नदियों में दर्ज किया गया था, जबकि टोंस नदी में आधार चौड़ा है। घंटी के आकार का ऐज पिरामिड बागेरियस बागेरियस के लिए दर्ज किया गया, जबकि गंगा नदी में रीता रीता के लिए भारी तल का आकार प्राप्त हुआ। कुल मिलाकर गंगा नदी प्रणाली में मछुआरों द्वारा मछली की प्रजातियों को लक्ष्य बनाकर पकड़ा जा रहा है, और टॉर टॉर प्रजाति, दोहन से भारी दबाव में है ।

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Author contributions: PN has critically reviewed the manuscript and provided valuable suggestions. ACD collected data, capture photographs and write the manuscript. ASM worked on table, graphs/charts preparation, and also critical review.

INTRODUCTION

Fish landing composition in Indian rivers fluctuates from year to year, especially in Sadiapur and Allahabad regions of the Ganga River basin (Anonymous 1976, 1991, 2003; Mayank & Dwivedi 2015; Pathak et al. 2015; Tripathi et al. 2017). In 1976 landing record, *Labeo calbasu*, *Cirrhinus mrigala, L. catla*, and *L. rohita* contributed 15.68, 11.60, 3.30, and 4.72 tonnes, respectively. The catfish *Sperata aor* and *S. seenghala* jointly contributed 19.27 tonnes and miscellaneous species contributed 36.17 tonnes (Anon 1976). However, in 2001–2002 the miscellaneous fish (72%) dominated *S. aor* & *S. seenghala* (total 14%), and Indian Major Carp (*C. mrigala, C. catla*, & *L. rohita*, 1.4%, 3.1%, & 2.9%, respectively). *Wallago attu* (1.6%) and *Hilsa ilisha* (1.8%) contributed small proportions. In 2002–2003 the share of exotic carps increased to 17.8% while the catfishes (13.1%) and the Indian Major Carp (6.4%) remained stable. Besides landings, the age of fish at catch may be an important tool for computing growth, mortality, recruitment, and other fundamental parameters of fish populations. This can also be used to determine current ecological state of fished stocks.

The age and growth rate are two aspects of leading parameters in assessing health of fish stocks and their response to various types of habitats with fisheries sustainability (Ujjania & Soni 2018; Mayank et al. 2018; Nautiyal & Dwivedi 2020). Age and growth of fish are essential elements for understanding the habitat suitability, food supply, fishing pressure, pollution load, competition (example food, space, oxygen, and breeding ground) with other fish species (especially exotic species), and life history of any fish species (Mir et al. 2013). Age determination of fishes is an essential first step in age-based fish stock assessment, biomass and successful resource management (Dwivedi 2013). Growth is the change in size (length, weight) over time. This is one of the most intensively studied aspects of fishery biology. The purpose of growth studies of fish is to determine the number of fish that can be produced with respect to time (Pathak et al. 2014; Singh et al. 2017). The annual variation in a fishery depends upon its growth pattern. However, growth of fish is a complex mechanism, which represents the outcome of the interactions among several biotic and abiotic factors operating on behavioural and physiological processes. Accurate fish growth rates are important for growth analysis, age structure analysis, and mortality rate estimation (Mishra et al. 2023). The information of fish growth increment is also necessary for species life history, reproductive biology, population dynamics, biomass, and fisheries sustainability studies (Mayank et al. 2015; Rana & Nautiyal 2023).

In fisheries, fish landing data can be used to assess the present position of fish stock and the prediction of population trends. The changes in the yield can help in detecting whether a population was declining in abundance or maintaining itself at a stable level. Fishing resembles natural mortality in often causing changes in the population structure, such as age composition, age of maturity, and sex ratio. Fishing not only reduces population but also alters its intraspecific and interspecific relations. Theoretically, selective fishing can alter the structure greatly and lead to "biological overfishing", a stage where a population cannot reproduce itself and maintain its stock (Nikolskii 1980). This contribution specifically concerns on the age structure of major (*L. rohita*, *L. calbasu*), minor cyprinid (*Tor tor*), and catfish (*B. bagarius*, *R. rita*) from the rivers in and around Allahabad (now Prayagraj), Uttar Pradesh, India. The present study was conducted to unravel the age pyramid, age composition, and first ring appearance of commercially important fish from the Ganga River system. However, Pathak et al (2011), Mayank et al. (2018), and Mishra et al. (2021) have reported declined age structure for these species from the Ganga River system.

In the present study, more than 20 years results have been presented and it will be helpful to researchers of current period to use this information as benchmark for age structure information of listed fish species. These fishes are keystone species for the Ganga River system. The outcome of this study will be helpful to the fishery managers, researchers, and planners in management of the riverine fisheries mainly Indian Major Carp (IMC) and the threatened Central Indian Mahseer *Tor tor*.

MATERIALS AND METHODS

Samples of the carps *L. rohita*, *T. tor*, and *L. calbasu* (Image 1) were collected from fishermen or from fish market at Banda for the Ken River and Karwi for the Paisuni River. In case of the Tons River, fish samples were collected from fish market at Sadiapur/Gaughat, Allahabad there was no local fish market at Chakghat (fishing place). The samples of various fish species were recorded randomly during December 2003 to June 2004 from fish landing centers in the Ken, Paisuni, and Tons rivers. The sample size of fish species comprised of 158, 147, and 159 individuals of *L. rohita*, *T. tor*, and *L.*

Image 1. Cyprinidae. a—Rohu *Labeo rohita* | b—Tor Mahseer *Tor tor* | c—Calbasu *Labeo calbasu*. © Amitabh Chandra Dwivedi.

calbasu, respectively. The collected fish samples were preserved in 10% formalin and brought to the laboratory for further study.

The catfish samples consisted of *Rita rita* ('Ritha', 'Belgagra', 'Patharchatti') and *Bagarius bagarius* ('Goonch' or 'Patharchatti'). They were collected from the river Ganga at Rasoolabad fishing sites in Allahabad from September 2001–August 2003 (Image 2). The sample size comprised of 105 individuals of *R. rita* and 68 of *B. bagarius.*

Methods of Age determination

Scales

The age of *L. rohita, T. tor,* and *L. calbasu* of family Cyprinidae were determined by removing scales (Bagenal & Tesch 1978; Nautiyal 1990; Nautiyal & Dwivedi 2020) from the row above lateral line below dorsal fin region of preserved fish sample. The scales were cleaned in 5% KOH solution to remove adhering tissues and finally washed in distilled water. The scales were then pressed while drying to avoid their curling (Bagenal & Tesch 1978).

Prior to age determination, it was essential to establish whether the fish scale radius increased with

Image 2. Catfish (Sisoridae, Bagridae): a—*Rita rita* | b—*Bagarius bagarius*. © Amitabh Chandra Dwivedi.

the length of fish or not, since scales may be lost, and regenerated. According to Jhingran (1959) the annual increment in length of the scale maintains a constant ratio with increase in length of the fish throughout the year. It is a great importance implying the suitability of their scales for age determination. This relationship must be established, even if such information exists for the same species from same river and same or nearby location as rates of increase in scale radius-fish length will differ as populations are dynamic entities.

Opercular bone

In case of catfish, since scales are lacking, the age determination was performed by removing opercular bone of each fish. The opercular bones were boiled in 10% KOH solution to clean the muscles. The completely dried opercular bones were placed in an envelope containing information on date of collection, fish species (*R. rita*, *B. bagarius*), length of fish, weight of fish, sex. Later, they were examined under binocular microscope by placing it against a black background under reflected light to determine the age of the fish.

Growth Rings

In scales uniformly spaced, circuli are deposited during part of year with no environmental and or physiological stress resulting in a wide transparent zone (T). In contrast, the part of the year with environmental and or physiological stress result in deposition of closely spaced circuli that break, bifurcate, or form a hyaline area (Bagenal & Tesch 1978; Nautiyal & Dwivedi 2020) resulting in a very narrow opaque zone (O). The transparent and opaque zones together constitute one growth ring, which if laid annually are known as 'annulus'. The scales in these species are known to have annuli (*T. tor*: Karamchandani et al. 1967; *L. calbasu*: Gupta & Jhingran 1973; *L. rohita*: Pandey 1993). In the calcified structures like operculum growth rings are formed through an accretion, which result in alternated translucent and opaque rings. Fish age was determined by counting the number of translucent or opaque rings. Age of individual fish species was determined based on number of annuli and designated as 0+, 1+, 2+, 3+, 4+ so on (Mayank et al. 2018; Ujjania & Soni 2018; Dwivedi & Nautiyal 2021).

Age structure

The number of each age group was recorded separately for *L. rohita, T. tor*, and *L. calbasu* from the rivers Ken, Paisuni and Tons. The number of fish in each age group were recorded and converted into percentage to obtain a pyramid. This pyramid represents the status of the fish stock based on the share of age groups. Age structure was determined based on annuli and designated as 0+, 1+, 2+, 3+, 4+ so on. The total numbers of annuli were recorded in each scale to assess the age of an individual fish. This was also done to compute age structure in different sex. To determine the age structure, the frequency was computed for each age class and recorded as percentage.

RESULTS AND DISCUSSION

Length-at-Age

Eight growth rings were recorded in *L. rohita* & *T. tor* while seven rings in *L. calbasu* stocks were recorded occurring in the rivers Ken, Paisuni, and Tons. Eight growth rings were recorded in *L. rohita* and *T. tor* from the Tons river while seven rings in *L. calbasu* stocks was recorded in Tons river. However, in case of *T. tor* fishes, eight rings were recorded only Tons river while six rings were recorded in the Ken and Paisuni rivers. In *L. rohita* 1st growth ring appeared in 24–30 cm size group in all the rivers, compared with 16–22 cm size in *T. tor* and 16–20 cm size in *L. calbasu*. However, the size of *L. rohita* below 18 cm did not show growth rings, thus attaining more length than other two carps in 1st year. The 2nd growth ring first appeared in 36–42 cm size groups in all rivers in case of *L. rohita*, 22–28 cm size in *T. tor*, and 20–28 cm in *L. calbasu*. The latter showed slight variation,

as the size was 20–24 cm in the Paisuni and the Tons River. In the Ken River slight variation was observed in 24–28 cm size. The 3rd and 4th growth ring first appeared in 54–60 cm and 60–66 cm size groups in all rivers in *L. rohita*. However, considerable variation occurred among the rivers in *T. tor* as well as *L. calbasu*. In the former 3rd ring was observed in 28–34 cm in the Tons and the Ken rivers, while 34–40 cm in the Paisuni River. The 4th growth ring in *T. tor* appeared in 40–46 cm size group in all rivers, while 32–36 cm in the Ken River and 36–40 cm in both the rivers Tons and the Paisuni.

The 5th growth ring was observed in 60–72 cm, 46–64 cm, and 40–48 cm in *L. rohita*, *T. tor*, and *L. calbasu*, respectively, showing variation among the rivers. The 6th growth ring was first laid in 78–84 cm, 64–76 cm and 48–52 cm size in *L. rohita*, *T. tor*, and *L. calbasu*, respectively. The 7th and 8th growth rings were laid in 84–90 cm in all *L. rohita* samples compared with 70–76 cm and 76–82 cm in *T. tor*. The 7th growth ring appeared in 56–60 cm size in *L. calbasu*.

It became obvious that *L. rohita* grow faster than *T. tor*. The *L. calbasu* indicated slow growth than other two species. However, *L. rohita* exhibited constant increase in length in all the three rivers till the formation of 4+ growth rings. For the 5th growth ring better size increase was observed in the Paisuni River followed by Ken River and least growth observed in the Tons River. Fish with more than 6+ growth rings were observed in the Tons River only. This was also true for other two species namely *T. tor* and *L. calbasu*.

Differences in growth of fishes may be observed in same species inhabiting different rivers of same ecoregion. In *T. putitora* 1st, 2nd, and 3rd growth rings appeared in 10–15 cm, 20–25 cm, 25–30 cm size, both in the Ganga and the Song rivers, but in 7–10 cm, 16–19 cm, 22–25 cm in the Nayar River. The 4th and 5th growth rings appeared in 35–40 cm and 45–50 cm size groups, respectively in the Ganga River. The 4th growth ring was observed in 40–45 cm size group in the Song River, 34–37 cm, and 52–55 cm size group in the Nayar River (Nautiyal 1990; Dhasmana 2004).

In *L. rohita* from Govindgarh Lake, 1+–8+ growth rings appeared in 24–30 cm, 48–54 cm, 60–66 cm, 66–72 cm, 72–78 cm, 78–84 cm, 84–90 cm, and 96–102 cm, respectively (Prakash & Gupta 1986). Pandey (1993) reported growth rings formation in *L. rohita* of 44 cm, 56.4 cm, 67.4 cm, 77.1 cm, and 85.8 cm for 1+–5+ age groups from the river Padma, West Bengal. Present study indicated that the increase in size for same age group was slow in the rivers Ken, Paisuni, and Tons. In *T. tor* 1st, 2nd,3rd, 4th, 5th, and 6th age groups were formed at 19.6 cm, 29.5 cm, 38.3 cm, 45.5 cm, 52.9 cm, 56.5 cm mean length (Desai 1982) in the Narmada River. The lengths-at-age for *T. tor* from similar ecoregion were comparable to the present observation.

Gupta & Jhingran (1973) observed that *L. calbasu* from the river Yamuna at Allahabad had a mean length of 18.85 cm, 29.10 cm, 38.10 cm, 46.85 cm, 54.35 cm, 61.85 cm, 68.10 cm, and 73.10 cm, for 1+–8+ age groups, respectively. Rao & Rao (1972) reported 1+–7+ age group of *L. calbasu* for lengths of 20.22 cm, 30.18 cm, 38.21 cm, 45.15 cm, 50.94 cm, 54.73 cm, and 61.62 cm, respectively in the Godavari River, while that from the Ghaggar River was 21.89 cm, 33.96 cm, 43.26 cm, 48 cm, 52.10 cm for 1+–5+ age groups (Tandon et al. 1989). The present observation also indicated similarity in lengths-at-age for *L. calbasu* from similar as well as different ecoregions.

Table 1. Percentage of non-reproductive and reproductive population of *L. rohita*, *T. tor*, and *L. calbasu* in the rivers Ken, Paisuni, and Tons.

Labeo rohita	**Share (expressed as %) in the rivers**		
	Ken	Paisuni	Tons
Non-reproductive	52.00	50.97	41.81
Reproductive	48.00	49.02	58.18
Tot tor			
Non-reproductive	26.83	34.54	26.92
Reproductive	73.17	65.45	73.06
Labeo calbasu			
Non-reproductive	34.61	37.25	15.52
Reproductive	65.38	62.74	84.48

Table 2. Percentage of non-reproductive and reproductive population of *R. Rita* and *B. Bagarius* in the Ganga River.

Categories	Share (expressed as %) in the Ganga River	
	Rita rita	***Bagarius bagarius***
Non-reproductive	73.19	52.32
Reproductive	26.81	47.68

Age composition of fish catch

***Labeo rohita*:** In the Ken River age pyramid showed a tendency for bell shape as groups occurred in unproportionally declining fashion from 2+–5+ age groups. In 5+ age group percentage abruptly declined by 8% thus distorting the bell shape (Figure 1). In the Paisuni river the base tends to be broader as proportion of 2+ age group contributed 39.21% and abruptly declined in 3+ age group. Similar condition again occurred in 5+

age group (Figure 2). In the Tons River bell shaped age pyramid was slightly distorted because proportions of 0+ and 1+ age groups varied more. The percentage abruptly declined in 3+ age group compared with 1+ and 2+ age groups (Figure 3). The age groups 0+ and 1+ constitute immature individuals in the stock. These age groups accounted for 52% in the Ken River compared to 50.9% in the Paisuni River and 41.81% in the Tons River (Table 1).

***Tor tor*:** In the Ken River age pyramid for *T. tor* showed a tendency for bell shape. It was distorted as groups occurred in uneven declining fashion in 3+–4+ and 5+–6+ age groups (Figure 4). In the Paisuni river bell-shaped age pyramid was obtained and percentage declined more or less uniformly (Figure 5). In the Tons River bell shaped age pyramid was distorted because proportions of 1+ and 2+ age groups varied more while decreasing percentage of higher age groups was same as in the Paisuni River (Figure 6). The age group 1+ constituted immature individuals in the stock. They accounted for 34.54% in the Paisuni River compared with 26.92% in the Tons River, and 26.83% in the Ken River (Table 1).

***Labeo calbasu*:** In the Ken and Paisuni rivers, heavy bottom or broad-based age pyramids were obtained. The 1+ and 2+ age groups contributed 61.53% in the Ken River and 62.74% in the Paisuni River. In the Paisuni River, the percentage abruptly declined between 3+–4+ as difference was about 16% (Figures 7, 8). In the Tons River, broader base was obtained as each of higher age groups beyond 2+ were <10% but did not decrease proportionally as in the Ken and Paisuni rivers. The 1+ and 2+ age groups contributed 66.52%. The age groups 1+ constituted immature individuals in the stock (Figure 9). They accounted for 15.52% in the Tons River compared with 37.25% in the Paisuni River and 34.61% in the Ken River (Table 1).

***Rita rita*:** The age group 0+–4+ constituted 90% of the total population, respectively from the Ganga River. Individuals belonging to 0+ and 1+ age group constituted around 58.09% of the total population. Since *R. rita* is known to mature after 2+ age, the 0+–2+ age groups comprising non-brooders accounted for 73.19% (Table 2), while the brooders ranging from 3+–7+ age contributed only 26.4%. The heavy bottom age pyramid was obtained (Figure 10).

***Bagarius bagarius*:** The age group 0+–5+ constituted 90% of the total population from the Ganga River. The age pyramid in *B. bagarius* is distorted form of broad base age pyramid (Figure 11). It indicated high percentage of young (52.32%) and hence a recovering type of population, similar to *R. rita* (Table 2).

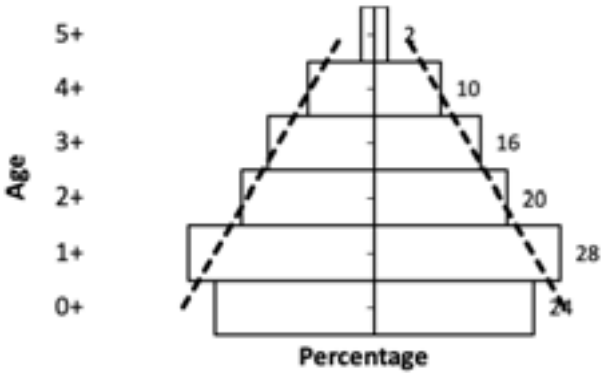

Figure 1. Age pyramid of *Labeo rohita* from the Ken River.

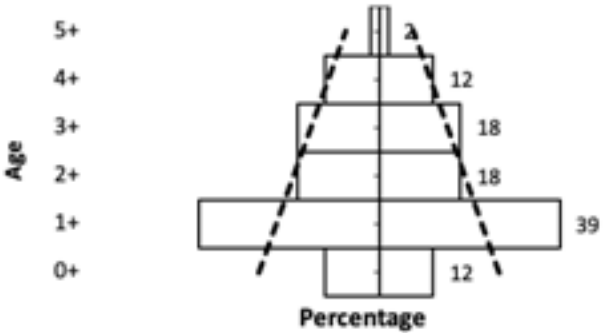

Figure 2. Age pyramid of *Labeo rohita* from the Paisuni River.

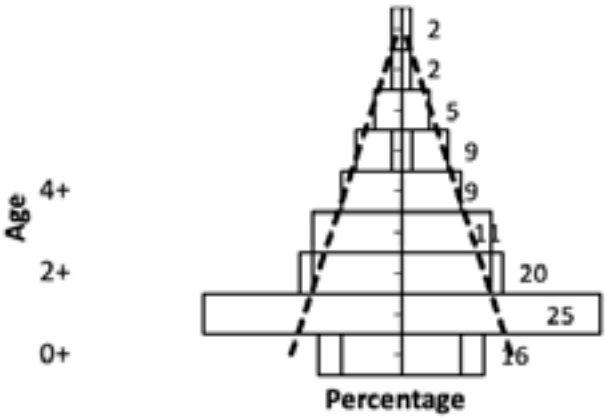

Figure 3. Age pyramid of *Labeo rohita* from the Tons River.

The male group of *R. rita* consisted of 0+–5+, while the female 0+–7+ age group from the Ganga River. First growth ring was not encountered till *R. rita* attained 14.9 cm size hence, fish below 15.0 cm were designated as 0+ age group. The size group 5.0–10.0 cm, 10.0-–5.0 cm, and 15.0–20.0 cm constituted 100% population of 0+ age groups. The size 20.0–25.0 cm comprised two age groups, dominated by 2+ (76.2%) compared to 1+ (23.8

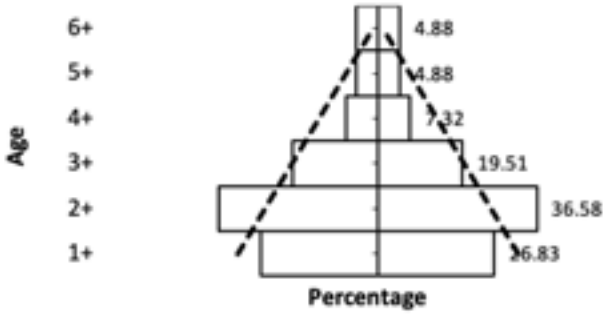

Figure 4. Age pyramid of *Tor tor* from the Ken River.

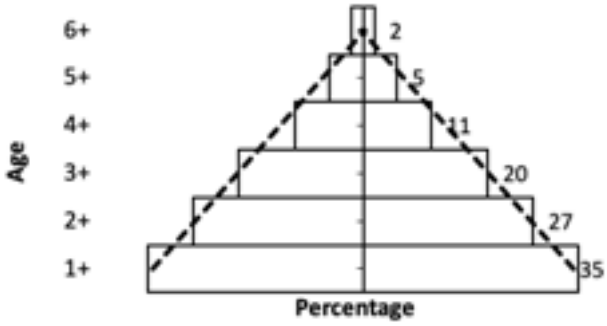

Figure 5. Age pyramid of *Tor tor* from the Paisuni River.

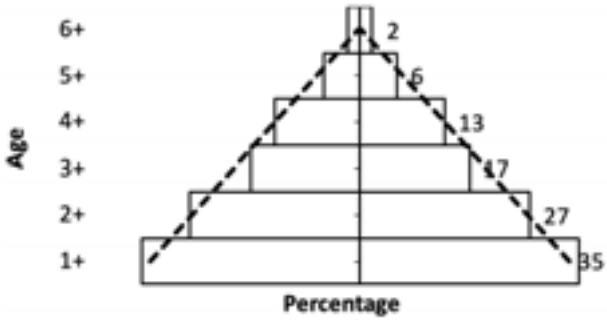

Figure 6. Age pyramid of *Tor tor* from the Tons River.

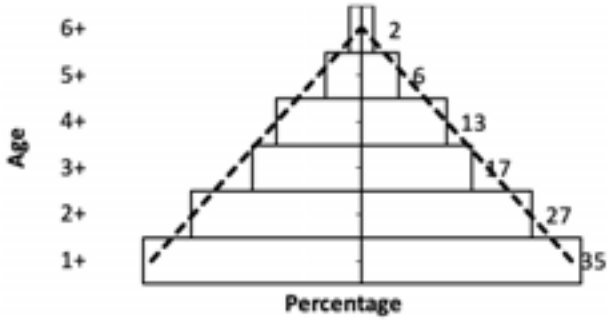

Figure 7. Age pyramid of Labeo calbasu from the Ken River.

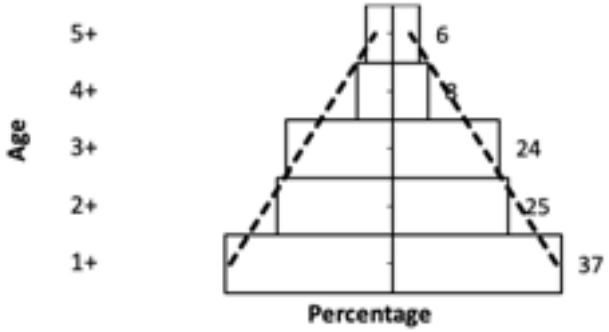

Figure 8. Age pyramid of Labeo calbasu from the Paisuni River.

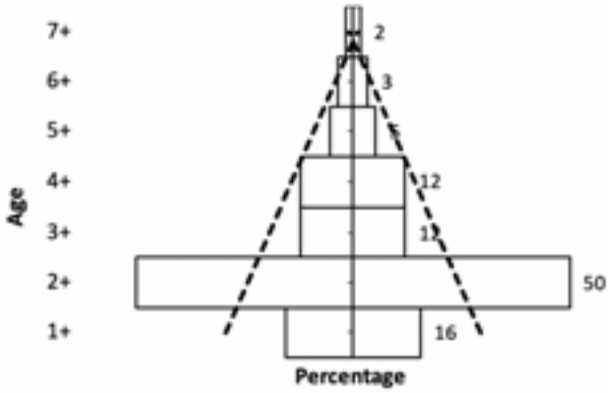

Figure 9. Age pyramid of Labeo calbasu from the Tons River.

%). The size 25.0–30.0 cm constituted fewer individuals of 2+ (25%) compared with 3+ (75%). However, 30.0–35.0 cm size was dominated by 4+ (75%) compared with 5+ (25%) age group. The size 35.0–40.0 cm was dominated by 5+ (100%) age group only, while 40.0–45.0 cm size consisted of only 33.3 % individuals of 6+ and 66.7% of 7+ age group.

Age groups 0+–5+ were observed for the male segment of *B. bagarius,* while 0+ –6+ age group for the female segment from the Ganga River. The size group 15.0–20.0 cm constituted 100% individuals of 0+ age group. The size group 20.0–25.0 cm comprised 0+ (6.7%), 1+ (60 %), and 2+ age groups (33.3 %) compared with 2+ (87.5%) and 3+ (12.5%) in the size 25.0–30.0 cm. In 30.0–35.0 cm and 35.0–40.0 cm size 3+ age group (72.7%, 71.4%, respectively) dominated, while in 40.0–45.0 cm 4+ age group prevailed (100%). The size 45.0–50.0 cm and 50.0–55.0 cm comprised 75%, 25%, 50%, and 50% of 5+ and 6+ population, respectively.

***Labeo rohita*:** The age groups varied from 0+–5+ in the Ken and Paisuni rivers, while 0+–8+ in the Tons River. The 0+ age group comprised 24%, 11.76% and 16.36% in the Ken, Paisuni, and Tons rivers, respectively. The age group 1+ dominated by virtue of numbers in the

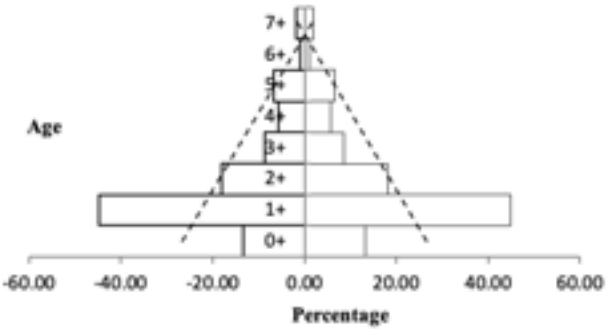

Figure 10. Age pyramid of *Rita rita* from the Ganga River.

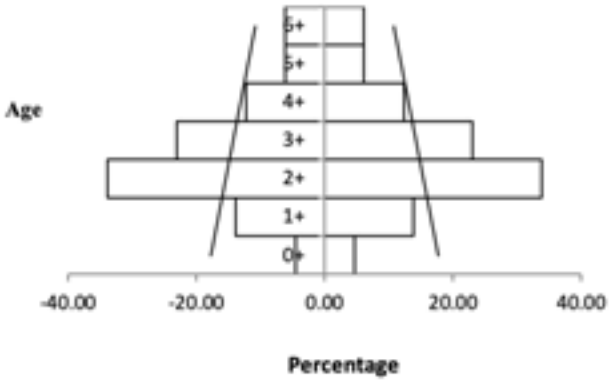

Figure 11. Age pyramid of *Bagarius bagarius* from the Ganga River.

Ken River (28%), in the Paisuni River (39.21%), and Tons River (25.45%) (Figures 1, 2, 3). Hence, the proportion of 0+ age group was much less than 1+ especially in the Paisuni and Tons rivers. The higher age groups contributed 16% (3+), 10% (4+), and 2% (5+) in the Ken River. The distribution was uneven between 1+–2+ and 4+–5+ age groups, as difference was high (8%) in each case. The higher age groups accounted for 17.65%, 11.76%, and 1.96% in 3+, 4+, and 5+, respectively in the Paisuni river. The share abruptly declined between 1+–2+ and 4+–5+ age groups. The difference was about 21.56% between 1+ & 2+ and 9.80% between 4+ & 5+ age groups. The higher age groups contributed 10.91%, 9.09%, and 9.09% in 3+, 4+, and 5+, respectively in the Tons River. The age groups 7+ and 8+ contributed 1.82%. The percentage abruptly declined between 2+–3+ age groups as difference was about 9.09%. The age groups varied from 1+–6+ in the Ken and the Paisuni rivers while 1+–8+ in the Tons River.

***Tor tor*:** The age group 2+ (36.58%) dominated in the Ken River, 1+ (34.54%) in the Paisuni River, and 3+ (30.77%) in the Tons River (Figures 4, 5, 6). The age groups 1+ in the Ken River and 2+ in the Paisuni and Tons rivers contributed 26.83%, 27.27%, and 19.23%, respectively. Hence, the proportion of these age groups was much lesser than dominant age groups, especially in the Ken and Tons rivers. The higher age groups accounted for 19.51% (3+), 7.32% (4+), and 4.88% (5+) in the Ken River. The distribution was uneven between 2+–3+ age group as difference was very high (17%). The higher age groups contributed 20.0% (3+), 10.91 (4+) %, and 5.45% (5+) in the Paisuni River. The share abruptly declined between 3+–4+ age groups as difference was 9%. The higher age accounted for 30.77% (3+), 7.69% (4+), and 9.61% (5+) in the Tons River. The distribution was uneven between 3+–4+ age group as difference was very high (23%).

***Labeo calbasu*:** The age groups varied from 1+–6+ in the Ken River, 1+–5+ in the Paisuni River and 1+–7+ in the Tons River. The age group 1+ dominated by virtue of numbers (34.61%) in the Ken River and (37.25%) in the Paisuni River while 2+ dominated in the Tons River (50%; Figures 7, 8, 9). Hence, the proportion of 2+ in the Ken and Paisuni rivers (26.92%, 25.49%) was higher, while the proportion of 1+ in the Tons River (15.52%) was less than dominant age group. The higher age groups accounted for 17.31% (3+), 13.46% (4+), and 5.77% (5+) in the Ken River. The distribution was uneven between 2+–3+ age group as difference was about 9%. The higher age groups contributed 23.53%, 7.84%, and 5.88% in 3+, 4+, and 5+, respectively in the Paisuni River. The distribution was uneven between 3+–4+ age group as difference was about 9%. The higher age groups accounted for 12.07% (3+ and 4+ each) while 5 + contributed only 5.17%. The percentage abruptly declined between 2+–3+ age groups as difference was about 37%.

***Rita rita*:** The age groups varied from 0+–7+ in the Ganga River. The age group 1+ dominated by virtue of numbers (44.76%). The age group 2+ comprised 18.09%, while 0+, 3+, 4+, 5+, 6+, 7+ constituted 13.3%, 8.57%, 5.71%, 6.67%, 0.95%, and 1.9% of the total sample, respectively. The distribution was uneven between 0+–1+ and 1+–3+ age groups as difference was about 31.43% and 26.66%, respectively (Figure 10).

***Bagarius bagarius*:** The age groups varied from 0+–6+ in the Ganga River. The age group 0+ comprised 13.3%. The age groups 2+, 3+, 4+, 5+, and 6+ constitute 33.8%, 23.1%, 2.3%, 6.15%, and 6.15%, of the total population, respectively. The distribution was uneven between 1+–2+ age group as difference was about 20% (Figure 11).

Age pyramids

Calcified structures have been used to estimate growth and age for a great diversity of fishes (Bagenal

& Tesch 1978; Sire & Akimenoko 2004; Mishra et al. 2023). Analysis of hard structures can provide a method of monitoring exploitation and population structure by providing biological data not only on age, but also on size & growth rate and to a limited extent on sex and sexual maturity, as well as other biological information, such as nutritional level (Esmaeili & Johal 2005; Dwivedi & Nautiyal 2010; Gopesh et al. 2021; Mayank et al 2021).

The rate of fishing is a powerful factor, which affects the age composition of the stock (Nikolskii 1980; Dwivedi & Nautiyal 2012; Dwivedi et al. 2017; Alam et al. 2022). Nikolskii (1980) suggested that intensified fishing reflected upon the age structure while it may not be true in other cases. Rate of fishing influenced the dynamics of age composition of the stock as well as of the year-class strength. According to Milner et al. (2003) fish population are subject to natural control processes that continually modify and adjust the structure and abundance of population and their life cycle in response to a wide range of factors. The proportion of different ages and sexes gave the population a definite structure. Ratio of young animals to adult often indicated whether a population was expanding, contracting, or stabilized. In stabilized population the number of offspring reaching reproductive maturity can never be greater or less then the number of adults themselves. The number of young that must be produced to permit such a population turnover gives a measure of the rigor of the environment and how well adapted a species is to its niche (Kendeigh 1980).

The composition of a population can be represented by the numbers and weight of individuals in each age or size group. It can also take account of the numbers of sexually mature individuals and their ratio to the balance. The structure also involved the ratio of the sexes in general and within age or size groups, as well as the morphological differences between individuals within a given generation and in the population as a whole. It can also take account of individuals in each age or size group (Nikolskii 1980).

According to Odum (1971) three kinds of distribution can be depicted by age pyramids:

i. Heavy bottom or broad-based pyramid: It indicates rapidly growing population with high percentage of young individuals.

ii. Bell shaped: It indicates a moderate proportion of young to old, i.e., pre-reproductive and reproductive age groups become more or less equal in size which is characteristic of stable population.

iii. Urn shaped: It indicates a low percentage of young individuals. If the birth rate is drastically reduced, the pre-reproductive group dwindles in proportion to the other two groups and it results in an urn- shaped figure which indicates that the population is senile.

Studies on the age structure revealed that the sexually immature (pre-reproductive) age groups 0+–1+ in *L. rohita*, 1+ in *T. tor,* and *L. calbasu* accounted for 41.81–52 %, 26.83–34.54 %, and 15.52–37.25 %, respectively. The remaining age groups (2+–8+ in *L. rohita*, *T. tor,* and 2+–7+ in *L. calbasu*) included mature or adult fish constituted the remaining part of their population. Among *L. rohita* adult component of the stock 2+–5+ age groups accounted for 48% and 49.02% in the Ken and Paisuni rivers, respectively. However, 2+–8+ age groups contributed 58.18% in the Tons River. In *T. tor* 2+–6+ age groups accounted for 73.17% and 65.45% in the Ken and Paisuni rivers, while 2+–8+ age groups accounted for 73.06% in the Tons River. In *L. calbasu* 2+–6+ age groups accounted for 65.38% in the Ken River, 2+–5+ formed 62.74% in the Paisuni River and 2+–7+ 84.48% in the Tons River. In case of *L. rohita* more or less pre-reproductive and reproductive population were equal in all rivers except Tons River while in case of *T. tor* & *L. calbasu* reproductive population was relatively higher in all rivers. The share of just two age groups comprising pre-reproductive individuals was higher and remaining 5–6 age groups of reproductive old individuals few with respect to the status of the *L. rohita, T. tor*, and *L. calbasu* stocks in the Ken, Paisuni, and Tons rivers.

The age pyramid exhibited distribution of different age groups in *R. rita* fits into the category of broad-based age pyramid because 0+ and 1+ age group constitute 58.1% of the total population which indicates expanding and hence a recovering population owing to high percentage of pre-reproductive age groups.

Warkantine et al. (1984) studied the population dynamics of Atlantic salmon *Menidia menidia*. The analysis revealed only 2+ age group in the population, in which <9.5 cm were 0+ while >9.5 cm were 1+. The former accounted for 97%, while 1+ was only 3%, which indicated a very short life span. Bhatt et al. (2000) determined the age structure of the Himalayan Mahseer (*T. putitora*) in the foothill section of the Ganga River and reported that the samples comprised of 1+ to 9+ age groups individuals. Of these 2+ and 4+ age groups constituted 66.01%, while 1+ was merely 8.07% of the total stock. Earlier, Nautiyal (1990) examined the samples from the Alaknanda and Nayar rivers, the tributary of the Ganga River and found that fish measuring 45.1–61.0 cm had 5 age classes of which 0+ and 1+ measuring 16 cm constituted 80% of the stock in the Nayar river,

while 28–40 cm constituted 40% in the Alaknanda River. It accounted for the major proportion of the stock especially in the Nayar river. Age structure may also vary between years as random events alter recruitment and survival (Milner et al. 2003).

Analysis of age composition to determine the status of the population of some commercially exploited carps revealed; longest life span (17 years) in *T. putitora* followed by *C. carpio* (15 yr), *C. mrigala* (12 yr) in the Ganga River and 8 yr in the Yamuna River, *Setipinna phasa* (8 yr), *L. fimbriatus,* and *L. gonius* (6 yr) while *B. bendelisis* and *B. vagra* in 2 yr, respectively (Jhingran 1959; Kamal 1969; Hanumantharao 1974; Nautiyal 1994; Nautiyal & Negi 2004). Three broad categories were depicted from this information:

(a) predominance of pre-reproductive age classes being highest in *T. putitora* (90%) compared with *C. mrigala* (71.3%) in the Ganga River, 69% in the Yamuna River, and *B. bendelisis* (63.97%). These fish exemplified expanding population.

(b) predominance of reproductive and old age classes, *C. mrigala* (78.3%) and *L. fimbriatus* (70.97%) in the Godavari River while *S. phasa* (73.7%) and *C. carpio* (82%) in the Ganga River.

(c) even distribution with slight dominance of reproductive age classes rest, *L. gonius* (56.5%) and *B. vagra* (52%), exemplifying stable distribution.

CONCLUSION

It may be concluded that the *L. rohita* stock was not stable and facing fishing pressure. In case of *T. tor* and *B. bagarius*, stocks were slightly senile and facing heavy fishing pressure. To date, Mahseer fishery is facing a lot of stress generated by human activities (Pinder et al. 2019; Rana & Nautiyal 2023). In case of *L. calbasu* and *R. rita*, stocks were showing stable and growing condition. Overall large size fishes (*L. rohita, T. tor,* and *B. bagarius*) were suffering from poor water discharge and water quality from the all rivers, especially in winter and summer seasons. While small size fishes (*R. rita* and *L. calbasu*) were safe in low water discharge.

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COMMUNICATION

Importance based on avian diversity of Pakhibitan Bird & Wildlife Sanctuary, Jalpaiguri District, West Bengal, India

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Abstract: A comprehensive inventory of faunal and floral species in a specific region holds significant value for scientific investigation. This study was conducted between 2015 and 2021, especially during the winter season, in Pakhibitan Bird & Wildlife Sanctuary (also known as Gajoldoba wetland) in West Bengal, which was established in 2016. This wetland surrounded by forests is located on the upper section of the Teesta Barrage in the Dooars region of Jalpaiguri District, and it attracts birds from the Central Asian Flyway. Around 124 bird species belonging to 14 orders and 37 families were documented. Passeriformes with 32 species, and Anatidae with 23 species, are the most abundant groups. Based on the IUCN Red Data Book (2022–23), six species are Near Threatened, four are Vulnerable, and one Endangered. About 50% of birds were resident, 44% migratory, and 6% local migrants.

Keywords: Avian communities, Central Asian Flyway, conservation efforts, Gajoldoba, habitat detoriation, migratory birds, protected areas, Ramsar site, Teesta barrage, wetland.

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Author contributions: ABR provided supervision and helped with the data collection and infrastructural facilities. TS, CSS and AR performed the result analysis and prepared original draft of the manuscript. LC collected the data and clicked pictures of the bird species and DD assisted in data collection in the field. AG provided support and guidance for the study. All authors reviewed the paper.

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INTRODUCTION

The Ramsar Convention recognizes the global significance of wetlands, especially as a habitat for waterfowl. According to the Convention's text (Article 1.1), wetlands are described as areas that can be natural or man-made, permanent or temporary, with either still or flowing water. They can be marshes, fens, peatlands, or bodies of water, including marine areas not deeper than 6m at low tide. Wetlands are crucial ecosystems, interconnected both socially and physically with processes occurring in a broader region. The Ramsar Convention aims to conserve the worldwide degradation of wetlands through sustainable management. It is an intra-governmental treaty that supports national action (Chandra et al. 2021; Roy et al. 2022). As India has increased the Ramsar sites to 85, many wetlands in India still face the threat of degradation and loss due to expanding developmental and commercial activities (Byju et al. 2023a). The risk of wetlands in Ramsar sites has increased with global warming and the rising sea level (Xi et al. 2020). They play a vital role in facilitating the movement of aquatic animals and promoting local species diversity (Amezaga et al. 2002). The shallow and unpredictable water regimes support unique biotic communities characterized by varied plants and animals adapted to these conditions (Weller 1999). The decline and deterioration of wetlands have negatively impacted waterbirds depending on wetlands for survival. Well-managed wetlands can serve as alternative or supplementary habitats for waterbirds and other associated birds, helping to alleviate the adverse effects of wetland decline and deterioration (Ma et al. 2010; Brandolin et al. 2013).

An example of a significant controlled wetland is the Pakhibitan Bird & Wildlife Sanctuary, also known as the Gajoldoba wetland, located in the northern region of West Bengal, India in the Dooars region of Jalpaiguri District in the Himalayan foothills. The upper section of the Teesta Barrage was the first reservoir constructed in the Teesta Basin for irrigation. Due to the dam construction, migratory birds have gathered in this landlocked water body surrounded by forests within the Central Asian Flyway (CAF). The wetland diversity of Gajoldoba, the newly established Pakhibitan Bird & Wildlife Sanctuary, has no detailed studies on the diversity of birds. In this background, the current study highlights the status and diversity of birds.

MATERIALS AND METHODS

Study Area

The Pakhibitan Bird & Wildlife Sanctuary is situated near the eastern bank of the Teesta barrage, specifically between 26.751N and 88.575E (Image 14). The mean temperature in this region varies 6.9–32.8 ^{0}C, and the yearly precipitation is approximately 3,160 mm. The monsoon season, which occurs from June to September, accounts for around 78% of the region's total rainfall. In contrast, the winter months of December to February contribute only 0.98% of the region's precipitation. The water level at Pakhibitan Bird & Wildlife Sanctuary peaks during the winter due to the closure of most of the barrage gates (Datta 2011). The sanctuary is approximately 64km from Siliguri in the Dooars region of West Bengal, India. It is a small yet picturesque area with rich biodiversity and natural beauty. The sanctuary is bounded by the lush and dense tropical forests of Baikunthapur, part of the Terai region of western Dooars. The Mahananda River flows to the west of the sanctuary, while the river Teesta meanders along its eastern side. This forested area supports a diverse array of wildlife, including a population of wild elephants. The sanctuary is divided between two districts: one part lies in the Jalpaiguri district, while the other area is in the Darjeeling district. Additionally, the Apalchand forest is located adjacent to the eastern bank of the Teesta River, further enhancing the ecological significance of the region. The sanctuary's location in Malbazar within the Jalpaiguri district places it in a vital position for conservation efforts and biodiversity studies. The construction of the Teesta barrage, initiated by Late Jyoti Basu, the former Chief Minister of West Bengal, on January 19, 1987, has played a crucial role in shaping the current ecological landscape of the sanctuary.

Methods

The survey was conducted during the winter season every week from 2015 to 2021. The species checklist was recorded through direct observation from 0600 h to 1600 h. The direct observation method used in this study (Bibby et al. 2000) emphasizes systematic and repeatable observations for accurate data collection in ornithological studies. Birds were observed from a boat using Olympus binoculars (10 x 50) for close-up observations. Species photography was carried out using a Nikon B600 camera. The checklist of birds was prepared following Grimmett et al. (2016). The IUCN status of the birds was determined using website (IUCN, 2023). Based on their movements and seasonal occurrence, the birds

were categorized into three groups: Migratory (M), Local Migrant (LM), and Resident (R). Statistical analysis was performed using Microsoft Excel.

RESULTS

A total of 124 bird species representing 14 orders and 37 families were observed in the current study. The order Passeriformes was the most prevalent, with 15 families and 32 species. It was followed by Anseriformes, which had one family and 23 species, Charadriiformes with seven families and 21 species, Accipitriformes with two families and 12 species, Pelecaniformes with two families and 11 species, Gruiformes with one family and six species, and Coraciiformes with two families and four species. Orders Ciconiiformes, Falconiformes, Podicipediformes, and Suliformes, consist of one family with three species each. In the case of Caprimulgiformes, Columbiformes, and Cuculiformes, each order has one family with one species each (Table 1, Images 1–12). Out of the 124 species documented, 77 bird species from 10 orders and 18 families were shown to have a direct dependence or association with the wetland.

Out of the 124 species of avifauna listed in Table 1, 113 are classified as 'Least Concern' (LC) according to the IUCN Red List. Six species—Ferruginous Pochard *Aythya nyroca*, Falcated Duck *Mareca falcata*, Himalayan Griffon *Gyps himalayensis*, Northern Lapwing *Vanellus vanellus*, River Lapwing *Vanellus duvaucelii*, and Great Thick-knee *Esacus recurvirostris*—are categorized as 'Near Threatened' (NT). Four species classified as 'Vulnerable' (VU) are the Common Pochard *Aythya ferina* (VU), Indian Spotted Eagle *Clanga hastata* (VU), Imperial Eagle *Aquila heliaca* (VU), and Lesser Adjutant *Leptoptilos javanicus* (VU). The Steppe Eagle *Aquila nipalensis* is classified as 'Endangered' (EN).

The residential status of observed species shows that 50% of the total species were resident (R) and 44% were migratory (M). Rest 6% of birds were local migrants (LM) (Table 3). Among the avian families, Anatidae and Ardeidae are the only dominant avian families from Winter Migrant and Resident status, respectively.

DISCUSSION

The avian diversity observed in Pakhibitan Bird & Wildlife Sanctuary underscores the ecological significance of this wetland habitat (Image 13). This study provides crucial insights into the bird species composition and their conservation status, which can make targeted conservation efforts. The results of this study showed a dominance of Passeriformes and Anatidae consistent

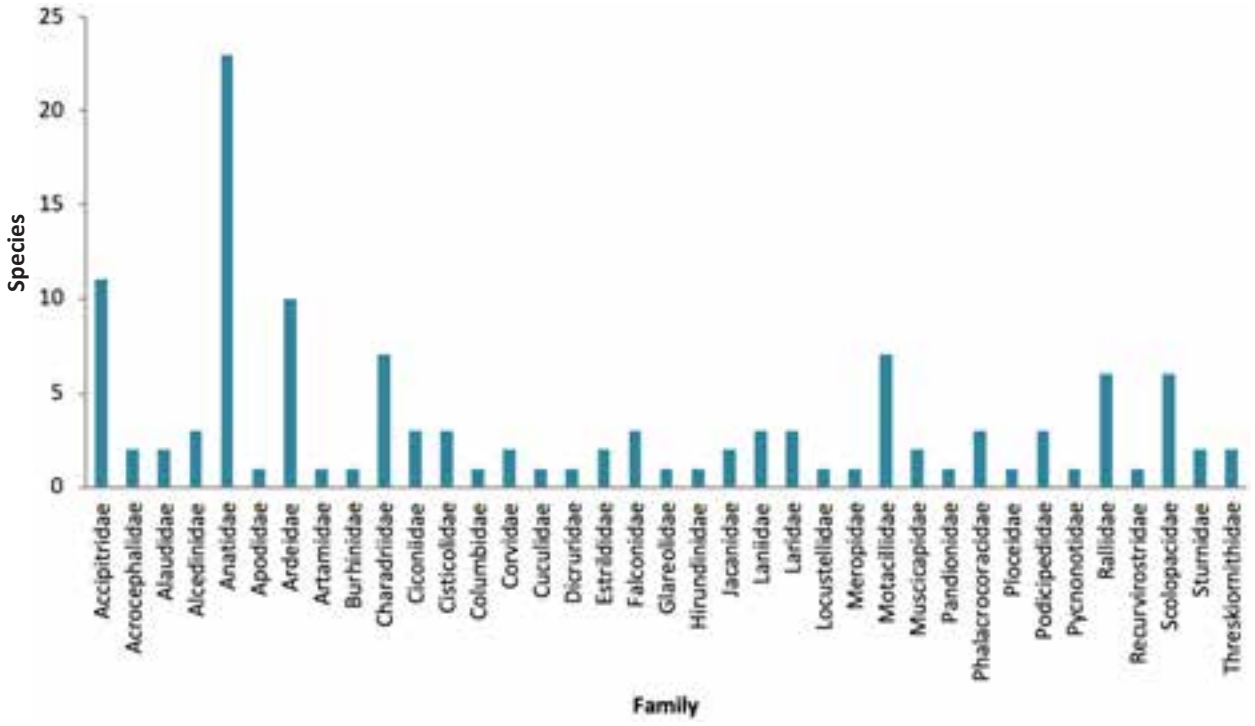

Figure 1. Family-wise distribution of avifauna in Pakhibitan Bird & Wildlife Sanctuary.

Table 1. List of observed species from Pakhibitan Bird & Wildlife Sanctuary 2015 to 2021.

	Common name	Scientific name	IUCN Red List status	Migration status	Dependence on waterbodies
Order: Anseriformes					
Family: Anatidae					
1	Lesser Whistling-duck	*Dendrocygna javanica* (Horsfield, 1821)	LC	R	WA
2	Cotton Pygmy-Goose	*Nettapus coromandelianus* (Gmelin, 1789)	LC	R	WA
3	Bar-headed Goose	*Anser indicus* (Latham, 1790)	LC	M	WA
4	Bean Goose	*Anser fabalis* (Latham, 1787)	LC	M	WA
5	Greylag Goose	*Anser anser* (Linnaeus, 1758)	LC	M	WA
6	Common Shelduck	*Tadorna tadorna* (Linnaeus, 1758)	LC	M	WA
7	Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	LC	M	WA
8	Gadwall	*Mareca strepera* (Linnaeus, 1758)	LC	M	WA
9	Eurasian Wigeon	*Mareca penelope* (Linnaeus, 1758)	LC	M	WA
10	Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)	LC	M	WA
11	Mallard	*Anas platyrhynchos* (Linnaeus, 1758)	LC	M	WA
12	Garganey	*Spatula querquedula* (Linnaeus, 1758)	LC	M	WA
13	Northern Pintail	*Anas acuta* (Linnaeus, 1758)	LC	M	WA
14	Common Teal	*Anas crecca* (Linnaeus, 1758)	LC	M	WA
15	Red-crested Pochard	*Netta rufina* (Pallas, 1773)	LC	M	WA
16	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	M	WA
17	Ferruginous Pochard	*Aythya nyroca* (Güldenstädt, 1770)	NT	M	WA
18	Tufted Duck	*Aythya fuligula* (Linnaeus, 1758)	LC	M	WA
19	Falcated Duck	*Mareca falcata* (Georgi, 1775)	NT	M	WA
20	Common Merganser	*Mergus merganser* (Linnaeus, 1758)	LC	M	WA
21	Red-breasted Merganser	*Mergus serrator* (Linnaeus, 1758)	LC	M	WA
22	Smew	*Mergellus albellus* (Linnaeus, 1758)	LC	M	WA
23	Common Goldeneye	*Bucephala clangula* (Linnaeus, 1758)	LC	M	WA
Order: Podicipediformes					
Family: Podicipedidae					
24	Little Grebe	*Tachybaptus ruficollis* (Pallas, 1764)	LC	R	WA
25	Great-crested Grebe	*Podiceps cristatus* (Linnaeus, 1758)	LC	M	WA
26	Black-necked Grebe	*Podiceps nigricollis* (Brehm, 1831)	LC	M	WA
Order: Ciconiiformes					
Family: Ciconiidae					
27	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	LC	R	WA
28	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	VU	R	WA
29	Black Stork	*Ciconia nigra* (Linnaeus, 1758)	LC	M	WA
Order: Pelecaniformes					
Family: Threskiornithidae					
30	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	LC	LM	WA
31	Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)	LC	R	WA
Family: Ardeidae					
32	Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)	LC	R	WA
33	Grey Heron	*Ardea cinerea* (Linnaeus, 1758)	LC	R	WA
34	Purple Heron	*Ardea purpurea* (Linnaeus, 1766)	LC	R	WA
35	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	LC	R	

	Common name	Scientific name	IUCN Red List status	Migration status	Dependence on waterbodies
36	Intermediate Egret	*Ardea intermedia* (Wagler, 1829)	LC	R	WA
37	Great Egret	*Ardea alba* (Linnaeus, 1758)	LC	R	WA
38	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	LC	R	WA
39	Yellow Bittern	*Ixobrychus sinensis* (Gmelin, 1789)	LC	R	WA
40	Black Bittern	*Ixobrychus flavicollis* (Latham, 1790)	LC	R	WA
Order: Suliformes					
Family: Phalacrocoracidae					
41	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	LC	R	WA
42	Indian Cormorant	*Phalacrocorax fuscicollis* (Stephens, 1826)	LC	LM	WA
43	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	LC	LM	WA
Order: Columbiformes					
Family: Columbidae					
44	Spotted Dove	*Spilopelia suratensis* (Gmelin, 1789)	LC	R	
Order: Cuculiformes					
Family: Cuculidae					
45	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	LC	R	
Order: Accipitriformes					
Family: Accipitridae					
46	Black Kite	*Milvus migrans* (Boddaert, 1783)	LC	R	
47	Himalayan Griffon	*Gyps himalayensis* (Hume, 1869)	NT	R	
48	Eurasian Marsh Harrier	*Circus aeruginosus* (Linnaeus, 1758)	LC	M	
49	Indian Spotted Eagle	*Clanga hastata* (Lesson, 1831)	VU	R	
50	Steppe Eagle	*Aquila nipalensis* (Hodgson, 1833)	EN	M	
51	Booted Eagle	*Hieraaetus pennatus* (Gmelin, 1788)	LC	M	
52	Eastern Imperial Eagle	*Aquila heliaca* (Savigny, 1809)	VU	M	
53	Shikra	*Accipiter badius* (Gmelin, 1788)	LC	R	
54	Pied Harrier	*Circus melanoleucos* (Pennant, 1769)	LC	M	
55	Long-legged Buzzard	*Buteo rufinus* (Cretzschmar, 1827)	LC	M	
56	Short-toed Snake Eagle	*Circaetus gallicus* (Gmelin, 1788)	LC	R	
Family: Pandionidae					
57	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	LC	M	WA
Order: Falconiformes					
Family: Falconidae					
58	Common Kestrel	*Falco tinnunculus* (Linnaeus, 1758)	LC	M	
59	Peregrine Falcon	*Falco peregrinus* (Tunstall, 1771)	LC	M	
60	Red-necked Falcon	*Falco ruficollis* (Swainson, 1837)	LC	M	
Order: Gruiformes					
Family: Rallidae					
61	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	LC	R	WA
62	Ruddy-breasted Crake	*Zapornia fusca* (Linnaeus, 1766)	LC	R	WA
63	Baillon's Crake	*Zapornia pusilla* (Pallas, 1776)	LC	R	WA
64	Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	LC	R	WA
65	Eurasian Coot	*Fulica atra* (Linnaeus, 1758)	LC	LM	WA
66	Grey-headed Swamphen	*Porphyrio porphyrio*(Linnaeus, 1758)	LC	R	WA

	Common name	Scientific name	IUCN Red List status	Migration status	Dependence on waterbodies
Order: Charadriiformes					
Family: Charadriidae					
67	Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	NT	M	WA
68	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	LC	R	
69	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	R	WA
70	Pacific Golden Plover	*Pluvialis fulva* (Gmelin, 1789)	LC	M	WA
71	Little-ringed Plover	*Charadrius dubius* (Scopoli, 1786)	LC	R	WA
72	Kentish Plover	*Charadrius alexandrinus* (Linnaeus, 1758)	LC	LM	WA
73	Lesser Sand Plover	*Charadrius mongolus* (Pallas, 1776)	LC	M	WA
Family: Jacanidae					
74	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)	LC	R	WA
75	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	LC	R	WA
Family: Scolopacidae					
76	Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)	LC	M	WA
77	Common Redshank	*Tringa totanus* (Linnaeus, 1758)	LC	M	WA
78	Wood Sandpiper	*Tringa glareola* (Linnaeus, 1758)	LC	M	WA
79	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	LC	M	WA
80	Little Stint	*Calidris minuta* (Leisler, 1812)	LC	M	WA
81	Temminck's Stint	*Calidris temminckii* (Leisler, 1812)	LC	M	WA
Family: Recurvirostridae					
82	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	LC	LM	WA
Family: Laridae					
83	Pallas's Gull	*Larus ichthyaetus*(Pallas, 1773)	LC	M	WA
84	Brown-headed Gull	*Larus brunnicephalus* (Jerdon, 1840)	LC	M	WA
85	Black-headed Gull	*Larus ridibundus* (Linnaeus, 1766)	LC	M	WA
Family: Glareolidae					
86	Small Pratincole	*Glareola lactea* (Temminck, 1820)	LC	R	WA
Family: Burhinidae					
87	Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)	NT	LM	WA
Order: Caprimulgiformes					
Family: Apodidae					
88	Asian Palm Swift	*Cypsiurus balasiensis* (Gray, 1829)	LC	R	
Order: Coraciiformes					
Family: Alcedinidae					
89	White-breasted Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	LC	R	WA
90	Common Kingfisher	*Alcedo atthis*(Linnaeus, 1758)	LC	R	WA
91	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	LC	R	WA
Family: Meropidae					
92	Asian Green Bee-eater	*Merops orientalis* (Latham, 1802)	LC	R	
Order: Passeriformes					
Family: Dicruridae					
93	Black Drongo	*Dicrurus macrocercus* (Vieillot, 1817)	LC	R	
Family: Artamidae					
94	Ashy Woodswallow	*Artamus fuscus* (Vieillot, 1817)	LC	R	

	Common name	Scientific name	IUCN Red List status	Migration status	Dependence on waterbodies
Family: Sturnidae					
95	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	LC	R	
96	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)	LC	R	
97	Asian Pied Starling	*Gracupica contra* (Linnaeus, 1758)	LC	R	
Family: Corvidae					
98	House Crow	*Corvus splendens* (Vieillot, 1817)	LC	R	
99	Large-billed Crow	*Corvus macrorhynchos* (Wagler, 1827)	LC	R	
Family: Hirundinidae					
100	Barn Swallow	*Hirundo rustica* (Linnaeus, 1758)	LC	LM	WA
Family: Laniidae					
101	Brown Shrike	*Lanius cristatus* (Linnaeus, 1758)	LC	M	
102	Grey-backed Shrike	*Lanius tephronotus* (Vigors, 1831)	LC	M	
103	Long-tailed Shrike	*Lanius schach* (Linnaeus, 1758)	LC	R	
Family: Alaudidae					
104	Sand Lark	*Alaudala raytal* (Blyth, 1844)	LC	R	
105	Bengal Bushlark	*Mirafra assamica* (Horsfield, 1840)	LC	R	
Family: Cisticolidae					
106	Plain Prinia	*Prinia inornata* (Sykes, 1832)	LC	R	
107	Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)	LC	R	
108	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)	LC	R	
Family: Ploceidae					
109	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)	LC	R	
Family: Estrildidae					
110	Scaly-breasted Munia	*Lonchura punctulata* (Linnaeus, 1758)	LC	R	
111	Tricolored Munia	*Lonchura malacca* (Linnaeus, 1766)	LC	R	
Family: Acrocephalidae					
112	Clamorous Reed Warbler	*Acrocephalus stentoreus* (Hemprich & Ehrenberg, 1833)	LC	M	
113	Paddyfield Warbler	*Acrocephalus agricola* (Jerdon, 1845)	LC	M	
Family: Locustellidae					
114	Striated Grassbird	*Megalurus palustris* (Horsfield, 1821)	LC	R	
Family: Muscicapidae					
115	White-capped Water-redstart	*Phoenicurus leucocephalus* (Vigors, 1831)	LC	R	
116	Common Stonechat	*Saxicola torquatus* (Linnaeus, 1766)	LC	R	
Family: Pycnonotidae					
117	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	LC	R	
Family: Motacillidae					
118	Citrine Wagtail	*Motacilla citreola* (Pallas, 1776)	LC	M	WA
119	White Wagtail	*Motacilla alba* (Linnaeus, 1758)	LC	M	WA
120	White-browed Wagtail	*Motacilla maderaspatensis* (Gmelin, 1789)	LC	R	WA
121	Grey Wagtail	*Motacilla cinerea* (Tunstall, 1771)	LC	M	WA
122	Rosy Pipit	*Anthus roseatus* (Blyth, 1847)	LC	M	
123	Paddyfield Pipit	*Anthus rufulus* (Vieillot, 1818)	LC	R	
124	Olive-backed Pipit	*Anthus hodgsoni* (Richmond, 1907)	LC	R	

EN—Endangered | NT—Near Threatened | VU—Vulnerable | LC—Least Concern | R—Resident | LM—Local Migrant | M—Migratory | WA—Water Associated.

Image 1–12. Some recorded species of Pakhibitan Wildlife Sanctuary: 1—Ruddy Shelduck *Tadorna ferruginea* | 2—Steppe Eagle *Aquila nipalensis* | 3—Common Shelduck *Tadorna tadorna* | 4—Himalayan Griffon *Gyps himalayensis* | 5—Great-crested Grebe *Podiceps cristatus* | 6—Great Thick-knee *Esacus recurvirostris* | 7—Bar-headed Goose *Anser indicus* | 8—Pallas's Gull *Larus ichthyaetus* | 9—Bean Goose *Anser fabalis* | 10—Northern Lapwing *Vanellus vanellus* | 11—Common Merganser *Mergus merganser americanus* | 12—Small Pratincole *Glareola lacteal*. © Lina Chatterjee.

with what has been observed in similar wetland habitats across India. For instance, the Dighal Wetland in Haryana and Beas River in Punjab, another significant bird habitat, report a similarly high diversity of bird species within these orders (Kumar & Kler 2021; Kumar & Kumar 2023). The richness of species in these families highlights the sanctuary's role as a crucial habitat for both resident and migratory birds. The sanctuary is home to a wide variety of bird species, showing its importance as a haven for birds. The different species recorded indicated a healthy ecosystem with diverse habitats and resources. This diversity is crucial for conservation and highlights the sanctuary's significance as a key area for protecting birds in the region. The sanctuary hosts six NT, four VU, and one EN species according to the IUCN Red List (2022), highlighting its importance for

Image 13. Habitats of Pakhibitan Wildlife Sanctuary: A—Sandy bed | B—Bank with stone | C—Marshy and bushy area | D—Open water area. © Lina Chatterjee.

avian conservation. This corroborates findings from the Bharatpur Bird Sanctuary, where the presence of threatened species has increased conservation efforts (Verma 2009; Bhadouria et al. 2012). The residential status analysis revealed that 41.94% of the species are residents, 44.35% are migratory, and 13.71% are local migrants. The predominance of migratory species underscores the sanctuary's importance as a stopover and wintering site for migratory birds, aligning with the findings of Byju et al. (2023b), which highlighted the critical role of Indian wetlands in supporting migratory bird populations. Among the avian families, Anatidae and Ardeidae are dominant during the winter migration and resident status periods, respectively. This pattern is consistent with findings from other wetland ecosystems, such as the Chilika Lake (Balachandran et al. 2020), where these families were also prominent. Furthermore, the dependence of 77 species on the wetland environment highlights the sanctuary's ecological significance for water-associated birds. This aligns with the studies of Sundar & Kittur (2013), who emphasized the crucial role of wetlands in supporting diverse avian communities in India. The family-wise distribution indicates that although Anatidae is the most abundant, several families are represented by only one species each, indicating a need for diversified conservation strategies to support all avian families present in the sanctuary.

CONCLUSION

The Pakhibitan Bird & Wildlife Sanctuary is a vital habitat for diversity bird species, including several that are threatened. The findings of this study highlight the urgent need for conservation actions to protect this biodiversity hotspot. By implementing effective management strategies and fostering community and governmental involvement, the sanctuary can be preserved for future generations, ensuring the continued survival of its avian inhabitants.

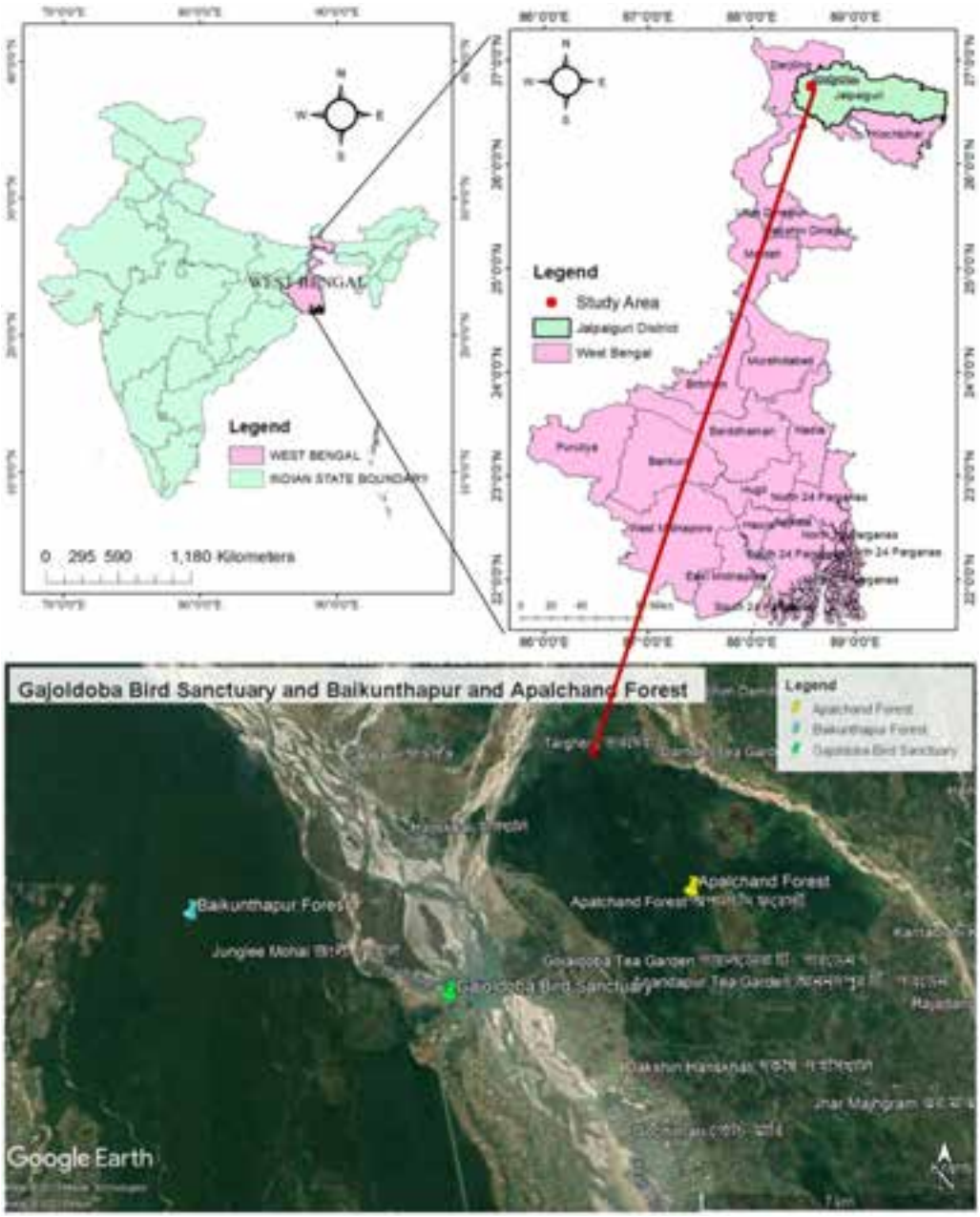

Image 14. Map of the study area.

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A drastic decline in avian diversity in and around the Bordoibam-Bilmukh Bird Sanctuary, Lakhimpur, Assam, India

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Abstract: Bordoibam-Bilmukh is a small wetland located at the boundary of the Dhemaji and Lakhimpur districts of Assam, India that provides shelter and breeding ground to many resident and migratory birds. A survey was conducted between October 2022 and March 2024 on the avian diversity of Bordoibam-Bilmukh Bird Sanctuary. A total of 47 bird species under 16 orders and 29 families were recorded during the survey. Order Passeriformes, recorded with the highest number of avian species (15). Among the families, the highest number of species (5) was recorded under Ardeidae. Out of all the species recorded, three species, viz., Brown Shrike, Citrine Wagtail, and White Wagtail were winter migratory; one species, the Lesser Kestrel, was summer migratory, and the remaining 43 were resident species. Besides, two species, viz., Lesser Adjutant and Greater Adjutant are listed as 'Near Threatened' species on the IUCN Red List. Comparing the avian diversity from 1997 to 2024, a decline in the number of avian species from 167 (as per the 1997 record) to 47 (as per the present study) has been observed in the sanctuary. Various anthropogenic activities such as habitat destruction and disturbance, hunting of birds, are the major causes of the decline of avian diversity. For future species diversity restoration in the sanctuary, these negative anthropogenic activities should be addressed immediately for conservation strategies.

Keywords: Ardeidae, conservation, Greater Adjutant, habitat destruction, IBA, Lesser Adjutant, migratory birds, Passeriformes, population decline, wetland.

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Author contributions: LS did the field surveys and identified the bird species. SSB did the field surveys, helped in identification and wrote the manuscript. KSD supervised the study, reviewed the manuscript, and prepared the final manuscript and communicated. All authors read and approved the final manuscript.

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INTRODUCTION

Assam is one of the biodiversity-rich states of India and home to about 950 bird species including 17 species that are endemic to the state (Choudhury 2000) with 55 Important Bird and Biodiversity Areas (IBAs) that act as the hotspots for various avian species. Many studies have been carried out on the avian diversity of the state including the Panidihing Bird Sanctuary of Sivasagar district with 165 species of birds (Mili & Acharjee 2014); Jhanjimuk-Kokilamuk IBA complex of Jorhat district recorded 205 species of birds (Mahanta et al. 2019); 284 bird species were reported from Orang National Park by Chakdar et al. (2019) and 227 avian species from the Raimona National Park by Mahanta et al. (2022). Recently, Bornodi Wildlife Sanctuary recorded 227 avian species (Chetry et al. 2024) and the Loharghat forest range of Kamrup district, 157 species (Talwar et al. 2024).

Among many important bird areas and hotspots of Assam, Bordoibam-Bilmukh wetland is also one of them. The wetland is located at the boundary of Dhemaji and Lakhimpur District of Assam, northeastern India. This wetland originated from the river Subansiri. A major earthquake created this wetland in 1950 (Sonowal et al. 2018). In 1996, the Assam government designated Bordoibam-Bilmukh as a Bird Sanctuary (BBBS), due to the great diversity of flora and fauna of this area due to its potential for ecotourism. It is also one of the IBAs of the north- eastern region of India (IBA code: IN372) (BirdLife International 2024).

The bird community structure of any area helps in understanding how the landscape changes over time (Kattan & Franco 2004; Byju et al 2023). Information on avifauna is vital for an ecosystem conservation effort, and for understanding the implications of habitat degradation or loss and climate change (Daniels et al. 1991; Peterson et al. 2000; Llanos et al. 2011). Wetlands provide excellent habitats for migratory waterbirds and shorebirds, for feeding, nesting, and rearing young ones, and as wintering grounds or stopover grounds (Anand et al. 2023). Many wetlands in India face the threat of degradation and loss due to expanding developmental and commercial activities (Fraser et al. 2005; Prigent et al. 2012).

The present work was carried out to record the current avian diversity of the BBBS and to compare the present data with previous studies to determine its current diversity status.

MATERIAL AND METHODS

A survey was conducted for 154 days, between October 2022 and March 2024 on the avian diversity of BBBS. During the study period, field surveys were carried out periodically in all seasons: winter, pre-monsoon, monsoon, and post-monsoon. The surveys were done by randomized walk (Lambert, 1984), visual encounter survey (Heyer et al. 1994), and point count method (Bibby et al. 2000). On average, 10 days of fieldwork were carried out per month. For observations, binoculars (Nikon Prostaff P3 8 x 30) were used. The observations were conducted in the morning (0600–0900 h) and evening (1530–1730 h).

The area of Bordoibam-Bilmukh (27.340^{0}N, 94.337^{0}E) is 11.25 km^2 and the altitude is 90–95 m (BirdLife International 2024). The mean annual rainfall of the district is 300 cm and experiences 31°C and 7°C maximum and minimum temperatures, respectively, in the district (NWAA 2010).

For the identification of the avian species, Grimmett et al. (2011); Grewal et al. (2016), and Samarpan (2019) field guides were used. The World Bird Database (Lepage 2016) and merlin.allaboutbirds.org were used for updated nomenclature.

RESULTS

A total of 47 avian species have been recorded from the current study in the Bordoibam-Bilmukh Bird Sanctuary. All the 47 bird species recorded from the study area belong to 16 orders and 29 families where the order Passeriformes was recorded with the highest number of avian species (15 species). Among the families, the highest number of species (five species) was recorded under the family Ardeidae. On the other hand, four species were recorded under the families Rallidae and Sturnidae. Family Ciconiidae comprised three species followed by Anatidae, Columbidae, Corvidae, Jacanidae, Motacillidae, and Megalaimidae (each with two species). In case of the families Accipitridae, Alcedinidae, Charadriidae, Cisticolidae, Coraciidae, Cuculidae, Dicruridae, Falconidae, Laniidae, Meropidae, Muscicapidae, Oriolidae, Paridae, Phalacrocoracidae, Psittaculidae, Pycnonotidae, Strigidae, Threskiornithidae and Upupidae only one species each were recorded during the study period.

Three of the recorded bird species, viz., Brown Shrike *Lanius cristatus*, Citrine Wagtail *Motacilla citreola*, and White Wagtail *Motacilla alba*, were winter migratory

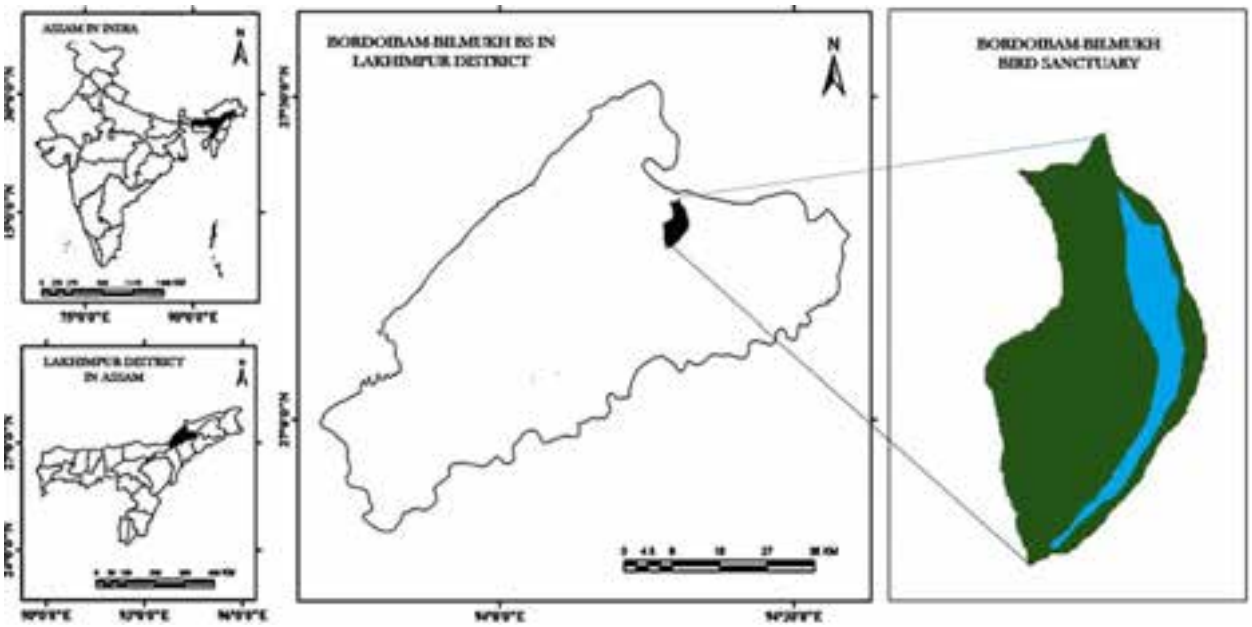

Figure 1. Map of Bordoibam-Bilmukh Bird Sanctuary, Lakhimpur.

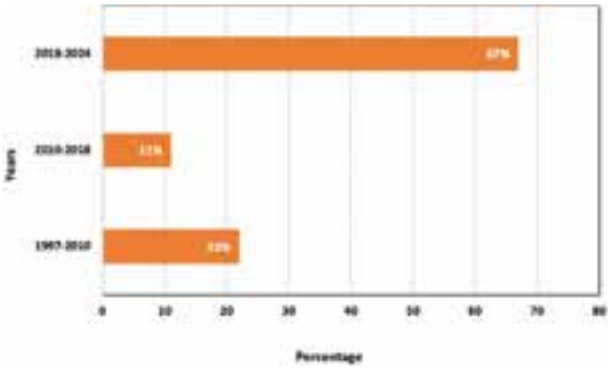

Figure 2. Percentage decline of bird species among the studies.

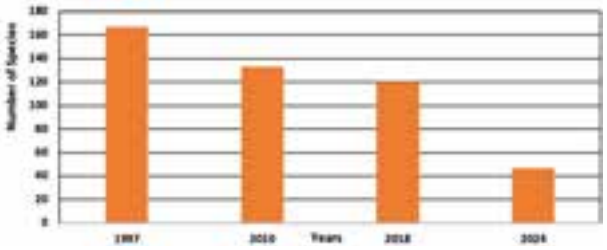

Figure 3. Number of species recorded in previous years (as reported in earlier studies) and present work.

birds and Lesser Kestrel *Falco naumanni* was a summer migratory. The rest 43 bird species were resident of the wetland and found in different numbers throughout the seasons. Two bird species, viz., Lesser Adjutant *Leptoptilos javanica* and Greater Adjutant *Leptoptilos dubius* are listed as 'Near Threatened' species on the IUCN Red List (Version 3.1, 2023). All the other bird species are listed as 'Least Concern' species.

DISCUSSION

Comparing the diversity data from 1997 to 2024, a drastic decline in bird species is observed. Phukan et al. (1997) recorded 167 bird species earlier. In another study, a total of 133 species of birds belonging to 41 families were recorded, out of which 86 species were resident, 23 were migratory and 24 were local migrants (Dutta et al. 2011). To evaluate the biodiversity and habitat conservation condition of BBBS, another preliminary study was carried out between April 2017 and March 2018 (Sonowal et al. 2018). The survey recorded 133 species of macrophytes, seven species of aquatic ferns, 68 species of fish, and 120 species of birds. In the present study, a decline in the avian diversity of the sanctuary was observed and the total number of bird species recorded was only 47 (Figure 2) which is significantly lower than the previous records. In every previous study, the avian diversity has been observed to be declining (Figure 3). Many groups of birds such as waterbirds, wood pecker, flower pecker, barbets, bea-eaters, babblers, pigeons and doves, kites, eagles, vultures, falcons, herons, bulbuls, sunbirds, weavers and munias which were recorded in previous studies, were

Table 1. Shows all the species recorded along with the details of their families, seasonality, and IUCN Red List status.

Order	Family		Scientific name	Common name	IUCN Red List	Phenological status
Accipitriformes	Accipitridae	01	*Milvus migrans*	Black Kite	LC	R
Anseriformes	Anatidae	02	*Dendrocygna javanica*	Lesser Whistling-Duck	LC	R
		03	*Dendrocygna bicolor*	Fulvous Whistling-Duck	LC	R
Bucerotiformes	Upupidae	04	*Upupa epops*	Common Hoopoe	LC	R
Charadriiformes	Charadriidae	05	*Vanellus indicus*	Red-wattled Lapwing	LC	R
	Jacanidae	06	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	LC	R
		07	*Metopidius indicus*	Bronze-winged Jacana	LC	R
Ciconiiformes	Ciconiidae	08	*Anastomous oscitans*	Asian Openbill	LC	R
		09	*Leptoptilos javanica*	Lesser Adjutant	NT	R
		10	*Leptoptilos dubius*	Greater Adjutant	NT	R
Columbiformes	Columbidae	11	*Spilopelia chinensis*	Eastern Spotted Dove	LC	R
		12	*Treron phoenicopterus*	Yellow-footed Green-Pigeon	LC	R
Coraciiformes	Alcedinidae	13	*Alcedo atthis*	Common Kingfisher	LC	R
	Coraciidae	14	*Coracias benghalensis*	Indian Roller	LC	R
	Meropidae	15	*Merops leschenaulti*	Chestnut-headed Bee-eater	LC	R
Cuculiformes	Cuculidae	16	*Eudynamys scolopaceus*	Asian Koel	LC	R
Falconiformes	Falconidae	17	*Falco naumanni*	Lesser Kestrel	LC	SV
Gruiformes	Rallidae	18	*Gallinula chloropus*	Common Moorhen	LC	R
		19	*Amaurornis phoenicurus*	White-breasted Waterhen	LC	R
		20	*Porphyrio porphyrio*	Purple Swamphen	LC	R
		21	*Gallicrex cinerea*	Watercock	LC	R
Passeriformes	Cisticolidae	22	*Orthotomus sutorius*	Common Tailorbird	LC	R
	Corvidae	23	*Dendrocitta vagabunda*	Rufous Treepie	LC	R
		24	*Corvus culminatus*	Indian Jungle Crow	LC	R
	Dicruridae	25	*Dicrurus macrocercus*	Black Drongo	LC	R
	Laniidae	26	*Lanius cristatus*	Brown Shrike	LC	WV
	Motacillidae	27	*Motacilla citreola*	Citrine Wagtail	LC	WV
		28	*Motacilla alba*	White Wagtail	LC	WV
	Muscicapidae	29	*Copsychus saularis*	Oriental Magpie-Robin	LC	R
	Oriolidae	30	*Oriolus xanthornus*	Black-hooded Oriole	LC	R
	Paridae	31	*Parus major*	Great Tit	LC	R
	Pycnonotidae	32	*Pycnonotus cafer*	Red-vented Bulbul	LC	R
	Sturnidae	33	*Gracupica contra*	Indian Pied Starling	LC	R
		34	*Sturnia malabarica*	Chestnut-tailed Starling	LC	R
		35	*Acridotheres tristis*	Common Myna	LC	R
		36	*Acridotheres fuscus*	Jungle Myna	LC	R
Pelecaniformes	Ardeidae	37	*Ardeola grayii*	Indian Pond-Heron	LC	R
		38	*Bubulcus ibis*	Cattle Egret	LC	R
		39	*Egretta garzetta*	Little Egret	LC	R
		40	*Ardea intermedia*	Intermediate Egret	LC	R
		41	*Ardea alba*	Great White Egret	LC	R
	Threskiornithidae	42	*Plegadis falcinellus*	Glossy Ibis	LC	R

Order	Family		Scientific name	Common name	IUCN Red List	Phenological status
Piciformes	Megalaimidae	43	*Psilopogon haemacephalus*	Coppersmith Barbet	LC	R
		44	*Psilopogon asiaticus*	Blue-throated Barbet	LC	R
Psittaciformes	Psittacidae	45	*Alexandrinus krameri*	Rose-ringed Parakeet	LC	R
Strigiformes	Strigidae	46	*Glaucidium brodiei*	Collared Owlet	LC	R
Suliformes	Phalacrocoracidae	47	*Phalacrocorax fuscicollis*	Indian Cormorant	LC	R

LC—Least Concern | NC—Near Threatened | R—Resident | WV—Winter Visitor | SV—Summer Visitor.

not recorded during the present study.

In the present study, it was observed that the major causes of species decline were various human activities by the local people. The degradation of wetland habitat may cause the water table to drop, the food chain to get disrupted, eventually migratory bird populations to decline, and the nutrient cycle to slow down, all of which are detrimental to the environment, ecosystem, and human beings (Kumar & Kanaujia 2014). Also, the destruction of the breeding grounds for the illegal collection of eggs and meat of various birds for consumption and conversion to farmland makes them unsuitable for migratory as well as resident species. Out of the 154 days of fieldwork, on around 101 days, the people of the nearby localities were observed to be fishing in the wetland area of the bird sanctuary, which is the primary foraging and breeding ground for many residents and migratory bird species. During fishing, they spread nets all over the wetland just below the water surface and wait for 7–8 h. But tragically, the feet of the birds get trapped in the net and the birds suffer, some even die. Both adults and children in the locality were seen with slingshots. They kill birds and destroy their nest on trees and shrubs with the slingshots not only because of their meat but also because of it as a sport. Furthermore, the cultivation of rice and other crops on the lands adjacent to the shore of the wetland using tractors and other farming machinery is also posing a threat to species diversity. Agriculture has been identified as the largest global threat to birds' survival (Green et al. 2005). Maas et al. (2013) also identified agricultural intensification as the major cause of the decline of most bird populations. The noise of these machines and the people involved in cultivation within the boundary of a bird sanctuary disturb its wildlife. Wetlands affected by developing intensive farming systems have lowered the species diversity (Golzar et al. 2019).

Anthropogenic activities such as fishing, and poaching of birds such as Lesser Whistling-Duck *Dendrocygna javanica*, Fulvous Whistling-Duck *Dendrocygna bicolor*, White-breasted Waterhen *Amaurornis phoenicurus*, Indian Pond-Heron *Ardeola grayii*, Eastern Spotted Dove *Spilopelia chinensis*, Yellow-footed Green-Pigeon *Treron phoenicopterus* and the use of the bird sanctuary land as pasture area, cultivating crops using machines with high decibel sound force the resident and most of the migratory birds to change their foraging and/or breeding grounds to somewhere else. Sonowal et al. (2018) also reported raising cattle, overfishing, harvesting aquatic plants in excess, poaching wild birds, and collecting bird eggs harmed the overall ecosystem and biodiversity including the avian species of the sanctuary. Adverse effects of anthropogenic disturbances, natural calamities, and climate change can greatly affect the quality and quantity of habitats for birds in terms of resources and shelter, which can further affect their diversity, abundance, and distribution (Chen et al. 2011; Şekercioğlu et al. 2012). According to the last IBA conservation assessment result (BirdLife International 2024), some threats identified on the species and their habitats were human intrusion and disturbance, agriculture expansion and intensification, and pollution. Previously, Sonowal et al. (2018) also reported encroachment in the sanctuary area by the local people for agricultural purposes. Encroachment in BBBS was also observed in the present study which corroborates with that of Sonowal et al. (2018) and indicates that there has not been any decrease in the negative human activities in the sanctuary which in turn affects the avian species negatively showing a drastic decline in its diversity.

CONCLUSION

The Bordoibam-Bilmukh Bird Sanctuary has been the home to a large number of avian species with other flora and fauna. A maximum of 167 species of birds have been reported to date from here, which depicts its rich avifaunal wealth. But the rapid decline in avian diversity is a sign of declining overall biodiversity which needs

immediate attention and action for the restoration and conservation of both fauna and flora. If no action is taken immediately, more damage will occur in the coming years and its significance as a bird sanctuary will be lost forever. Immediate steps for habitat restoration and to develop management initiatives in the Bordoibam-Bilmukh Bird Sanctuary to safeguard avian diversity are required.

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Bits and fragments: documenting an unreported coral genus *Heterocyathus* Milne Edwards & Haime, 1848 from northwestern Bay of Bengal (Odisha coast) and a call for further assessment

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Abstract: The collection of a dead specimen of the coral *Heterocyathus* cf. *sulcatus* on a sandy beach in southern Odisha highlights the importance of exploring offshore waters along this coast. The specimen was identified based on prominent taxonomic characters and association with coral boring worm. This genus was previously known to occur along the eastern coast of India, from the Gulf of Mannar/ Palk Bay and off the Chennai coast. The presence of rocky offshore outcrops and a sandy substratum in the vicinity suggests that the specimen likely originated from that location.

Keywords: Caryophillidae, coral reefs, habitat, new record, rocky offshore, sandy beach, taxonomic characters.

Abbreviations: EBRC—The Estuarine Biology Regional Centre | ZSI—Zoological Survey of India.

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Author contributions: DPB: Writing, reviewing and editing, Specimen collection, Validation, Conceptualization; RRD: Writing original draft, reviewing and editing; Conceptualization, Validation.

Competing interests: The authors declare no competing interests.

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Gujarat Institute Of Desert Ecology

INTRODUCTION

The family Caryophylliidae Dana, 1846 under which *Heterocyathus* originates has the highest diversity of species (>300) worldwide (Cairns 1999a,b; Reyes 2009). This azooxanthellate/apozooxanthellate genus is free-living, preferring a sandy substratum (Hoeksema & Best 1991; DeVantier et al. 2006) and occurs near offshore patchy reefs as seen in Sulawesi (Hoeksema 1990; Hoeksema & Best 1991). Found at a depth ranging from 0 to around 320 m (FAO 2011), it has also been reported beyond 500 m (Cairns 1999b). The genus consists of seven valid species: *H. aequicostatus* Milne Edwards & Haime, 1848; *H. alternatus* Verrill, 1865; *H. antoniae* Reyes, Santodomingo & Cairns, 2009; *H. hemisphaericus* Gray, 1849; *H. japonicus* Verill, 1866; *H. monileseptatum* Filander & Kitahara, 2021; and *H. sulcatus* Verrill, 1866. *H. sulcatus*, *H. aequicostatus*, and *H. alternatus* have been reported from Indian waters (Alcock 1893; CMFRI 1970; Pillai 1983; Venkataraman 2007). Unique characters for species level distinction include the arrangement and lateral projection of septa, and coloration patterns (Reyes et al. 2009). The genus can be seen associated with the polychaete worm *Aspidosiphon muelleri* Diesing, 1851 (Hoeksema & Best 1991; Stolarski et al. 2001). It is important to note that all the three species reported from Indian waters are under the 'Least Concern' category of the IUCN Red List of Threatened Species (2018).

In this paper our main objectives are to: (1) report the observation of an unreported coral genus (*Heterocyathus*) from the northwestern coast of Bay of Bengal (Odisha) and (2) emphasize the need to explore the offshore waters of the coast.

MATERIAL AND METHODS

The Gopalpur coast (Figure 1), the point of origin for this specimen is located within the southern part of Odisha State. It is known for its tourism and fishing activities involving trawlers and small fishing boats

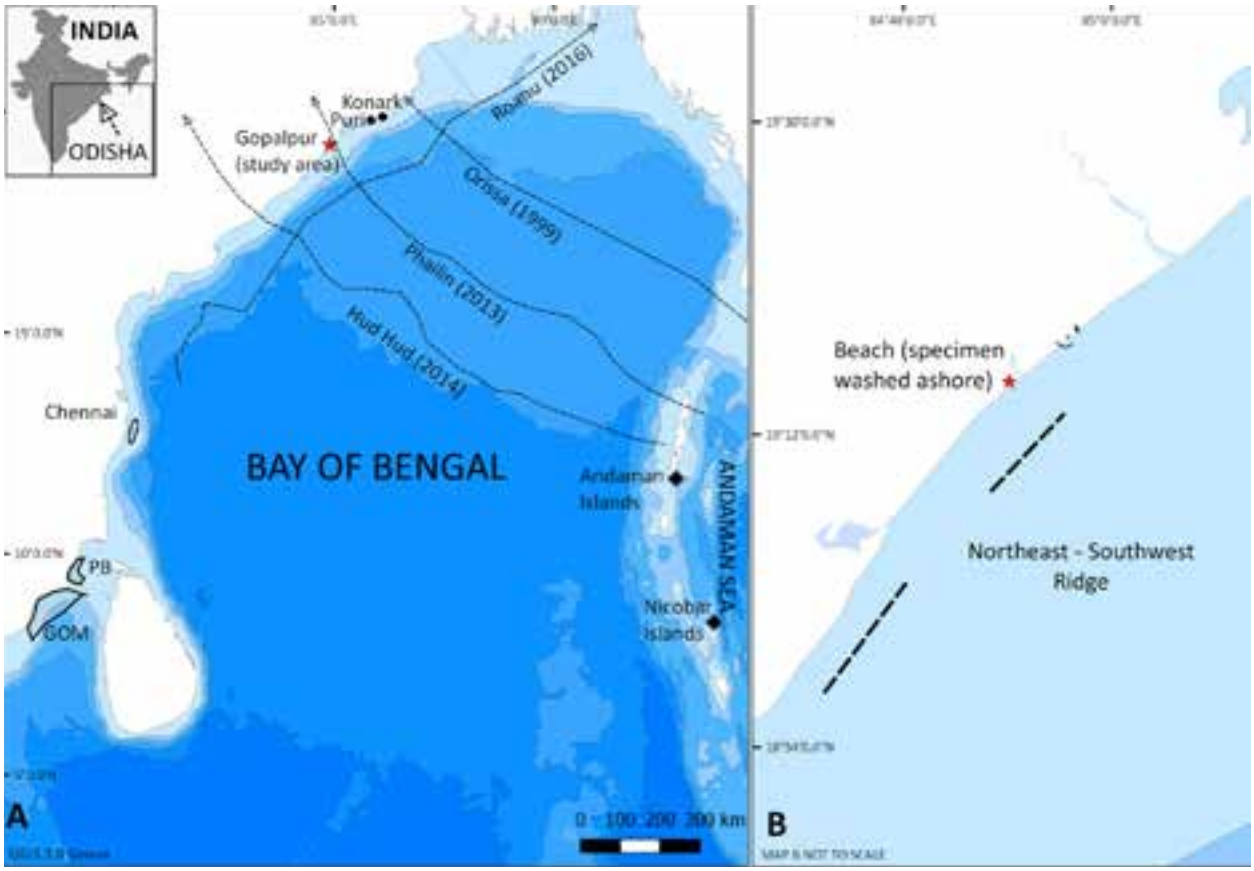

Figure 1. Study map: A—Various cyclones affecting the area of observation, triangular dots and polygons are previously reported areas and circular dots indicating locality having possible patchy reefs offshore. PB: Palk Bay; GOM: Gulf of Mannar | B —The NE-SW ridge, known to harbour various corals and other associated organisms. [Cyclone track obtained from NASA, RAMMB and JAXA, Base map source: Free vector and raster map data @ naturalearthdata.com.]

(Mahapatro et al. 2015; Behera et al. 2017a,b). The area comprises of various creeks, rivers, and the Chilika lagoon in its vicinity. Off the coast lies a submerged ridge which runs parallel to the Gopalpur coast extending further till Andhra Pradesh (see Bapuji et al. 1999; Rao et al. 2001). The area is also highly exposed to tropical cyclones that originate from the Bay of Bengal and the Andaman Sea (Figure 1).

During a regular field visit, a single dead specimen of the non-reef building Indo-pacific scleractinian genus *Heterocyathus* was observed on the sandy beach. The specimen was documented for further taxonomic identification. The specimen was identified based on its morphological characters following Stolarski et al. (2001), Reyes et al. (2009), and Cairns & Kitahara (2012). Morphological measurements were taken in the field with a digital Vernier caliper and were later reassessed with ImageJ v1.51. Study map was created using QGis 3.0. The stacked bar chart was created using R programming software version 4.0.5 (2021-03-31), using the packages "ggplot2" and "tidyverse" (Wickham 2016; Wickham et al. 2019).

RESULTS AND DISCUSSION

Systematics

Phylum Cnidaria Verrill, 1865
Class Anthozoa Ehrenberg, 1834
Order Scleractinia Bourne, 1900
Family Caryophylliidae Dana, 1846
Genus *Heterocyathus* Milne Edwards & Haime, 1848
Heterocyathus cf. *sulcatus*
(Image 1)

Material Examined: One dead specimen washed ashore observed on 25 February 2016, Gopalpur coast (19.2506N, 85.9013E), southern Odisha, obs. by: Durga Prasad Behera. Deposited at EBRC/ZSI/Cn – 11146.

Description: Corallum solitary, unattached, globular with commensal sipunculid derived pores (polyporous type of corallum modification), theca non-porous, imperforate. Calicular Diameter 7.21 mm, height 5.81 mm with a base diameter of 7.43 x 6.93 mm. Dark brownish to blackish colour prominent in the central region of calices. Four sipunculid derived basal holes present: two in the center and one each on the left and right respectively. The right most hole is the main orifice (diameter 0.99 mm) (Image 1C). A thin and smooth layer observed on the interior surface of the main orifice. Three additional holes are in the intercostal furrows of the theca (Image 1B). The base consists of uneven granules resulting in an uneven texture. Coastae prominent, extends till the base with height significantly reduced. Accurate description of lateral septal projection not possible as the specimen is worn out.

Remarks: The genus *Heterocyathus* has close similarity with genus *Heteropsammia* Milne Edwards & Haime, 1848; however, the latter bears a perforated theca with prominent coastae absent**.** Our specimen is believed to be *H. sulcatus* (Verrill 1866) due to the similar colouration pattern in the central portion of the calices. The height of our specimen also closely correlates with the original description of *H. sulcatus* which was initially described as *Stephanoseris sulcata* Verrill, 1866 from Sri Lanka (see. Verill 1866).

Distribution: Indian waters – The genus is reported from Andaman & Nicobar Islands (Alcock 1893; Pillai 1983; GBIF 2023); off Chennai coast (Tamil Nadu) (Venkataraman 2007), Gulf of Mannar and Palk Bay (CMFRI 1970; Pillai 1983), and off the coast of Mumbai (Maharashtra), Gujarat, and Kerala (GBIF 2023). Elsewhere – Pacific and Indian Ocean (Vanuatu and Wallis & Futuna, Tuscarora bank, Waterwitch bank, Tanna, Erromango, Efate, southeastern Espiritu Santo, northeastern Espiritu Santo, Anatom) (Cairns 1999b), Great Barrier Reef (Devantier et al. 2006), Japan (Until Northern Honshu), Taiwan (Yabe & Eguchi 1932; Zibrowius 1998), Indonesia (Hoeksema & Best 1991), South China Sea (Renlin & Xilian 1983), Gulf of Thailand (Hoeksema & Matthews 2015), Sri Lanka (MOE 2012), Pakistan (Moazzam & Moazzam 2016), Persian Gulf (Maghsoudlou 2010), Seychelles, Coast of Africa (GBIF 2023), Gulf of California, western coast of Mexico (Zibrowius 1998; Reyes-Bonilla & Cruz-Piñón 2000), and northeastern Caribbean coast (Reyes 2009).

A review of the literature indicates that there are few published papers which have tried to explore the coral reef or its associated faunal diversity off the coast of Odisha (Bapuji et al. 1999; Rao et al. 2001; Jayaprakash & Radhakrishnan 2014), it has not been highlighted in most of the coral reef literature present due to this limited knowledge (e.g., Pillai 1996; Muley et al. 2000; Rajasuriya et al. 2000; Venkataraman & Wafar 2005; Tamelander & Rajasuriya et al. 2008). Recent observation of coral reef indicating fishes and coral fragments off Konark coast (Figure 1b) and the report of the presence of *Gorgonia ventalina* Linnaeus, 1758 (a protected species) off Puri coast (Figure 1b) (Odishatv 2016; De et al. 2017) have created much interest among the coral reef researchers in the country. This indicates that coastal waters of southern Odisha might not be the only place with the presence of a patchy reef. Therefore,

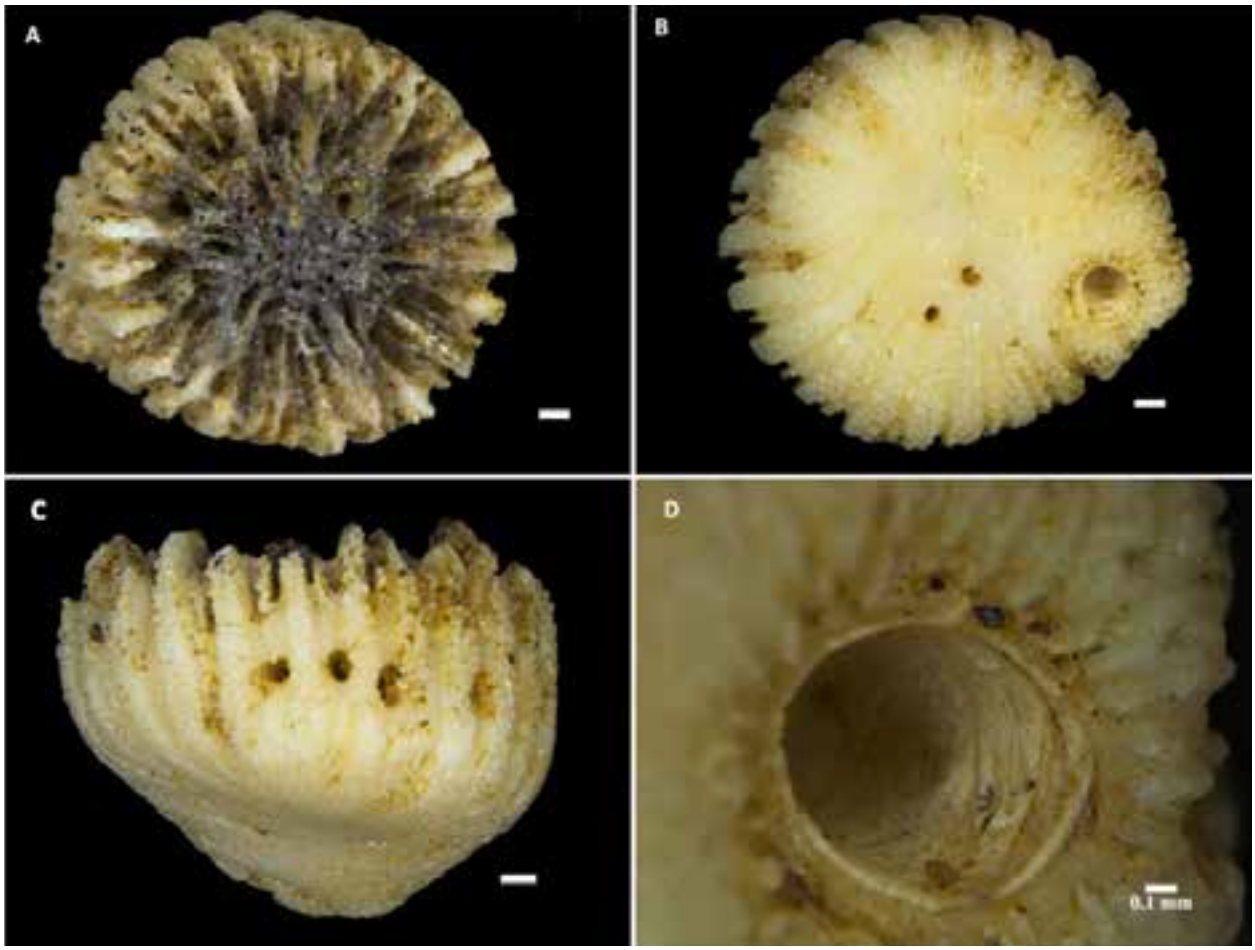

Image 1. *Heterocyathus* cf. *sulcatus*: A—Calicular view: center of calices dark in colour | B—Basal view | C—Lateral view: additional sipunculid holes in the intercoastal furrows | D—Zoomed in basal view: porous holes associated with sipunculid and main orifice. ©Rocktim Ramen Das.

more focus on the lack of survey efforts to explore the ecology of the submerged ridge should be stressed upon.

Our observation lies perpendicular to the rocky outcrop, which is divided into two segments. The rocky outcrop with a length of approximately 14 km extends from Gopalpur to further south with an elevation of 3–5 km spread across 150–250 m (Bapuji et al. 1999; Rao et al. 2001). The faunal diversity of both the segments has been highlighted in Figure 2. Though regarded as a preliminary observation by the authors, follow-up studies do not exist. Recent reports indicate the presence of reefs off Konark and Puri (~100+ km) is also limited to non-scientific reports. Recently, Behera et al. (2017a), mentioned these rocky outcrops and their fauna based on previous literature, but the author's finding was more related to fish rather than corals. Based on our knowledge on the region, we can hypothesize that the north-west–south-east ridge and the sandy substratum in its vicinity can act as a good habitat for solitary coral species and might contain more undocumented aggregation of free-living corals which can in fact be the original source of our present observation. The vulnerability of the coast to frequent cyclones could also be the cause of the specimen being washed ashore as observed in other Indian reefs affected by cyclones (Krishnan et al. 2012).

CONCLUSION

Till recently, the ahermatypic/apozooxanthellate corals have received less attention in this part of the world (Venkataraman et al. 2003; Venkataraman & Wafar 2005) but various recent reports indicate the possibility of undocumented species (see. Venkataraman 2007; Raghuraman & Raghunathan 2015; Tenjing et al. 2019). Our observation indicates that we know very little about the offshore waters of Odisha and builds further evidence that many corals, reef-associated sedentary or mobile species remain undocumented in the region.

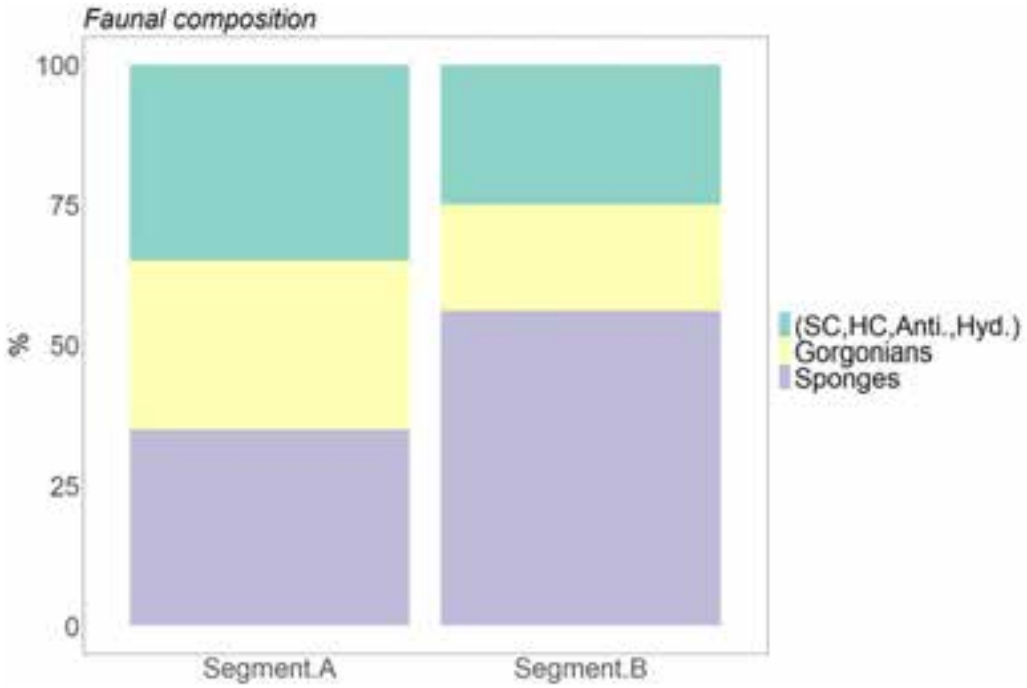

Figure 2. Faunal composition as reported from the rocky outcrops off the coast of Gopalpur (Odisha/ NW Bay of Bengal). SC—Soft Coral | HC—Hard Coral | Anti.—Antipatharian | Hyd.—Hydroids. Data obtained from Rao et al. (2001).

Reporting a genus or a species significantly improves our knowledge regarding its distribution and range. Still, our observation will remain a mere testimony if its habitat and surrounding ecosystem is not studied further. Thus, we communicate our findings to stimulate interest and motivate future scientific endeavors.

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OPEN ACCESS

COMMUNICATION

Evaluating the IUCN conservation status of *Tritaxis kurnoolensis* (R.R.V.Raju & Pull.) R.Y.Yu. & Welzen (Euphorbiaceae), an endemic tree species found in the Eastern Ghats region of Andhra Pradesh, India

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Abstract: *Tritaxis kurnoolensis,* a small tree of the Euphorbiaceae family, is endemic to a valley within the Sullavai Sandstone plateau in close proximity to the Paleru Reservoir (Owk dam). The species is a narrow endemic. No documented sightings of this species have been recorded beyond the type locality since its description in 1994 by Venkataraju & Pullaiah as *Dimorphocalyx kurnoolensis* from the Nandyal District of Andhra Pradesh. In this study, the authors applied the grid method for quantification and subjected the species to a meticulous analysis aligning with IUCN Red List Criteria. The distribution was found to be restricted due to habitat (valley) fragmentation, reservoir which is arresting seed dispersal, and destruction caused by tunnel construction civil works. The area of occupancy (AOO) at 16 km² and the extent of occurrence (EOO) at 0.474 km², were systematically computed using GeoCAT. The species is assessed here using the Red List methodology for evaluating extinction risk. Based on its AOO, EOO, and population size, it has been classified as Critically Endangered.

Keywords: Critically Endangered, endemic, grid method, Nandyal, Owk dam, quantification, small tree, sullavai sandstone, type locality, unisexual flowers.

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Author contributions: SD—writing draft, data analysis, photo settings. RKS—field data collection, data analysis, draft preparation.

Competing interests: The authors declare no competing interests.

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INTRODUCTION

Globally, there are 295,383 species and 13,164 genera of seed plants (Bramwell 2002; Govaerts 2003; Christenhusz & Byng 2016) among which 20% are threatened (Joppa et al. 2001). The majority of these are in the tropics and subtropics. Often, an overestimation of taxonomic or nomenclatural artefacts can be expected (Stefan 2004). As an example of this, Indian floristic studies have not been published with species distribution patterns and their endemism as a cumulative record for the entire geographical region except in old floras such as Flora British India (Hooker 1872–1897). The Botanical Survey of India (BSI) is trying to complete a set of volumes with detailed information on the species distribution and their endemism. However, over 75% of species are not covered.

There is ambiguity in the list of species which are endemic and Red Listed from India. According to Ravikanth et al. (2018), about 1,052 species are Red Listed of which 387 are plant species. Most of these 387 species are medicinal, among which 77 species are 'Critically Endangered' (CR). In the Western Ghats alone, more than 100 plant species of high economic importance are listed as threatened (Ravikanth et al. 2018).

There are many reasons for these species becoming threatened. India, like other countries, has had extensive developmental activities over the past few decades in forested areas. Railway lines, power grids, dams, and urban expansion have all taken their toll. The extensive exploitation of medicinal plants (collection of crude drugs), podu-cultivation, livestock grazing, dominant invasive species, and the disregard of government regulations have pushed endemic and threatened species to higher levels of risk. Immediate action is necessary to address these issues.

The IUCN Red List is centrally managed on a global level to address species conservation issues. Four entities are involved in the IUCN Red List Assessment process: (i) assessors, (ii) reviewers, (iii) Red List Authorities (RLAs), and (iv) the IUCN Red List Unit (RLU). Assessors gather data and apply the IUCN Red List Categories and Criteria to evaluate a species. Reviewers are independent experts who review the assessments before they are submitted for final checks. RLAs, which typically include IUCN Specialist Groups, Red List Partner institutions, or standalone Red List Authorities, are responsible for assessing species within their remit. The RLU acts as the gatekeeper for the Red List, ensuring that all published assessments meet the required standards (IUCN 2016).

The steps involved in the assessment are (i) data collection that is gathering data on species and identifying potential risks, (ii) initial assessment in which assessors apply the IUCN Red list categories and criteria, and (iii) peer review – an independent experts review to ensure the accuracy and consistency of the assessment. The assessment is submitted to the relevant RLA. Then, final checks are made by RLU to verify that all standards are met. Publication is the last stage where the assessment results are published on the IUCN Red List (IUCN 2016).

Baillon (1858) described the genus *Tritaxis* based on *T. gaudichaudii* Bail., which features three whorls of stamens in the type. Subsequently, two more species were published under the genus *Tritaxis*, but later they were transferred to other genera. For instance, *Tritaxis zeylanica* Müll.Arg. was moved as *Paracroton zeylanicus* (Müll.Arg.) N.P.Balakr. & Chakrab. and *T. macrophylla* Müll.Arg. became *Paracroton pendulus* ssp. *pendulus*, while establishing *Paracroton pendulus* ssp. *zeylanicus* (Thwaites) N.P.Balakr. & Chakrab.

The Dharmavana Nature Ark has undertaken the conservation of threatened woody species from the Deccan Peninsula and Eastern Ghats of India. The initiative began in 2004 by establishing a seedling nursery. This was followed by plantation of species to a 400-acre site where specific niches were designated for different groups of species.

During a visit to the type locality of *Tritaxis kurnoolensis* (R.R.V.Raju & Pull.) R.Y.Yu & Welzen (Yu et al. 2019) for seed collection, we were unable to find healthy seeds for nursery development. It was observed that individuals of the species were facing high stress and threat due to the dumping of stones and soil during the establishment of a reservoir (Image 2a vs b) and particularly so during the construction of inlet canals and the cutting of mature trees by the locals (Image 4a–f). Subsequent visits in 2023 aimed to understand the growth, survival, and recruitment as well as to obtain viable seeds. However, the attempts to establish seedlings were unsuccessful as the seeds were not viable (without kernal). Given the adverse conditions for species establishment through natural recruitment, special attention was given to conserving *Tritaxis kurnoolensis*, focusing on seed germination, air layering, and root cuttings collection. The focus now is on estimating the population size in the area and implementing conservation measures in a systematic, step-by-step manner.

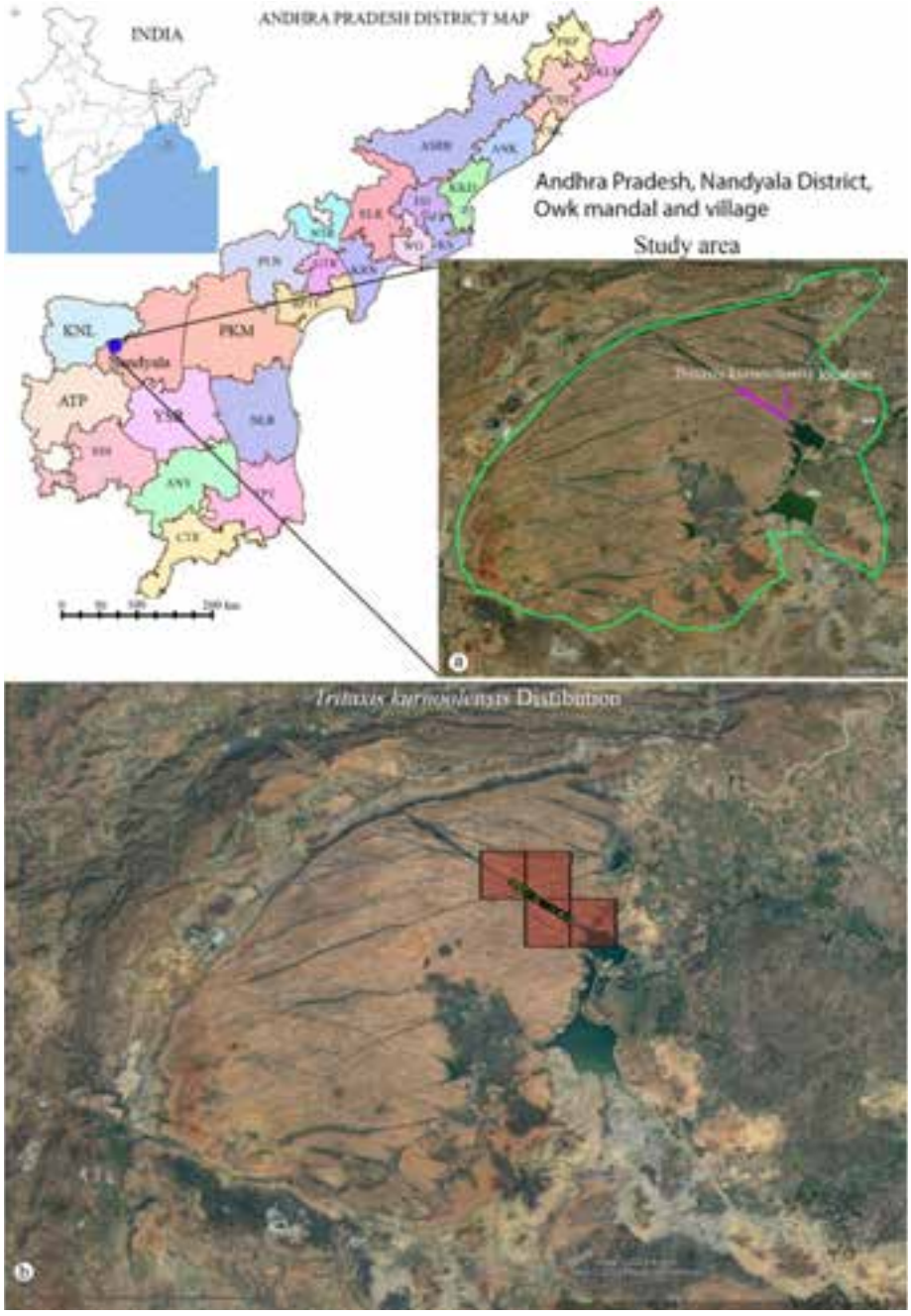

Image 1. Location of the rocky plateau study area of *Tritaxis kurnoolesi*: a—Isolated location of *Tritaxis kurnoolensis* (Green line- study area 286km^2, pink – single location) | b—Quantitative assessment (grid size 2 × 2 km).

MATERIAL AND METHODS

To measure the size of the population and the count of mature individuals, the authors categorized the habitat into four grids, each measuring 2 × 2 km as IUCN recommended and default option in the GeoCat. The presence of *Tritaxis kurnoolensis* was documented in each grid using covering a 10 × 10 m area. Across the four grids, a total of 85 quadrats were deployed, revealing a cumulative count of 164 mature individuals. The population within each specific quadrat was then determined. The locations of the taxon's occurrence were recorded using the global positioning system (GPS). For the IUCN Red List assessment, we employed GeoCAT (Geospatial Conservation Assessment Tool), an open-source tool used to calculate the taxon's extent of occurrence (EOO) and area of occupancy (AOO) based on GPS readings. These GPS readings, along with other

data such as catalogue ID, collector, country, event date, institution, locality, scientific name of the taxon, state, and elevation, were entered into a CSV file and uploaded to GeoCAT. A map was generated using GeoCAT (Bachman et al. 2011). This process is carried out in a transparent, repeatable, and rapid manner within a user-friendly interface, as described by Bachman et al. (2011). Based on the initial assessment in the study area, the EOO and AOO for this taxon were approximated in square kilometers (Figures 1 & 2).

RESULTS

Tritaxis kurnoolensis (R.R.V.Raju & Pull.) R.Y.Yu & Welzen (= *Dimorphocalyx kurnoolensis* R.R.V.Raju & Pull. Botanical Bulletin of Academia Sinica 35: 201 (1994))

Monoecious deciduous small trees, up to 4-m high, bark dark brown, scaly, blaze light yellowish-brown, branches terete, striate, pubescent. Leaves glabrous, 5–15 × 3–7 cm, elliptic-oblong or obovate, base attenuate, margin entire–sinuate, apex sub-acute obtuse; lateral veins up to nine pairs; petiole up to 3 cm, shallowly channeled above; stipules deltoid. Inflorescens terminal, lax receme. Male and female inflorescences on different branches of same plant, diclinous flowers (Figure 3). Male flowers cymose clusters on terminal pubescent peduncle; peduncle up to 7 cm long; flowers subsessile, 4–5 mm cross, ovate bud, pedicels to 2 mm long, bracts lanceolate, 1–2 × 2–3 mm, densely pubescent, acute-acuminate; tepals in two whorls (5 + 5); outer green (sepals), cupular, 5-lobed, connate, adpressed-pilose, lobes subovate orbicular; inner (petals) white, polypetalous, each oblong, obtuse, often emarginated, bent out. Stamens biseriate, 5+11–17; outer five basally connate to the inner staminal column, filaments 1.8 mm; anthers 1.2 mm across, widely oblong; inner (11–17) stamens on 7 mm long staminal column with their individual 0.5 mm long connectives; anthers 0.8 mm across, monodelphous, orbicular, acute; disc glands 5, free, ovate-oblate, hairy at top. Female flowers few, in short pedunculate racemes; flowers 5–8 mm across; pedicel 8mm long, pubescent; tepals in two whorls (5+5); outer (sepals) green, cupular, shortly 5-lobed, connate at base, adpressed-pilose without; lobes suborbicular, 2 × 2.5 mm; inner (petals) white, polypetalous, oblong-obtuse, often emarginated; ovary 4 × 3 mm, adpressed-pilose, three locular; styles 3, connate at base, each 2-fid from above the middle, papillose; disc glands as in the male flower. Capsule 1–1.3 × 1.3–1.7 cm, sub-globose, depressed, adpressed-pilose, 3-lobed, deeply furrowed, fruiting calyx (sepals) deeply 5-lobed, lobes 5.5 × 3.5 mm, adpressed-pilose without. Seed shiney, 8 × 7 mm, elliptic-oblong, brown mottled with grey, tips acute, hilum circular, testa smooth, ecarunculate (Image 1). Flowering is in December–March and fruiting in February–April.

Habitat and Distribution

Tritaxis kurnoolensis is endemic to a valley where there is sullavai sandstone (as surface stone). We chose the entire plateau of around 286 km^2 as a study area for the present taxon IUCN assessment. This species is associated with *Ziziphus oenopolia* (L.) Mill., *Grewia damine* Gaertn., *G. flavescens* Juss., *Ficus mollis* Vahl, *Pterospermum xylocarpum* (Gaertn.) Oken, *Ixora pavetta* Andrews (= *Ixora arborea* Roxb. ex Sm.), *Vitex leucoxylon* L.f., and *Tamarindus indica* L. *Tritaxis kurnoolensis* is distributed in only one valley even though there are four valleys in the study area.

This species has been in continuing decline because of reservoir and tunnel construction. Prior to construction, trees likely lined the natural, original water stream. Unfortunately, these water streams were converted into canals for irrigation purposes resulting in a significant loss of habitat and trees. This impact is

Table 1. Number of mature individuals of *Tritaxis kurnoolensis* counted in the study area.

Grid ID	No. of individuals from 5 quadrants in a grid	No. of individuals in whole grid (200 × 200 m)
1	20	23
2	6	6
3	27	46
4	20	21
5	8	8
6	18	29
7	13	22
8	4	4
9	10	11
10	8	8
11	10	15
12	8	8
13	1	1
14	2	2
15	5	5
16	3	3
17	1	1
Total	**164**	**213**

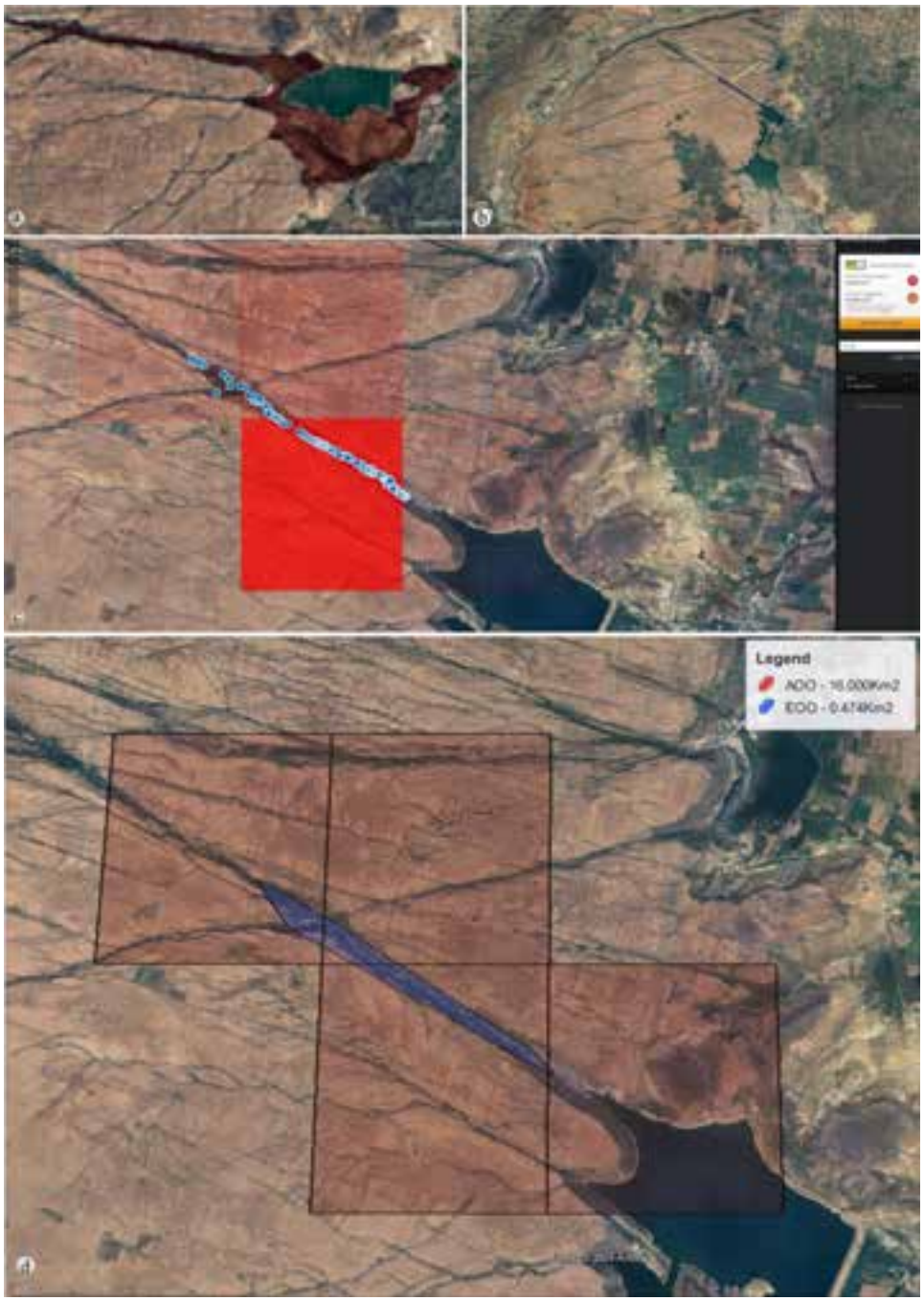

Figure 2. Faunal composition as reported from the rocky outcrops off the coast of Gopalpur (Odisha/ NW Bay of Bengal). SC—Soft Coral | HC—Hard Coral | Anti.—Antipatharian | Hyd.—Hydroids. Data obtained from Rao et al. (2001).

particularly apparent following dam construction since the natural dispersion of seeds and recruitment for the next generation were severely depressed (Image 2a–f).

Threats

The seeds of this species disperse through an explosive fruit mechanism at drying, contributing to a low probability of horizontal spreading. Seeds disperse over a maximum radius of 5 m from the mother plant. Seeds are relocated by rainwater and some may decompose in the reservoir. Mature stems are harvested for firewood and serve as support sticks for banana plants. Additionally, waste stones are dumped into the area due to water inlet (tunnels which connect to the Gorukallu balancing reservoir about 60 km away) development activities (Image 4). Owk reservoir development commenced

in 2003, greatly enlarging what was initially two large ponds utilized for agricultural purposes.

IUCN Red List Assessment

Tritaxis kurnoolensis is restricted to a valley of the sandstone plateau of the Paleru reservoir (Owk dam) area, Nandyal District, Andhra Pradesh, India (Image 1a,b). Based on the distribution of the taxon and the decline in the number of individuals since 1994, its habitat area has decreased from 3.48 km² to 0.474 km². In addition to ongoing threats such as forest fires, reduced production of healthy seeds, and inadequate conditions for seed germination, there is now a significant additional threat from waste stone dumping on individuals confined to the valley. Considering these factors along with the AOO and EOO values, population size, and number of locations, we have evaluated its conservation status. Notable data parameter the EOO at 0.474km² is calculated using a minimum convex polygon (MCP). The IUCN threat status is classified under 'Critically Endangered' (CR) following IUCN (2022), verson 15.1 guidelines, B1ab(i,ii). This species meets B1- Extent of occurrence (EOO) is less than 100 km² (Image 2), B1a – number of locations is 1 (Image 1a), B2b (i) – decline in extent of occurrence (Image 2a *vs* b), (ii) – decline in area of occupancy since 1994 (Image 2a vs b) from 3.48 km² to 0.474 km². Taking these criteria, we concluded the species IUCN Red List threat status as 'Critically Endangered'. There is an immediate need to plan in situ and ex situ conservation of this species. Research to monitor trends in population decline and stop the threats are imperative.

Conservation Action

The Dharmavana Nature Ark team conducted several seasonal visits from January 2023 to gather healthy seeds. However, due to the lack of properly formed seeds, they initiated a regeneration strategy via vegetative propagation such as air layering. The objective is to successfully cultivate at least 10 individuals from various mother plants. Once these plants thrive in pots, they will be transplanted to appropriate microhabitats within the Dharmavana Nature Ark ecosystem that has been strategically designed to accommodate different plant groups based on their original habitats (Image 4).

DISCUSSION

The population of *Tritaxis kurnoolensis* is declining due to habitat fragmentation and destruction caused by tunnel construction and reservoir civil works. The species has become a narrow endemic, largely confined to a small area. Its decline has been ongoing since 1994, following the conversion of two ponds into a dam. Previously, the species was found along the bunds of the two ponds and the canals that directed water to agricultural fields. However, with the expansion of the ponds and the renovation of the canals, much of its habitat has been lost. In addition to the dam's construction, two connecting tunnels from the Gorukallu Balancing Reservoir, about 60 km away, have also contributed to its decline. During the excavation of these tunnels, waste soil and stone were dumped on *Tritaxis kurnoolensis* individuals, leading to the trapping and drying out of many plants in recent years. We suspect that diminishing population sizes coupled with human-made threats and habitat fragmentation have driven species far below sustainable levels. Based on fruit setting and seed germination percentages, we also suspect that inbreeding, loss of pollinators, and climate change are contributing to the species' extinction (Image 2a,b; Image 4). No documented sightings of this species have been recorded since 1994 beyond the type locality from the Kurnool District (now the area comes under newly formed Nandyal District) of Andhra Pradesh. GeoCAT analysis reveals a small AOO (16 km²), EOO (0.474 km²) and number of individuals less than 250, categorizing the species as Critically Endangered. Urgent conservation action is recommended by Dharmavana Nature Ark and the authors to save this species, as the number of individual trees counted 213 (Table 1).

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Image 3. a—Habit of a healthy undamaged tree of *Tritaxis kurnoolensis* | b—Habit of a damaged tree with cluster of stems | c—Male flowers and healthy leaves | d—Female flowers | e—Fruiting branch | f—Mature fruits | g—Seeds. © RajaKswamy.

Image 4. Threats to *Tritaxis kurnoolensis*: a—Trees dying from fallen rocks | b, c—Cluster of stems covered by dumped stones | d—Root system of the tree damaged by soil erroson | e—a tree in the valley among the waste stones | f—Tree fall due to the weight of stones dumped on it | g—Air layering. © RajaKswamy.

Image 5. Male and female flowers on the same tree of *Tritaxis kurnoolensis*. © RajaKswamy.

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COMMUNICATION

Notes on the extended distribution of *Ceropegia gardneri* Thwaites and other rare species of *Ceropegia* from southern Western Ghats, India

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Abstract: The extended distributional record of a threatened species of *Ceropegia* namely *Ceropegia gardneri* from Kerala is provided. This species exhibits a narrow range of distribution along the Western Ghats and in Sri Lanka. Details of four other rare species of *Ceropegia* are also given. Notes on taxonomy, phenology, distribution and conservation status are also provided for the better understanding of the species.

Keywords: *Ceropegia candelabrum*, *Ceropegia decaisneana*, *Ceropegia elegans*, *Ceropegia fimbriifera*, *Ceropegia hirsuta*, endemic, grasslands, Kerala, new record, Paithalmala.

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Author contributions: EJJ collected the specimens and identified it based on the morphological characters. PB and JA helped in taking the photographs, arranging the colour plate and preparation of the manuscript. All authors read and approved the final manuscript.

Competing interests: The authors declare no competing interests.

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INTRODUCTION

The genus *Ceropegia* L.(s.l.) is represented by 740 species (Bruyns et al. 2020) which are distributed in the tropical regions of the world from Macaronesia and Africa to northern Australia (Huber 1957). Among these, 160 species with erect stem and radiate flowers were delimited to the Genus *Brachystelma* (Prasad & Venu 2015, 2020). In India, the genus *Ceropegia* s.s. is represented by 64 species (Kamble & Yadav 2019) mostly from the Western Ghats. *C. gardneri* Thwaites, often considered as a synonym of *C. elegans* Wall. is mostly distributed in Sri Lanka, was distinguished as a distinct species and was recorded from Baba Budan Giri hills of Chikmagalur District of Karnataka State for the first time from India (Kamble & Yadav 2012, 2013). No other records for this taxon are found anywhere from India. During the exploration of flowering plants of Paithalmala Hills of southern Western Ghats of Kerala, the authors encountered this species along with five other species of *Ceropegia* most of which belong to rare or threatened category. *C. gardneri* is recorded here as a new record to Kerala and also provided the details of five other rare species of *Ceropegia* from the locality.

MATERIALS AND METHODS

The current study is based on seasonal plant explorations in Paithalmala of southern Western Ghats. The authors found species of *Ceropegia* growing in different habitats like rock crevices, grassland thickettes, and margins of evergreen forests. The specimens are collected and dissected under Zoom Stereo Microscope M 125. Photographs of the specimens were taken using Nikon 530 D camera. The specimens were then pressed and herbaria were prepared using the standard methods (Bridson & Forman 1991) and deposited in the herbarium of St. Thomas College, Palai for further studies. The specimens were identified using pertinent literature (Hooker 1885; Gamble 1921; Manilal & Sivarajan 1982; Ramachandran & Nair 1988; Murthy & Yoganarasimhan 1990; Kambale & Yadav 2014) and by comparing with the specimens available in various herbaria (K! K000305478 Brutt B.D. 14.05.1930; K000857808 Wight R 27.03.1844; K000894295 Gamble J.S. date not supplied; KFRI! 936 Sasidharan N. 11.10.1979; 932 Sasidharan N. 29.09.1978; 2485 Nambiar & Sasidharan 26.10.1982).

RESULTS AND DISCUSSION

The present study showed the existence of six species of *Ceropegia* from Paithalmala hills of southern Western Ghats. The species identified include *C. fimbriifera*, *C. hirsuta*, *C. elegans*, *C. candelabrum*, *C. gardneri* and *C. decaisneana.* Most of these species fail to set fruit and seeds and survive only by means of underground rhizomes. Moreover they exhibit narrow microclimatic conditions in the Western Ghats.

1. Plants erect herbs ..... *C. fimbriifera*
1. Plants twiners 2
2. Stem hirsute ..... *C. hirsuta*
2. Stem glabrous 3
3. Inner and outer lobes of corona equal ..... *C. elegans*
3. Inner and outer lobes of corona unequal 4
4. Corolla lobes up to 1 cm long ..... *C. candelabrum*
4. Corolla lobes more than 1 cm long 5
5. Rounded pouches between corolla lobes present ..... *C. gardneri*
5. Rounded pouches between corolla lobes absent ..... *C. decaisneana*

Taxonomic treatment

Ceropegia gardneri Thwaites, Enum. Pl. Zeyl. 3: 199. 1860; Kambale & Yadav, Asklepios 114. 2012. Typus: C.P. 2838 PDA! Sri Lanka.

Twiners; roots tuberous, fascicled; stem terete, glabrous; internodes c. 8 cm long. Leaves opposite, petiolate; lamina lanceolate, 4–7 × 2–3.5 cm, apex acuminate, base rounded, margin entire, ciliate, nerves indistinct above, ciliate beneath; petiole c. 2 cm long, glabrous, canaliculate above. Flowers in axillary few flowered cymes, purplish, c. 4.5 cm long; peduncle short, c. 5 mm long, glabrous; bracts subulate, c. 2 mm long; pedicel c. 1.5 cm long, glabrous. Calyx lobes 5, free, linear, 4–6 mm long and glabrous. Corolla tube 2.5–3 cm long, white with purple blotches, glabrous; base swollen, purplish spotted; mouth funnel-shaped, purplish lines within, with a ring of downwardly pointed hairs, c. 3 mm long, purplish; lobes 1.4–1.7 cm long, connivent, spreading, purplish, apex greenish, hairy within and ciliate at apex. Corona 2-seriate, outer 2-fid, connate, c. 3 mm long hispid, shorter than inner lobes, hairy within; inner c. 2 mm long, connate, glabrous. Pollinaria ovoid, c. 0.2 x 0. 2.5 mm and reddish. Ovary oblong, carpels 2, free; style 2, c. 3 mm long; glabrous, stylar dome 5 sided.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 1,208 m. 12.1039 °N, 75.3221 °E, JEJ 1712.

Distribution: India (Karnataka, Kerala) & Sri Lanka.

Habitat: Margins of evergreen forests.

Notes: *C. gardneri* Thwaites was reported from India for the first time from Hassan District of Karnataka. The species show restricted distribution in India and Sri Lanka along the margins of rainforests and associated streams. Poor fruit formation and seed setting are likely reasons for restricted distribution of the species. Further studies are necessary to assess the distribution and possible threats to the species (NE).

Ceropegia candelabrum L., Sp. Pl. 1: 211. 1753, var. *candelabrum*; Hook.f., Fl. Brit. India 4: 66. 1883; Gamble, Fl. Pres. Madras 856. 1923. Manilal & Sivar., Fl. Calicut 150. 1982; V.S. Ramach. & V.J. Nair, Fl. Cannanore 283. 1988; Murthy & Yoganarasimhan, Fl. Coorg 280. 1990. Typus: Plate of Rheede, Hor. Mal. 9: 27. t. 16, 1763.

Twiners; stem terete, glabrous; internodes 3–8 cm long. Leaves opposite, decussate; elliptic-ovate, 2.5–8 × 2–4.5 cm, apex apiculate, glabrous, membranous; lateral veins 3 or 4 pairs; petiole 1–2 cm long, glabrous, slender. Inflorescence axillary few-flowered cymes. Flowers 3–6, purplish-yellow, c. 2.5 cm long; pedicel c. 0.8 cm long. Sepals 5, linear-lanceolate, c. 2.5 × 0.5 mm, acute. Corolla tube c. 2.5 cm long, swollen below, yellowish with purple lines; lobes 5, oblong, 3–4 × 2.5–3 mm, apiculate, yellow, hispid at apex and inside, with purplish beaks. Corona 2-seriate, outer corona c. 3 × 2 mm, hispid; inner corona erect, c. 2.5 × 1.5 mm, linear, connivent. Pollinia 5, yellow, oblong. Ovary ellipsoid, carpels free; stigma dome shaped.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 920 m. 12.1042 °N, 75.3215 °E, JEJ 2663.

Distribution: India & Sri Lanka.

Habitat: Thickets in grasslands.

Notes: It is the most common species found in the lower altitudes and can survive in dry habitats.

Ceropegia decaisneana Wight, Icon. Pl. Ind. Orient. 4: t. 1259 1848; Gamble, Fl. Pres. Madras 859, 1924; Murthy & Yoganarasimhan, Fl. Coorg 269. 1990. *Ceropegia brevicollis* Hook.f., Fl. Brit. India 4: 74 1883. Lectotype: K! 000857806 Kambale & Yadav, INDIA.

Twiners; stem terete, glabrous, herbaceous; internodes 5–20 cm long. Leaves opposite; lamina lanceolate, 10–14 × 4–6 cm, apex acute, membranous, hispid above, veins sparsely hispid below, lateral veins 4–6 pairs. Inflorescence axillary, umbellate cymes; peduncle c. 4 cm long and glabrous. Flowers 4–6, c. 4 cm long, purplish; bracts lanceolate, c. 2.5 × 0.5 mm, acute. Sepals 5, linear lanceolate, c. 6 × 1 mm, acute. Corolla tube c. 3 cm long, base swollen, c. 5–8 mm long; middle tubular, c. 1.2 cm long, puberulent, dark purplish inside; lobes 5, c. 2 cm long, midrib prominent, apex connate, ciliate at the tips and inside. Outer corona lobes bifid, base connate, c. 3 mm long, hispid along the margins; inner lobes longer c. 3 mm long, spathulate. Pollinaria 5, elliptic, 0.2 mm long, caudicle short, c. 0.5 mm long. Ovary linear-oblong, c. 0.8 mm long; style 2, c. 4 mm long; stylar dome 5-sided.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 920 m, 12.1042 °N, 075.3215 °E, JEJ 2668.

Distribution: Endemic to the Western Ghats: Vulnerable (V)

Habitat: Margins of evergreen forests.

Notes: This species survives by means of underground tubers and has restricted distribution in the Western Ghats where it is found in the interiors of rain forests. Its leaves are edible and used by tribal communities

Ceropegia elegans Wall. in Curtis, Bot. Mag. 57: t. 3015 1830; Hook.f., Fl. Brit. India 4:68.1883, Gamble, Fl. Pres. Madras 857, 1923; V.S.Ramach &V.J.Nair, Fl. Cannanore 282. 1988. *Ceropegia mysorensis* Wight, Icon. Pl. Ind. Orient. 3: t. 846. 1844; Hook.f., Fl. Brit. India 4: 69. 1883; Gamble, Fl. Pres. Madras 857.1924. *Ceropegia walkerae* Wight, Icon. Pl. Ind. Orient. 4: t. 1266 1848; Hook.f., Fl. Brit. India 4: 69. 1883; Gamble, Fl. Pres. Madras 857.1923.Lectotype: Wallich 1830: t. 3, 1930.

Twiners; roots fasciculated, tuberous; stem terete, purplish, glabrous, herbaceous; internodes c. 10 cm long. Leaves opposite; lamina lanceolate, 6–9 × 2.5–3.5 cm, apex acute-acuminate, base rounded, margins entire, leathery, glabrous; lateral veins 5 pairs; petiole c. 1.5 cm long, sparsely hispid, pubescent. Inflorescence axillary, umbellate cymes, few flowered. Flowers c. 3.5 cm long, purplish; peduncle light purplish, c. 2 cm long; pedicel c. 1 cm long. Sepals 5, linear 1–2 mm long, acute. Corolla purplish; tube 3–3.5 cm long, base swollen, c. 5 mm long, with purplish dots outside; lobes 5, ovate-elliptic, 1–1.5 × 0.5–1 cm, bent inwardly, purplish, apiculate, purplish ciliate, involute. Outer corona lobes 5, c. 2 mm long, light purplish, 2-fid, hispid inside; inner corona c. 2 mm long, linear, purplish. Pollinaria 5, ovoid, yellow; caudicle c. 0.5 mm, ovary c. 1 mm long, oblong, carpels free; styles 2, c. 2 mm long; stigmatic dome 5-sided.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 920 m, 12.1136 °N, 075.3121 °E, JEJ 3771.

Distribution: India & Sri Lanka.

Habitat: Evergreen forests.

Notes: This species collected from different parts of peninsular India showed variation in its morphology and it is well represented in many parts of the Western

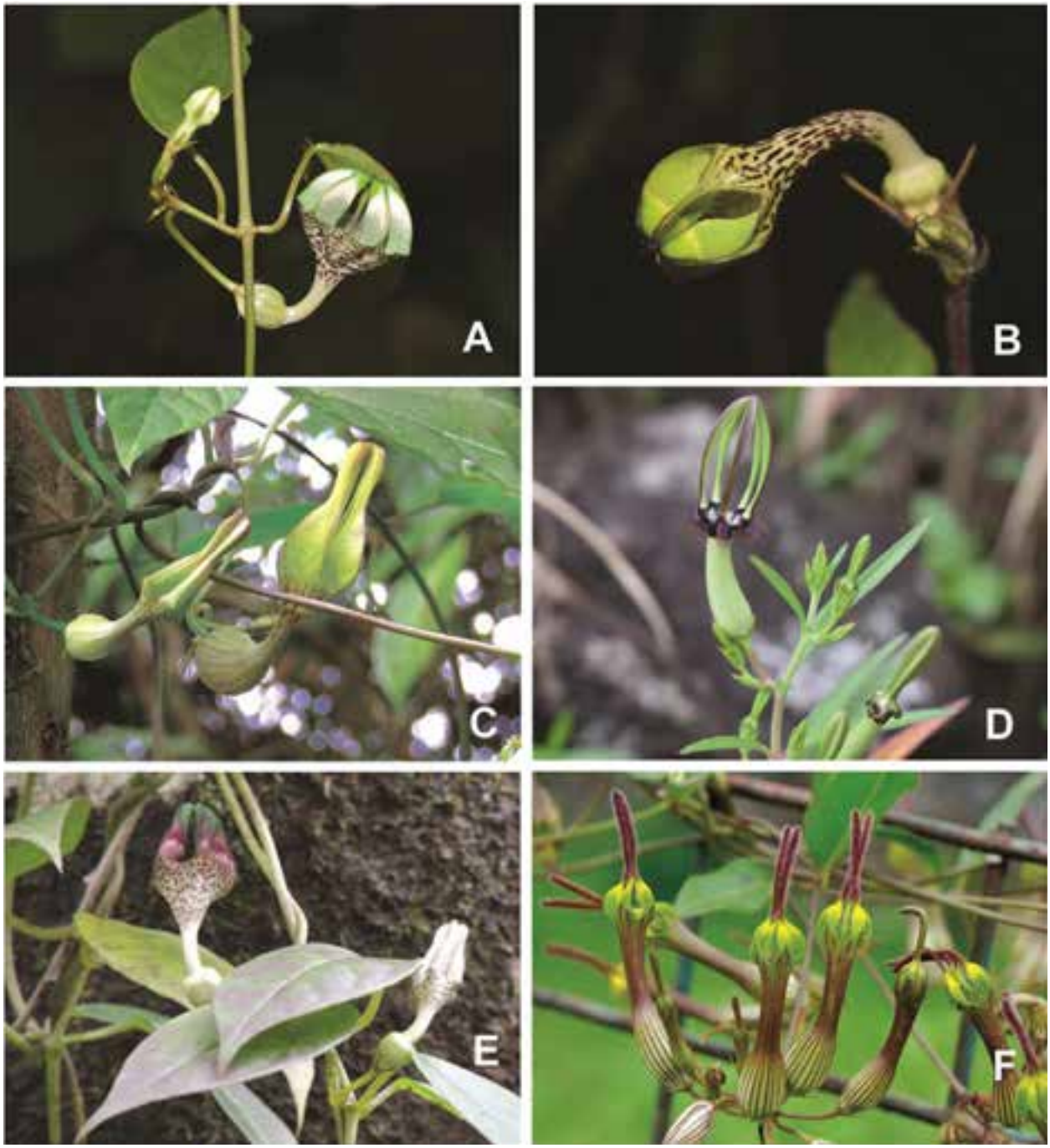

Image 1. A—*Ceropegia gardneri* | B—*C. hirsuta* | C—*C. decaisneana* | D—*C. fimbriifera* | E—*C. elegans* | F—*C. candelabrum*. © E.J. Josekutty.

Ghats. Further studies are necessary for the delimitation of this taxon.

Ceropegia fimbriifera Bedd., Madras J. Lit. Sci. III, 1: 53 1864; Hook.f., Fl. Brit. India 4: 66. 1883; Gamble, Fl. Pres. Madras 856. 1923. Lectotype: R.H. Beddome BM001014217, INDIA.

Tuberous, erect herbs, c. 25 cm high; tuber depressed globose, brownish, c. 1.5 cm across; stem purplish, puberulent, nodes close. Leaves alternate; lamina linear-lanceolate, 3–5 × 0.4–0.5 cm, apex and base acute, entire, ciliate, puberulent; lateral veins indistinct; petiole 4–6 mm long, glabrous, grooved. Flowers axillary, solitary or few flowered cymes; peduncle c. 3 mm long, terete; bract linear-lanceolate, c. 2 mm long, acute, puberulent; pedicel c. 8 mm long, hispid. Sepals 5, linear-lanceolate,

acuminate, puberulent above, ciliate. Corolla tube swollen near the base, grooved, tubular above, c. 2.2 cm long, purplish; lobes 5, confluent above, purplish, linear-lanceolate, with purplish gland tipped hairs in between. Corona 2-seriate, outer 2-lobed, smaller c. 1.5 mm long, obtuse with purplish hairs; inner longer c. 3 mm long, purplish. Pollinia 5, yellow, oblong. Ovary oblong, 2-locular, free; style short, stigma dome shaped.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 920 m, 12.1104 °N, 75.3131 °E, JEJ 1496.

Distribution: Endemic to southern Western Ghats.

Habitat: Rock crevices in grasslands.

Notes: This species is rare and survives by its depressed spherical tubers. It is found in the grasslands. Wild fires and conversion of grasslands forming monoculture plantations and tourism are considered to be threats to this rare species.

Ceropegia hirsuta Wight & Arn. in Wight, Contrib. 30. 1834; Hook.f., Fl. Brit. India 4: 7. 1883; Gamble, Fl. Pres. Madras 562. 1922. *Ceropegia hirsuta* var. *stenophylla* Hook.f., Fl. Brit. India 4: 71. 1983; Gamble, Fl. Pres. Madras 859. 1923. Lectotype: R. Wight K000894263, INDIA.

Twiners; stem terete, purplish, hirsute; internodes 5–10 cm long. Leaves opposite; lamina ovate-lanceolate, 4–10 × 3–4.5 cm, apex acuminate, chartaceous; lateral veins 3–5 pairs; petiole 4–7 mm long, hirsute. Inflorescence axillary, few-flowered cymes. Flowers purplish, c. 2.8 cm long. Calyx tube short; lobes linear, 5–6 mm long, hispid. Corolla tube c. 2.2 cm long, base swollen, hispid within; lobes oblong, c. 6 mm long, acute, hispid inside; corona 2-seriate; outer corona c. 5 mm long; lobes triangular, bifid, densely hispid; inner corona linear, c. 2 mm long, bent, base hispid. Pollinaria 5, ellipsoid, yellow. Ovary oblong, carpels 2, free, hispid; style 2, c. 4 mm long, thick, stylar dome 5 sided, truncate.

Specimens examined: India, Kerala, Kannur District, Paithalmala, 450 m, 12.1128 °N, 75.3142 °E, JEJ 1499.

Distribution: Endemic to India; Vulnerable (V).

Habitat: Slopes in grasslands.

Notes: Even though restricted to India, this species has wide representation in peninsular India and Indo-gangetic plains. The species is well adapted to survive in drier habitats as well as along the high altitudes of the Western Ghats.

CONCLUSION

The present study documents six species of Ceropegia from Paithalmala in Kannur District of Kerala. Among these *C. gardneri* is a new report to Kerala as it is reported only from Karnataka so far from India. *C. fimbriifera* is very rare and there is no recent report for this species from Kerala and was mentioned only in the Flora of British India and Flora of the Presidency of Madras, which were published about a century ago. *C. decaisneana* Wight and *C. hirsuta* Wight & Arn. are endemic and vulnerable species.

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SHORT COMMUNICATION

First sighting record of a Ruddy Mongoose *Urva smithii* Gray, 1837 feeding on a pipistrelle bat in Nagarahole Tiger Reserve, India

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Abstract: Bats are predated regularly by mammals like cats, birds, and snakes. However, bats are rarely observed to be predated by mongooses. Herein we document and describe a Ruddy Mongoose opportunistically predating on a pipistrelle bat at its roosting site inside a tree crevice at Nagarahole Tiger Reserve, Karnataka in December 2022. Our observation may indicate that the Ruddy Mongoose *Urva smithii* could be an opportunistic but not a selective hunter of bats.

Keywords: Feeding behaviour, herpestid, meso-carnivore, predator, prey consumption, tropical moist deciduous forest.

Exploring the diets of predators is crucial to understanding their life-history strategies since the survival of a predator is dependent upon the quality and quantity of its diet (Miquelle et al. 1996). Foraging habits of mammals thus become an imperative criterion to explore any ecosystem and is a crucial theme in ecology and population biology research.

Mongooses are carnivorous mammals that play important roles in the ecology of a community by consuming a range of prey species including both invertebrates and vertebrates like amphibians, reptiles, birds, and mammals (Seaman & Randall 1962; Kamath & Seshadri 2019). Feldliamer et al. (1999) have documented mongooses feeding on vegetable matter in the form of tubers, fruits, and berries too.

Of the seven Indian mongoose species, belonging to the subfamily Herpestinae and family Herpestidae, Ruddy Mongoose *Urva smithii,* distributed in India and Sri Lanka. It is a forested species distinguished from the Indian Grey Mongoose by its tad larger size and jet black-tipped tail (Mudappa & Choudhury 2016). They are considered to be 'Least Concern' according to the IUCN Red List category and have been documented in forested areas of Nepal (Subba et al. 2014) in recent years. To the best of our knowledge, information on Ruddy Mongoose's feeding behaviour is almost nil or scanty. We herein for the first time report these mongooses feeding on bats at the Nagarahole Tiger Reserve (Rajiv

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Image 1. Ruddy Mongoose *Urva smithii* feeding on a pipistrelle bat in Nagarahole Tiger Reserve, Karnataka, India, 25 December 2022.

Gandhi National Park).

Methods

We exhaustively searched all relevant information on the predation of bats by mongooses employing Google Scholar and Science Direct search engines. Predation was defined as the consumption of one organism (the prey) by another organism (the predator), in which the prey is alive when the predator first attacks it (Begon et al. 2005). Thus, we used only records that gave us details on capture and subsequent prey consumption. We did not account for studies where the prey was not successfully caught or when caught it was not consumed by the predator. The study followed the search process criteria of PRISMA 2020 updated guideline (Page et al. 2021). Geographical coordinates and elevation of the location were recorded using a Garmin etrex10 global positioning system (GPS) handheld unit.

Nagarahole Tiger Reserve is a part of Nilgiri Biosphere Reserve receiving about 1,000 –1,540 mm annual rainfall with temperatures ranging 12–32 ^{0}C and elevation ranging 687–960 m with a total geographical area of the reserve is 843.96 km^2 located in the Kodagu and Mysore districts of Karnataka, India (Rashmitha et al. 2024). This protected area supports tropical moist deciduous forests (Habib et al. 2020).

The event

A Ruddy Mongoose was photographed by the first author at Sunkadakatte, Nagarahole Tiger Reserve (11.582 N, 76.127 E) on 25 December 2022 between 1200 and 1300 h at an elevation of 746 m. A solitary male Ruddy Mongoose ~30 m away from the first author was seen climbing an eight-foot dead *Terminalia anogeissiana* (locally known as 'Dindiga Mara') tree and inserted its pointed snout and one-fourth of its frontal body into tree hole to catch the pipistrelle individual. The bat species assessment was based on two factors, viz., size proportional to the mouth of the mongoose and the pelage colour of the body. The mongoose after catching the pipistrelle came out and foraged the individual for about 10 minutes (Image 1). Once consumed, the agile mongoose speedily climbed down the tree and vanished into a grassy bush nearby. An attempt to find and identify remains of prey species around the tree went in vain 15 minutes after the mongoose disappeared from the predation spot.

There have been several anecdotal observations of Ruddy Mongoose individuals (at least two) around the aforementioned site. In fact, the first author has often sighted two Ruddy Mongoose individuals around the same habitat and one feeding on a Jungle Owlet *Glaucidium radiatum* (Image 2) a couple of months post this event. To the best of our knowledge, scientific documentation of Ruddy Mongoose feeding on bats is perhaps the first of its kind. Interestingly, Mallick et al. (2021) have reported Indian Grey Mongoose *Herpestes edwardsii*, attacking an Indian Flying Fox *Pteropus medius* colony and snatching away an individual from a colony in & around Ajodhya hill area of Purulia, West Bengal, India. In fact, pipistrelle bats are known to be predated by feral cats (Corbett et al. 2003), Black Rats (Pryde et al. 2005), Wolf Snake, Kestrels, Yellow Ants, and giant centipede (James 2005) but none by a mongoose so far. In conclusion, Ruddy Mongoose being strategic hunters could be consuming a variety of food items including bats in this vicinity which needs to be thoroughly investigated and documented. We herein strongly advocate an assessment of resource

Image 2. Ruddy Mongoose feeding on a Jungle Owlet in Nagarahole Tiger Reserve, Karnataka, India, 15 April 2023.

disposal and allocation and other similar environmental parameters for a superior comprehension of the habitats of this rarely documented forest meso-carnivore.

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Taxonomic significance of seeds and seedling morphology in the threatened Indian endemic palm genus *Bentinckia* (Arecaceae)

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Abstract: A comparative morphological study was carried out to evaluate the taxonomic significance of seed and seedling traits of *Bentinckia condapanna* and *B. nicobarica* (Arecaceae), the threatened endemic palm species. Both species are unique and have specific requirements for seedling recruitment. An effort was made to cultivate these species ex situ at the Botanical Survey of India's National Orchidarium and Experimental Garden (NOEG) in Yercaud, Tamil Nadu, and Dhanikhari Experimental Garden cum Arboretum (DEGCA), in Andaman & Nicobar Islands. The seeds and seedlings of the two species differ in the beak and ridges on the seed, endosperm colour and the shape of the eophyll.

Keywords: Disjunct distribution, fruit, hotspots, IUCN, Sahyadri, seed germination, taxonomic importance.

Bentinckia Berry ex Roxb. (Arecaceae) consists of two species, *B. condapanna* Berry ex Roxb. and *B. nicobarica* (Kurz) Becc., occurring in southern India and the Nicobar Islands. These tall palms are characterized by their stems ringed with conspicuous leaf scars, leaf sheath forming a distinct green cylindrical crown shaft, and inflorescence appearing from below the crown shaft. This genus is a prime example of disjunct distribution, with only two known species occupying different niches and ecosystems and separated by seawater. Both species were studied by the first author in their natural habitat, viz., *B. condapanna* at Chemunji hills in Agasthyamalai Biosphere Reserve, southern Western Ghats (Image 1A) and *B. nicobarica* at Trinket Island, Central Nicobar, Nicobar group of Islands (Image 1B).

Bentinckia condapanna trees are 6–12 m tall, with stems measuring 15–20 cm in diameter. The leaves are 1–1.5 m long, arching to spreading, becoming pendulous, forming a conspicuous crown shaft. The inflorescence is borne below the leaves, completely covered with two bracts, flowering branches pale red, male flowers scarlet, female flowers lilac (Image 1C). The fruits are globose to ovoid, deep scarlet red. The seeds are conspicuously grooved adaxially and laterally (Renuka & Sreekumar 2012; Sarkar 2012). The flowering is from April to June, and the fruiting period is June to September. This species is a narrow endemic and restricted in the tail end of southern Western Ghats, in Agasthyamalai Hills, Palni Hills, at around 760–1,830 m elevation (Sarkar 2012). This palm occupies the second-highest elevation niche among all palms in India (Kulkarni & Mulani 2004). It has

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been assigned with the IUCN Red List status 'Vulnerable' (Johnson 1998a). *B. condapanna* prefers and colonizes steep rocky slopes fully exposed to sunlight in the tropical wet evergreen forests of the Western Ghats. Major threats, such as habitat destruction by the gradual encroachment of *Ochlandra* reed brakes and vagrancy of dry months (Sarkar 2012), felling for terminal tender shoots by humans and elephants, and clearing forest areas for tea plantations, are the main reasons for its restricted distribution (Kulkarni & Mulani 2004). The other factors threatening the populations include the following: the inflorescences are harvested and used in religious ceremonies; the terminal buds and juvenile leaves are eaten by Kani tribes (Sarkar 2012); the fruits used for the treatment of asthma; the fruits are eaten by the Lion-tailed Macaques and elephants (Quattrocchi 2017), frugivorous birds such as Malabar Grey Hornbill, White-cheeked Barbet, Malabar Barbet, and Grey-fronted Green Pigeon, and mammals such as bats and Bonnet Macaques were observed feeding on the fruits of this palm (Murukesh & Ashokan 2018); and the shoot apices are relished by elephants (Kulkarni & Mulani 2004). Natural seed germination and survival percentage is about 10–20% (Gangaprasad & Matthew 2017), and it has been observed that this palm does not thrive well outside its natural habitat (Renuka et al. 1996). A need for ex situ conservation and the promotion of its cultivation as an ornamental has previously been suggested (Kulkarni & Mulani 2004; Sarkar 2012).

Bentinckia nicobarica trees are much taller, growing up to 20 m, and their stems are significantly thicker, reaching up to 40 cm in diameter. The leaves are ascending or arching, about 2.5 m long, with a crown shaft of about 1 m long. The inflorescences are borne from below the leaves, and the flowering branches are greenish-yellow to ivory (Image 1D). The fruits are subglobose to ellipsoid and deep brown. The seeds are not as conspicuously grooved as in *B. condapanna* (Renuka & Sreekumar 2012). This species is endemic and restricted to Andaman & Nicobar Islands at 10–150 m altitude. It has been assessed as 'Endangered' under the IUCN Red List Criteria & Category (Johnson 1998b). The grasslands of the Nancowry Islands are its natural habitat, and they are found growing abundantly in the tropical evergreen forest patches along the fringes of savannah-like grass-heath. The main threats for this species are habitat alteration, including wildfire and illegal felling. This species is sensitive to insulating shade, and altering the shaded, humid habitats could lead to its extinction. The local inhabitants widely use this palm to construct huts and fences (Sreekumar & Coomar 1999). It is a fast-growing tree in cultivation and sets fruits in abundance, but the fresh seeds take 55–60 days to germinate, and their natural germination under the mother tree is rare (Basu 1984). Similarly, the natural regeneration of *B. condapanna* seeds under the mother tree has been reported to be low (Renuka et al. 1996). Due to its habitat specificity and several other threats faced by its populations, immediate conservation measures are required for *B. nicobarica* (Sreekumar & Coomar 1999).

Rationale and Methods

Since almost all palms are propagated by seeds, the subject of germination is pivotal, and the present study attempts a survey of germination and seedlings in the genus *Bentinckia* in India and the possibility of their taxonomic significance. In general, there are three types of germination in palms: adjacent ligular, remote ligular, and remote tubular (Henderson 2006). In *B. condapanna*, the type of germination is unknown. In the previous experiments, the seeds either did not germinate or the germination percentage was low. Moreover, the seedlings of *B. condapanna,* a high-altitude plant, do not establish well in low altitudes (Renuka et al. 1996). Basu (1984) noted that *B. nicobarica* is cross-pollinated and fruit setting is abundant; the first sheath of the seedling is achlorophyllous, the second sheath is tubular and truncate at the rim, and the third sheath is slightly greenish and obliquely truncate; the eophyll is bifid, each lobe ca 20 × 5 cm, acuminate and toothed. The morphological characterization of seeds and seedling germination was attempted to find characters of taxonomic relevance.

Fruits of *B. condapanna* were collected from plants growing in the National Orchidarium and Experimental Garden (NOEG), Botanical Survey of India (BSI), Yercaud, Tamil Nadu and those of *B. nicobarica* from the plants growing in the BSI, Andaman Nicobar Regional Centre, Port Blair. The freshly fallen fruits were used to study the morphological characteristics of fruits and seeds. After the study, the seeds were cleaned by removing the fleshy fibrous pericarp and washed in running tap water in the laboratory. The seeds were germinated using sand and soil mix (2:1) as germination medium. Seedlings of both species were studied at different stages of development. The quantitative and qualitative morphological features of the collected and germinated seeds were studied by direct observation using a hand lens. Measurements were taken using graph papers and scale. Images were processed in Adobe Photoshop.

Image 1. A & C—*Bentinckia condapanna* | B & D—*B. nicobarica* | A & B—habit | C & D—inflorescence, crown shaft. © M.Y. Kamble

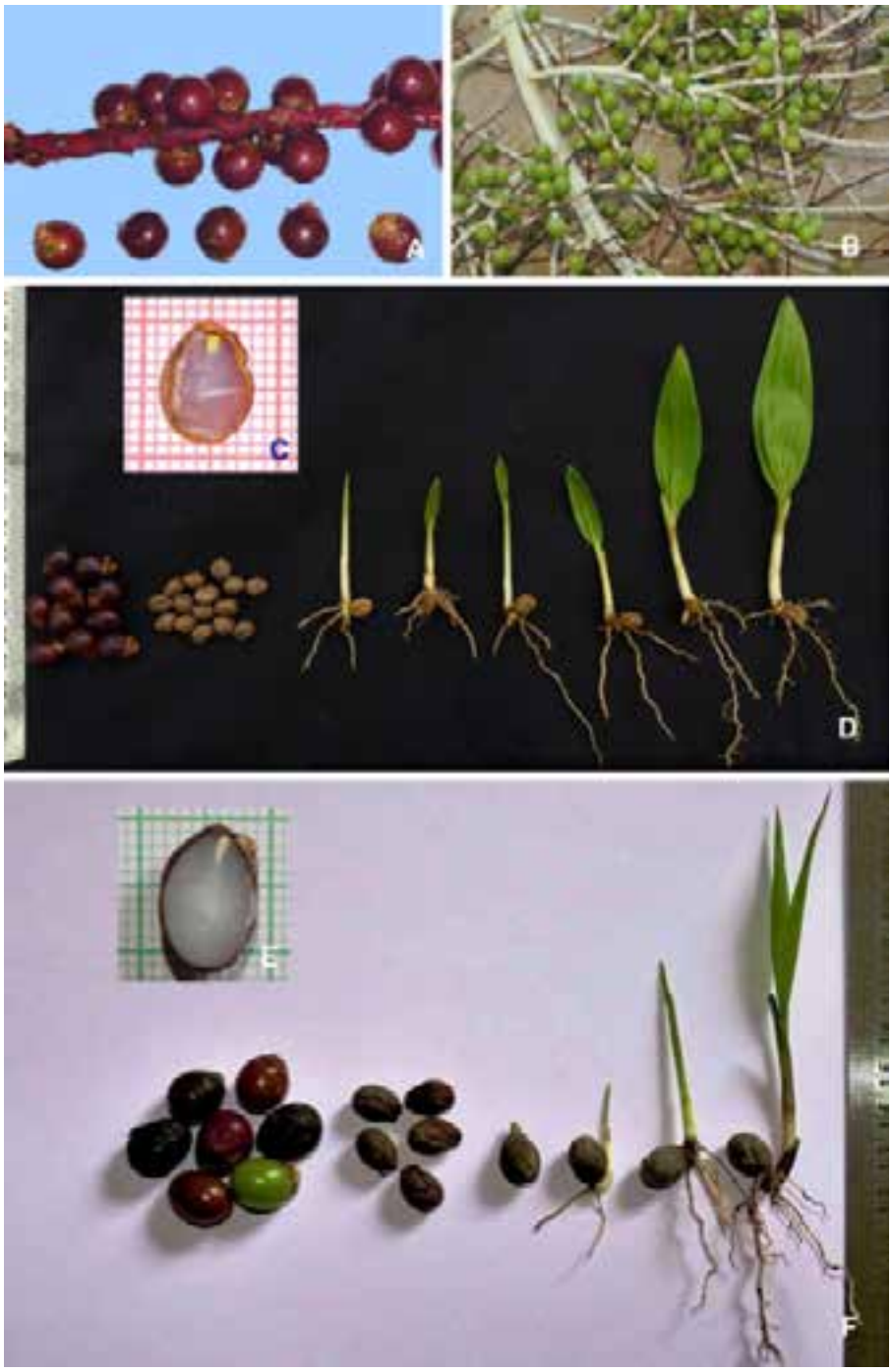

Image 2. C & D—*Bentinckia condapanna* | B,E & F—*B. nicobarica* | A&B—young fruits | C & E—V.S. of seeds showing embryo and endosperm | D & F—mature fruits, seeds & seedlings. © (A–D)—M.Y. Kamble, (E–F)—C.P. Vivek.

Results and Discussion

The genus *Bentinckia* is endemic to India and holds considerable taxonomical and phytogeographical importance. The genus is represented by only two species, and both are strict endemics to their respective habitats, viz., *B. condapanna* to the Western Ghats and *B. nicobarica* to the Andaman & Nicobar Islands. These two species are geographically disjunct, with a gap of more than 1,500 km between them. They also have different habitat specificities: *B. condapanna* prefers steep rocky cliffs at an altitude of above 700 m, while *B. nicobarica* prefers savannah-like grasslands at a maximum altitude of 150 m. There are remarkable differences in their growth patterns in natural habitats

Table 1. Common traits in fruits, seeds, and seedlings of both species of *Bentinckia*.

Character	*B. condapanna*	*B. nicobarica*
Crown shaft	Cinereous tinged with light maroon	Pale green
Inflorescence colour	Maroon	Ivory
Fruit colour when young	Maroon	Green
Fruit colour at maturity	Dark maroon	Maroon or greenish-brown to dark brown
Shape of mature fruit	Globose	Ovoid
Seed colour	Pale brown	Dark brown
Ridges on the seed surface	Distinct	Not prominent
Fruit Length	1.2–1.6 cm	1.4–1.6 cm
Fruit Breadth	1.1–1.4 cm	1.1–1.3 cm
Seed length	7–9 mm	7–12 mm
Seed breadth	6–7 mm	5–7 mm
Seed germination type	Adjacent ligular	Adjacent ligular
Seed beak	Away from embryo	Near embryo
Endosperm	Purplish-white	Greyish-white
Embryo	1–1.2 mm, dark yellow	About 2 mm, ivory
Eophyll (first leaf)	Simple	Bifid

as well as ex situ conservation. According to the IUCN Red List Category and Criteria, both species are assessed as 'Threatened.' The decline in their natural populations can be attributed to both human-imposed as well as natural factors. Thus, the present paper recommends in-situ conservation of their natural populations. The propagation of both species occurs through seeds, highlighting the importance of seed germination and seedling survival in conservation efforts.

The present study observed the differences between *B. condapanna* and *B. nicobarica,* which share similar vegetative characteristics. Both species are distinguished by their reproductive characteristics (Table 1). The distinguishing features include the fruit colour, which is maroon vs. green when young (Image 2A,B) and dark maroon to scarlet red vs. greenish-brown or dark brown to maroon when ripe (Image 2D,F), the shape of the fruit (globose vs. ovoid), seed colour (pale brown vs. dark brown), and ridges on seed surface (well developed vs. indistinct). The fruit and seed sizes between the two species are quite similar. Also, both species exhibit 'adjacent ligular' type germination. This is the first report for *B. condapanna.* The notable difference was observed in the position of the seed beak (Image 2C,E), which was away from the embryo in *B. condapanna* and nearer to the embryo in *B. nicobarica.* The endosperm is purplish-white in *B. condapanna* and greyish-white in *B. nicobarica* (Image 2C,E). In this study, the eophylls (Image 2D,F) were observed to be simple in *B. condapanna,* whereas they are bifid in *B. nicobarica* (Basu 1984). Therefore, apart from the fruit colour, seed ridges and endosperm colour, the eophyll shape in seedlings can also be used to differentiate the two species. Ex-situ conservation of both species has been effectively carried out in the National Orchidarium and Experimental Garden (NOEG), Botanical Survey of India (BSI), Yercaud, Tamil Nadu and in the Experimental Garden cum Arboretum of BSI, Andaman Nicobar Regional Centre, Port Blair.

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SHORT COMMUNICATION

Impatiens devendrae Pusalkar (Balsaminaceae): an addition to the flora of Jammu & Kashmir, India

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Abstract: *Impatiens devendrae* Pusalkar is reported here as a new distribution record for the flora of Jammu & Kashmir from the Nathatop area in the forest range Batote of Ramban District. The identifying characteristics of the species include the presence of yellow streaks on the triangular lateral united petals, pinkish-white flowers, oblong-bucciniform lower sepals, abruptly constricted into hooked spurs. Previously, the species was reported from Uttarakhand.

Keywords: Balsams, Batote Forest Range, flora, new record, Nathatop, Ramban District.

Impatiens L. is the largest genus of the family Balsaminaceae and comprises 1,120 species in the world (POWO 2024). The genus *Impatiens* is mainly distributed to five distinct areas of the world: the eastern Himalaya, southern India, Sri Lanka, southeastern Asia, tropical Africa, and Madagascar (Grey-Wilson 1980). The Himalaya and Western Ghats are the major centres of *Impatiens* diversity in India (Vivekananthan et al. 1997; Viswanathan & Manikandan 2003). In India, the genus consists of 340 taxa (314 species and 26 varieties/subspecies) mainly distributed in the eastern Himalaya, the neighbouring northeastern states, and the Western Ghats (Prabhukumar et al. 2022; Richard & Ravichandran 2023). In recent years, a few studies have been done in the western Himalaya (Pusalkar & Singh 2010; Akhter 2018; Sharma et al. 2019; Singh et al. 2022; Thakur et al. 2023; Singh & Kumar 2024). The members of the genus *Impatiens* commonly called 'Balsams' are beautiful plants bearing curious and variously colored flowers with peculiar floral structures and are responsible for their great horticultural potential (Akhter et al. 2018).

Methods

Study area: The field exploration was carried out during 2019–2023 in the Ramban District of Jammu & Kashmir, for the assessment and documentation of floristic diversity. While exploring the floristic diversity, the first author found an interesting population of *Impatiens* in the Nathatop area (Figure 1) of the Batote Forest Range in the Ramban District, growing in moist, humid places, near the passage of water, along the roadside at an elevation ranging 1,800–2,290 m. The live sample specimens were collected,

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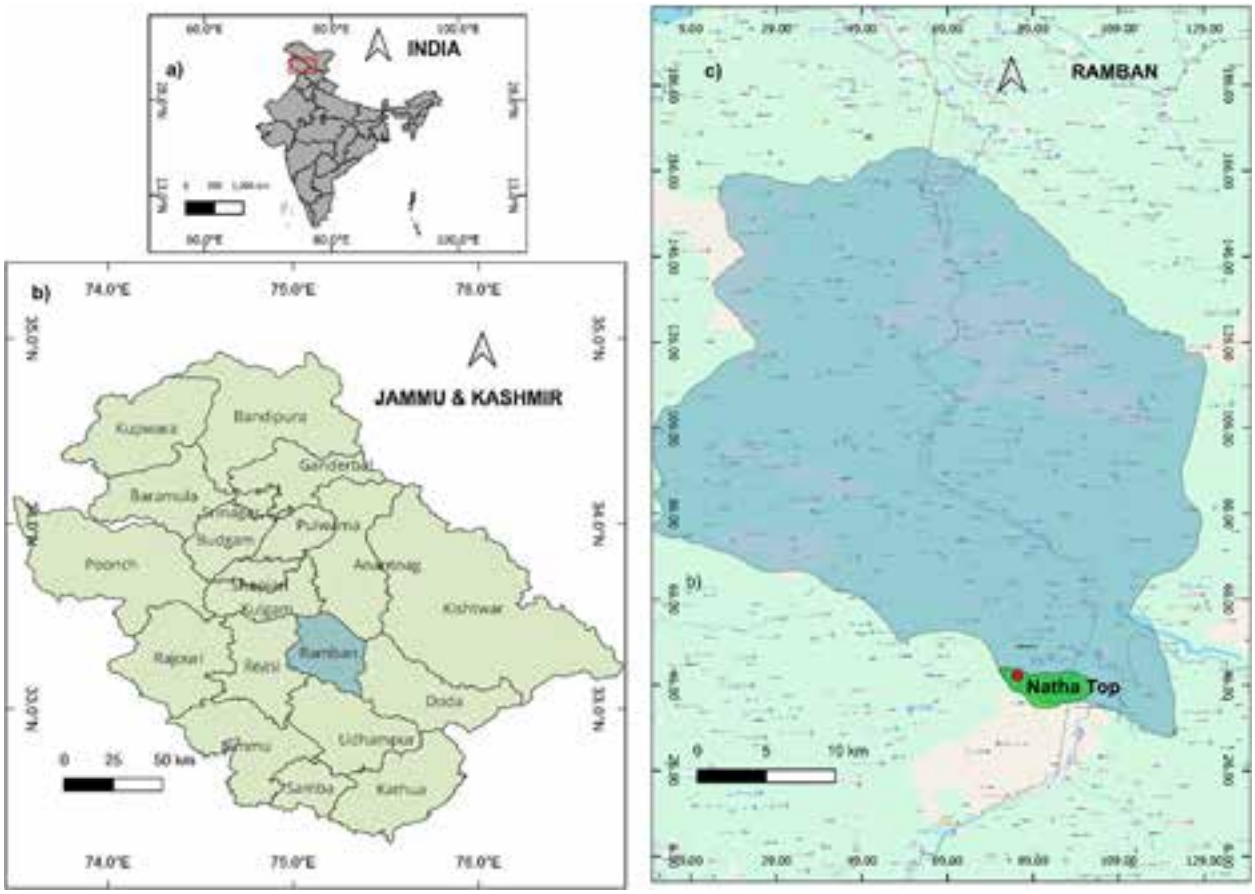

Figure 1. Distribution record of *Trillium govanianum* in Arunachal Pradesh, India.

and photographed. The specimen was examined for detailed micromorphological characters using a Leica stereo microscope (S8 APO). The scrutiny of protologue (Pusalkar & Singh 2010) and available relevant literature Polunin & Stainton (1984), Naithani (1984), Pusalkar & Singh (2012), Rana et al. (2003), Singh & Kachroo (1987), Sharma & Kachroo (1981), Swami & Gupta (1998), Kapur & Sarin (1990), Ishwari et al. (2017), Naithani (2019), Collett & Botting (1921), Singh & Prakash (2002), Sharma & Jamwal (1988), and Roxburgh (1875) has confirmed the identity of the specimen as *Impatiens devendrae* Pusalkar. The species was first collected from Nathatop on the way to Sanasar, in the Bataote forest range of Ramban district. Earlier, this species was reported from the state of Uttarakhand, India (Pusalkar & Singh 2010); it has not yet been reported from the Jammu & Kashmir Union Territory. The present study therefore revealed that the species would be an addition to the flora of Jammu & Kashmir, India. The collected plant herbarium specimen was prepared following the standard methods of De Vogel (1987) and Bridson & Forman (1998), and deposited in the LWG herbarium of CSIR-National Botanical Research Institute, Lucknow for future reference (Image 2). The habit, habitat, and flower close-up photographs are provided for easy identification (Image 1).

Taxonomic treatment

Impatiens devendrae Pusalkar.

Type: India, western Himalaya, Uttarakhand, Chamoli District, Nanda Devi Biosphere Reserve, Alkananda Valley, on way to Ghangria, 1 km behind Ghangaria towards Govindghat, 2,900–3,100 m, 06 August 2008, Pusalkar 111017 (holotype et isotype: BSD).

Terrestrial, erect annual herb, 30–80 cm in height. Stem branched sparsely, erect, cylindrical, green, glabrous; sessile glands rounded. Leaves simple, alternate below, aggregated at the top of the stem, 5–20 × 2.5–10 cm, elliptic-lanceolate, base cuneate, apex acuminate, margin crenate with basal teeth or bristle, glabrous abaxially and adaxially, petiolated 1–4 cm long. Inflorescence both axillary and terminal, interrupted racemes, 5–15 flowered. Bract at base of pedicel, ovate, 2.5–5 × 1.5–2 mm, apex acuminate, glabrous. Flowers

2.5–3.0 cm long, pink, pedicellate; pedicel 1.8–2 cm long, glabrous. Lateral sepals 2, broadly ovate, 3.5 × 2.5 mm, green with pinkish tinge, apex acuminate, gland-tipped, glabrous. Lower sepal bacciform, 2.2 × 1.5 mm pink, abruptly constricted into spur, apex beaked, glabrous; Spur hooked, curved downwards, ca. 7–10 mm long, yellow pinkish, tip unifid. Standard petal ellipsoid, cucullate, 13–15 × 23–26 mm, pinkish, dorsally keeled; keel beaked at its apex, glabrous. Lateral united petals bilobed, 19–22 mm long, pink flushed with white and red or brown streaks on the lower portion of basal lobe; basal lobe broadly triangular 9 × 12 mm, distal lobe, 12 × 8 mm, orbicular; dorsal auricle 2 mm, rounded. Stamens 5, filaments 6.0–7.1 mm long, pinkish. Ovary ca. 6 mm long, linear, apex acuminate, green, glabrous. Capsule 18–25 mm long, linear or cylindrical, green; fruiting pedicel 22 mm long. Seeds 5–9 per capsule, 3 × 2 mm, brown, rough surface.

Specimens examined: India. Jammu & Kashmir, Ramban District, Nathatop, on the way to Sanasar, 33.115^{0}N, 75.247^{0}E, 2,290m, 7 June 2019, Naresh Kumar 119393 (LWG); Uttarakhand, Chamoli District, Nanda Devi Biosphere Reserve, Alkananda Valley, on way to Ghangria, 1 km behind Ghangaria towards Govindghat, 2,900–3,100 m, 6 August 2008, Pusalkar 111017 (BSD).

Phenology: June–September

Habitats: Common in moist humid places, near the passage of water, along the roadside at an elevation range of 1,800–2,290 m.

Distribution: India (Uttarakhand and Jammu & Kashmir).

Discussion

Impatiens devendrae Pusalkar was previously reported from the Uttarakhand District of Chamoli, the Nanda Devi Biosphere Reserve, the Alkananda Valley, on the way to Ghangria, behind Ghangaria towards Govindghat in Uttarakhand (Pusalkar & Singh 2010). The species is distinguished from all the allied species by its pinkish-white flowers; oblong-bucciniform lower sepal;

Image 1. *Impatiens devendrae* Pusalkar: A—Habit | B—Plant with flower & fruits | C—Close up of the flower | D—Habitat of the species. © Naresh Kumar.

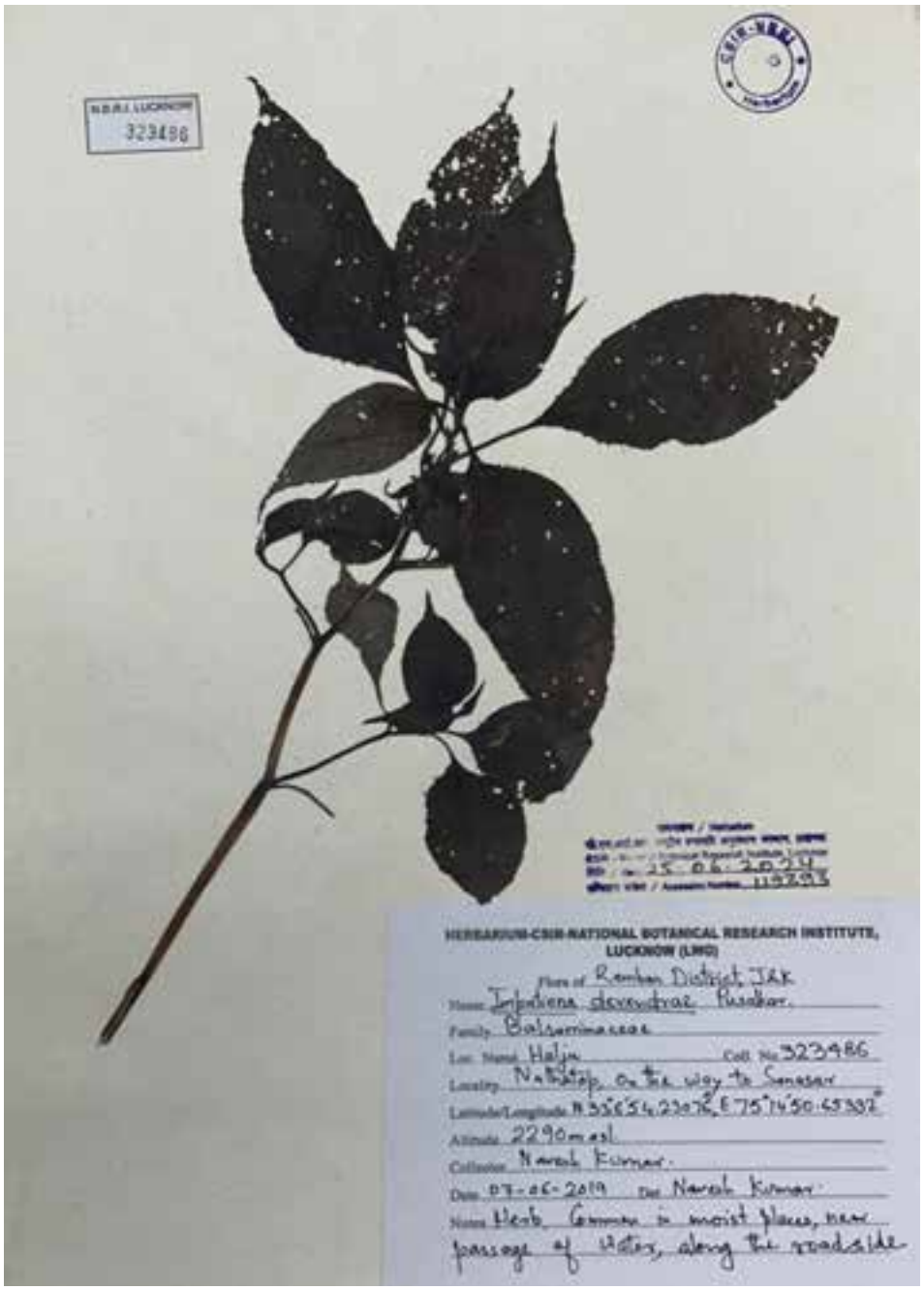

Image 2. *Impatiens devendrae* herbarium specimen [119393 (LWG)].

abruptly constricted into the hooked spur, lip white with yellowish-orange and purple spots or purple streaks within, appears pale from the outside, upper petal keeled with keel purplish-maroon on back, upper lateral petals, somewhat triangular in outline with orange, purple-colored and lower lateral petals lobed with oblong or oblong-triangular lobes, lateral lobes of lower petals are not auricle-like, usually as long as or larger than lower lobes and lower lobes of lower wings. The species was first collected from Nathatop on the way to Sanasar, in the Bataote Forest Range of Ramban District, it has not yet been reported from Jammu & Kashmir Union Territory. The present study therefore revealed that the species would be an addition to the flora of Jammu & Kashmir, India. The species is used as a fodder plant for domesticated animals and as an ornamental plant by the local inhabitants.

IUCN Status: Not assessed.

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New photographic and distribution records of the Beautiful Nuthatch *Sitta formosa* (Blyth, 1843) and Lesser Adjutant *Leptoptilos javanicus* (Horsfield, 1821) from the Tsirang District landscape in Bhutan

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The Beautiful Nuthatch *Sitta Formosa*—was first described by Edward Blyth from a specimen collected in Darjeeling (Blyth, 1843). Globally, *S. formosa* occurs in the eastern Himalaya, in the hills of northeastern India, Bhutan, extending through the highlands of Myanmar into Laos & Vietnam, also in southern China and northern Thailand (BirdLife International 2001, 2020; Grimmett et al. 2019). In Bhutan the species has been recorded from Samdrup Jongkhar, Thimphu, Mongar, Zhemgang, Lhuentse, Samtse, Chukha, Dagana, Sarpang, Wangduephodrang, Trashigang, Pemagatshel, and Trongsa (Bishop 1999; Spierenburg 2005; Tobgay 2018; eBird 2024). Although the species is widely distributed in the mainland of Southeast Asia, it appears to be rare and highly localized throughout its range, making population estimation difficult. Furthermore, deforestation resulting from expanding development activities has led to the classification of its IUCN Red List status as 'Vulnerable' in recent years (BirdLife International 2020).

Lesser Adjutant *Leptoptilos javanicus* has a global population estimated to be between 5,000–15,000 individuals across its range (Birdlife International 2023), including India, Nepal, Sri Lanka, Bangladesh, Myanmar, Thailand, Vietnam, Malaysia, Laos, Singapore, Indonesia, and Cambodia. In Bhutan, the presence of *L. javanicus* was confirmed at the border of Royal Manas National Park in Zhemgang and Daifam (Samdrup Jongkhar) in 2004 (Choudhury 2005). It has subsequently been recorded from Gelephu (Sarpang District) (Tobgay 2018; Wangdi 2018), and in Bashaling & Langthel (Trongsa District) (Rinchen 2020). Birdlife International (2023)

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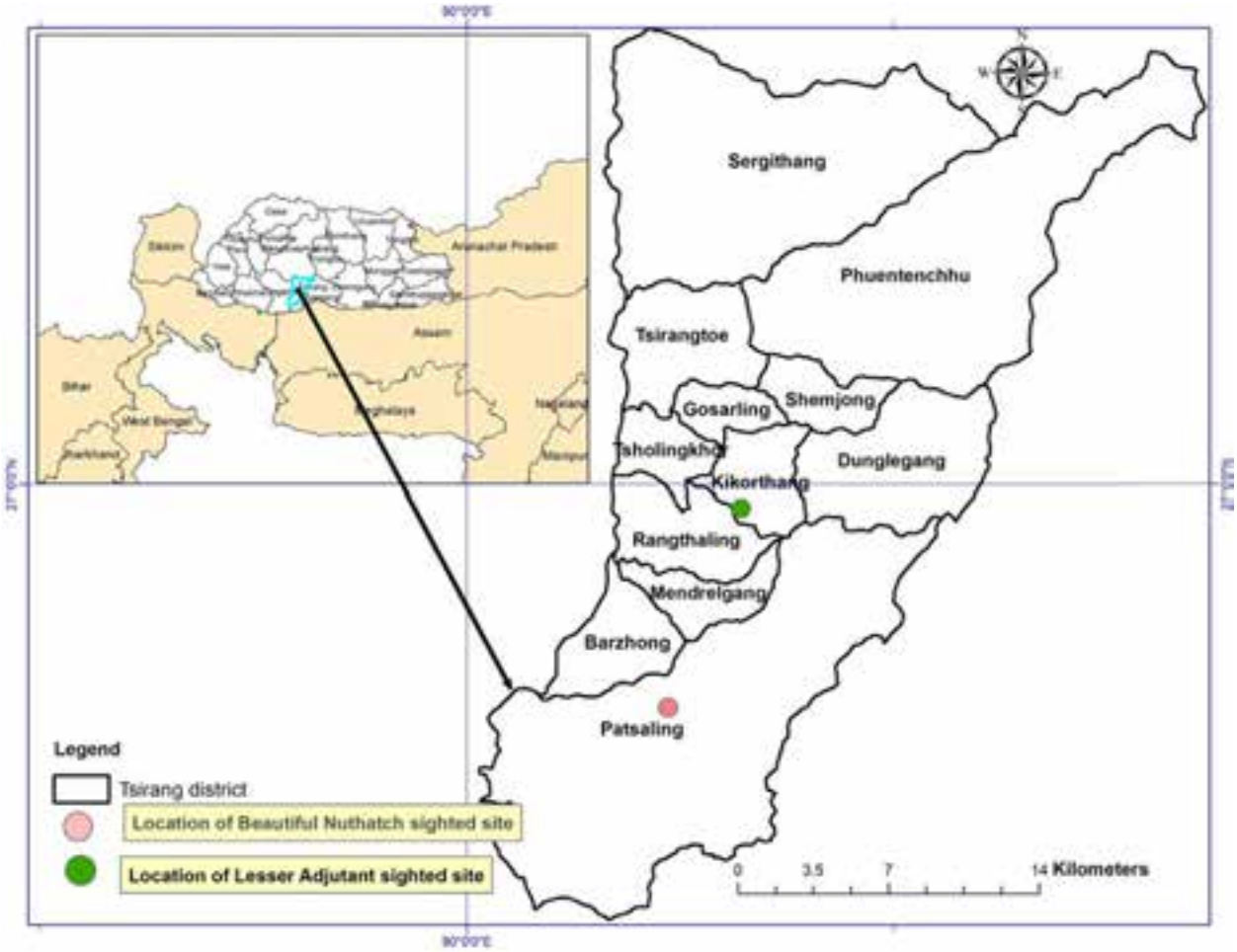

Figure 1. Sighting location of Beautiful Nuthatch (Red icon) and Lesser Adjutant (Green icon) inside the Tsirang District, Bhutan.

have suggested that the species appears in Bhutan as a vagrant, especially during the summer season.

The Tsirang District encompasses a total geographical area of 639 km² located in the south- central part of Bhutan, within altitude ranges of 160–4,144 m (Figure 1). Within this area, 15.52% (6329 ha) is covered by Biological Corridor No. 03, which connects with ecologically diverse protected areas such as Jigme Singye Wangchuck National Park (JSWNP) to the north, Royal Manas National Park (RMNP) to the east, and Phibsoo Wildlife Sanctuary (PWS) to the south. Additionally, the Punatsangchhu basin, one of Bhutan's major rivers, flows from north to south, providing primary habitat for the 'Critically Endangered' White-bellied Heron *Ardea insignis* as well as other globally threatened water bird species within the riverine landscape. The landscape is predominantly composed of warm broadleaved forest (47%), followed by sub-tropical forest (17.2%), cool broadleaved forest (17%), with scattered patches of evergreen oak and Chirpine forest (DoFPS 2022).

S. formosa was sighted by the first author in the vicinity of Pangthang village (26.940°N, 90.116°E) in the Patshaling Gewog on 5 April 2023, during a field trip (Image 1a,b). The photograph was uploaded to the online Bhutan Biodiversity Portal in 2023. The author observed it foraging on the trunk of an oak tree (*Quercus indica*) along with a flock of other sympatric species, including the Himalayan Shrike-babbler *Pteruthius aeralatus*, Lesser Racket-tailed Drongo *Dicrurus remifer*, Sultan Tit *Melanochlora sultanea*, Scarlet Minivet *Pericrocotus speciosus*, Red-tailed Minla *Minla ignotincta*, Blue-winged Minla *Actinodura cyanouroptera*, Maroon Oriole *Oriolus traillii,* and Ashy Drongo *Dicrurus leucophaeus*. Similarly, Bishop (1999) and Tobgay (2018) also reported sightings of Beautiful Nuthatch in flocks with other species from lower elevations in the Dewathang area of Samdrup Jongkhar District. In terms of elevation and forest types, in Tsirang the species was recorded at 1,400 m in warm broadleaved forests dominated by *Quercus* spp., *Macaranga* spp., *Alnus nepalensis*, and *Rhus* spp.,

Image 1. Dorsal and ventral part of the Beautiful Nuthatch *Sitta formosa* captured from Pangthang Village under Mendrelgang Range Office, Tsirang District. © Birkha B. Mongar.

Image 2. Ventral view of *Leptoptilos javanicus* captured from the Nyizergang Village under Tsirang District. © Birkha B. Mongar.

which is consistent with the findings of Bishop (1999) and Tobgay (2018).

L. javanicus was opportunistically recorded from Nyizergang (27.004°N, 90.131°E) in the Tsirang District on 13 March 2024. The bird was chased by feral dogs but was later rescued with minor injuries by a team of foresters from the Forest Range Office, Tsirang. Due to damage to its left eye and body weakness, it might have missed the regular migratory routes resulting in its landing at central Tsirang District. Currently, this

individual is being cared for and treated at the White-bellied Heron Conservation Center established by the Royal Society for the Protection of Nature (RSPN), based in Changchey. The species has previously been reported up to 500 m (BirdLife International 2023) but this record at 1,469 m, has established a new distribution record for Bhutan and other range countries as well.

Owing to its rarity and the disturbances stemming from ongoing agricultural expansion, the species was recently reclassified from 'Least Concern' to 'Near Threatened' in 2023 (Birdlife International 2023). Separate studies are needed to ensure the long-term conservation of Beautiful Nuthatch, and to confirm whether Lesser Adjutant is a regular visitor in Tsirang.

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First photographic record of Brown Bullfinch *Pyrrhula nipalensis* (Aves: Passeriformes: Fringillidae) from Jammu & Kashmir, India

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Brown Bullfinch *Pyrrhula nipalensis* is a passerine bird in the family Fringillidae, class Aves, and order Passeriformes. The species has a mainly brown plumage; males tend to exhibit a slightly richer brown hue compared to the more subdued tones of females. This species is characterized by its stout, finch-like bill, which is well-suited for a diet primarily consisting of seeds (Grimmett et al. 2011).

A flock of five individuals was sighted through a camera trap installed in Butamali Tullail, a famous meadow for herders at an altitude of 3,400 m, 34.546388˚N, 75.019806˚E, on a northeastern aspect in a Betula forest. The flock was observed feeding on fallen Betula seeds on snow in October 2023. The species is known for its elusive and shy behaviour, often remaining hidden within dense foliage. It is typically observed foraging in pairs or small flocks, rarely straying far from cover. Brown Bullfinch primarily feeds on seeds, but its diet also includes berries and buds, which it forages from trees and shrubs. The birds were observed in 30 camera trap photographs and almost all the photographs were of foraging below the Betula trees. They used the Betula stump as a perch and were feeding on fallen seeds on ground. The trap was installed on a Betula tree.

The species has already been documented from Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Manipur, Nagaland but has not previously been recorded from Jammu & Kashmir (Oommen et al. 2005; Praveen 2016; Sharma 2020). This study documents the first photographic evidence of the species from Jammu & Kashmir.

Brown Bullfinch thrives in dense, temperate forests, favouring mixed woodlands, and coniferous forests. Rhododendron thickets are particularly favoured, providing ample cover and abundant food resources (Ali & Ripley 1983; Rasmussen & Anderton 2005). These habitats offer a variety of seeds, berries, and buds—the primary components of the Brown Bullfinch's diet. The dense foliage also provides excellent nesting sites and protection from predators.

Brown Bullfinch is currently classified as 'Least Concern' by the IUCN Red List, indicating that it is not at immediate risk of significant population decline. In Gurez, people are more dependent on forests than in other parts of Jammu & Kashmir. The houses are primarily made of wood to provide better insulation during winter, when temperatures drop to around minus 10^0C. Additionally, they rely on wood-based cooking

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Image 1. Brown Bullfinch *Pyrrhula nipalensis* photographed in Betula Forest, Butamali Gurez, Jammu & Kashmir.

and heating appliances during the colder months. Deforestation for urban development of tourist spots and logging for house construction are primary concerns that could impact the availability of suitable habitats for this species. However, ongoing habitat destruction and fragmentation due to the newly road construction in border area of valley also pose potential threats to the species. Conservation efforts should focus on protecting and preserving the temperate forests of the Himalayan region to ensure the long-term survival of the Brown Bullfinch. Betula serves as a crucial food source for the species during winter as recorded from camera trap photographs. Therefore, any climate impacts on Betula may also significantly affect the bullfinch's habitat.

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New record of the antlion *Palpares contrarius* Walker, 1853 (Insecta: Neuroptera: Myrmeleontidae) in Tamil Nadu, India

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Madras Christian College (MCC) is a 320 acre scrub jungle with a plethora of flora and fauna peculiar to the urban landscape. The campus is home to many insects like the butterflies and moths, dragonflies and damselflies, beetles and weevils, and many more groups of insects. A few insects are rarely seen because of their cryptic lifestyle where their existence is rarely seen in the open or they spend less time conspicuous to human identification. One such group is the order Neuroptera, which includes the lacewings, mantidflies, and antlions. The antlion under the family Myrmeleontidae, with its slender body, is often mistaken for damselfly except for its curved or clubbed antenna (Mares 1999) and its distinct fluttering flight (poor fliers).

Neuroptera consists of over 5,939 species in 15 families world over (Figure 1) (Pandher 2024) and about 337 species under 120 genera in India (Figure 2) belonging to 11 families (Oswald 2023) in India (Figure 1) of which 128 species from 69 genera and 11 families are reported from northeastern India (Gosh 2000). The family Myrmeleontidae is the largest group in Neuroptera and is popularly called the antlions, consisting of over 2,000 species the world over (Engel et al. 2018). Among the many groups of family Myrmeleontidae, genus *Palpares* are large-sized antlions with magnificently speckled wings with dark spots and patterns. The lifecycle of the species of Myrmeleontidae is complicated as most of their life is spent as a larva inside the soil and debris and the adult stage is relatively for a short period with an average lifespan ranging from 20 to 25 days (Yasseri & Parzefall 1996).

The insect is cylindrical and long with a small head, short thorax with subequal wings, and a relatively long 10-segmented abdomen. The head is small, hypognathous with lateral eyes and a pair of segmented antennae longer than the head. Legs are slender or stout based on species.

Insect collection details

Collector's name: Dr. Anita Pearline Esther

Collection date and time: 12 June 2023 & 2015 h.

Collection locality: An illuminated house located near scrub vegetation in the Madras Christian College Campus, Tambaram, Chennai, Tamil Nadu 600059, India (12.9181^{0}N & 80.1242^{0}E).

Source for identification: S.K. Ghosh 2000. Neuroptera fauna of northeastern India and Chandra et al. 2011. Fauna of Madhya Pradesh (including Chhattisgarh).

Genus *Palpares* Rambur, 1842

The genus *Palpares* consists of the most distinguishable and attractive species of the antlions. The

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Figure 1. Distribution of *Palpares* sp. worldwide

Figure 2. Distribution of *Palpares* sp. in India ★; new record in Tamil Nadu ✦

species are differentiated on a relatively minor scale of differences in the marking on the forewings, hindwings, sinuation, and the length of the antenna.

***Palpares contrarius* (Walker, 1853)**

It is a large species found mostly in Africa, Myanmar, Thailand, and Sri Lanka and seen in isolated parts of India (Figure 2) like Odisha, Maharashtra, Karnataka, Mizoram, Uttarakhand, and Madhya Pradesh (Ghosh & Sen 1977; Ghosh 2000; Chandra & Sharma 2013; Giacomino & Abraham 2018). The insect is large with a wingspan of more than 110 mm in length (Image 1). The antenna is black; thorax with three dark stripes; forewings undulating in the borders, mostly pale in colour, median band crosses the wing, stigma spot projects towards the median, distinct with no spot at the fork of the cubitus in the hind wing but has dark bands or spots spread across the hind wing. The margin of the forewing is sinuate, tips of the hind wings do not falcate. Abdomen is darker towards the apex (Ghosh 2000; Chandra et al. 2011).

Entire insect: Large (Image 2).

Head: Small with antenna, prominent lateral eyes (Image 2b), antenna longer than the head, multisegmented, black, clubbed, and flattened at the tip.

Vertex: Has two black bands and a black spot behind the hind band (Image 2c).

Thorax: Pronotum has a median stripe and also a stripe on either side. The mesonotum and metanotum have three interrupted black stripes.

Wings: About 55 mm per wing (Image 2d), pterostigma inconspicuous, wings undulating along the hind border.

Forewing: A pale brown tint, especially at the tip, the forewing has four oblique dark brown bands on the disc

Image 1. *Palpares contrarius*. © Pranay Umesh.

(Image 2). The first band is broken at the center, with a spot between it and the base; the second band extends to the hind border; the third band is shorter; and the fourth band is interrupted at the middle.

Hindwing: Three dark brown bands: the apical band wider toward the hind border, the stigmal band extending to the hind border with a projection towards the tip of the median band, the median band reaching the fore-and hind border, and an oblique blackish streak

Image 2 . a—*Palpares contrarius* (habitus) | b—head & antenna | c—thorax | d—forewing | e—hindwing. © Pranay Umesh.

along the postcosta on the hind border (Image 2e).

The incidence of *Palpares contrarius* in Madras Christian College is a new record in Tamil Nadu. This was confirmed, and the specimen was deposited in the Zoological Survey of India, Chennai Station (Reg. No. I/NE-01 Dtd. 01.09.2023).

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Extended distribution of *Trillium govanianum* Wall. ex D.Don (Melanthiaceae), an endangered species from Arunachal Pradesh, India

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The Indian Himalayan region (IHR) is known for its rich biodiversity, where a large number of threatened plant species have been reported (Mehta et al. 2021). A large number of endemic species have been found to occur from the western to eastern Himalayan regions of India. Apart from its natural beauty and mountainous terrain, it is home to various rich cultural heritage with diverse ethnic groups and languages coexisting in the region. Moreover, the state of Arunachal Pradesh which falls under the eastern Himalaya region is considered a major hub of plant diversity (Choudhury et al. 2009). A large number of both endemic and medicinally important plant species have been recorded from Arunachal Pradesh, India (Paul et al. 2005; Sarma et al. 2023). Despite the rich biological diversity of the state, the biodiversity is yet to be explored and not properly documented.

The genus *Trillium* L. (Melanthiaceae) is represented by 38 species from North America and 11 species from Asia (POWO 2023) from which two species, viz., *Trillium govanianum* and *Trillium tschonoskii* are endemic to the Indian Himalayan region (Kubota et al. 2006; Chauhan et al. 2019, 2020). So far, the species has been recorded from other regions of Asia like Japan, which has recorded the highest number of species of this genus *Trillium* (11 species; Chauhan et al. 2019, 2020). Among the two species of *Trillium* in India, is *T. govanianum* Wall. ex D.Don is a long perennial herb with an underground medicinally important rhizome (Kubota et al. 2006). The species is commonly known as 'Nag Chhatri' in India, which is native to the Himalayan region, including India, Nepal, Bhutan, China (Tibet), and Pakistan (Fukuda

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Competing interests: The authors declare no competing interests.

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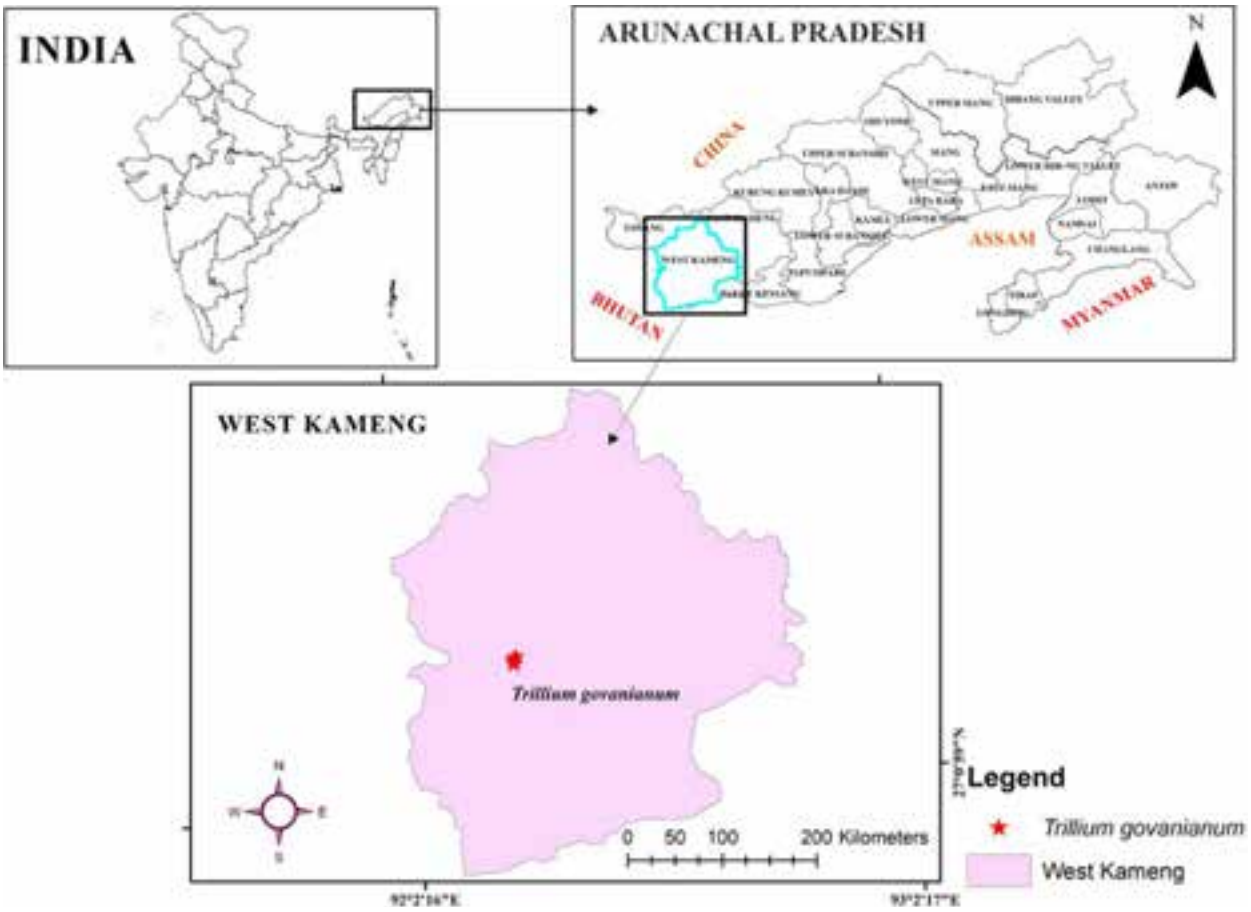

Figure 1. Distribution record of *Trillium govanianum* in Arunachal Pradesh, India.

2001; Roskov et al. 2018). The species mostly grow in the temperate and sub-alpine regions at an altitude of 2,400–3,500 m (Uniyal & Datta 2012; Sharma et al. 2018). The species distribution is restricted to distinct pockets in the Himalaya due to specialised ecological needs (Chauhan et al. 2020). In the Indian Himalaya, the species is known from Uttarakhand (Gangotri, Govind Pasu Vihar, Harsil, Kedarnath, Munsiyari, Pindari, Panchachuli, Raithal, Sukhi, Sayara, Sunderdunga, and Tehri-Garhwal in Bhagirathi Valley), Himachal Pradesh (Kullu, Shimla, Kinnaur, and Lahul Spiti), Jammu & Kashmir (Doda & Kishtwar, Bandipora district, Fatehpur, Gulmarg, Kanzalwan, Pahalgam, Poonch, Gurez, Sonamarg, Machil, Sinthan top, Lidderwat, Bangus, and Ramnagar forest range), and Sikkim (Chauhan & Bisht 2020). The population of *T. govanianum* species has drastically decreased from its natural habitat within the Himalayan region since 2010 due to its high medicinal properties which are very similar to *Paris polyphylla* Smith (Ajuha 2013). The rhizome of this species is used to treat different ailments such as inflammation, menstrual, and sexual illness and possesses other properties such as anti-inflammatory, antifungal, and anticancer (Pant & Samant 2010; Rahman et al. 2017; Singh et al. 2017; Chauhan et al. 2019; Chauhan & Bisht 2020). Over the past few years, high demand for rhizomes in the commercial market resulted in unsustainable harvesting and over-exploitation by the local inhabitants of the Himalayan region. Therefore, the population status of the species *T. govanianum* is considered 'Endangered' under criterion A4cd as per the IUCN Red List of Threatened Species (Chauhan & Bisht 2020). While exploring medicinal plant diversity in Arunachal Pradesh from April 2022 to May 2023, an interesting species was recorded at Mandala, West Kameng District, Arunachal Pradesh. Scrutiny of relevant taxonomic literature (Hajra et al. 1996; Wu & Raven 2000), the species is identified as *Trillium govanianum*. The identity has been confirmed through consultation of protologue and image of the type specimen (E00318412image!). Even though this part of the eastern Himalaya has been aptly surveyed botanically by different botanists since the period of Griffith (1836), Hooker (1892), Ward (1929), Ward (1930), Bor (1938), none of them reported the existence of the

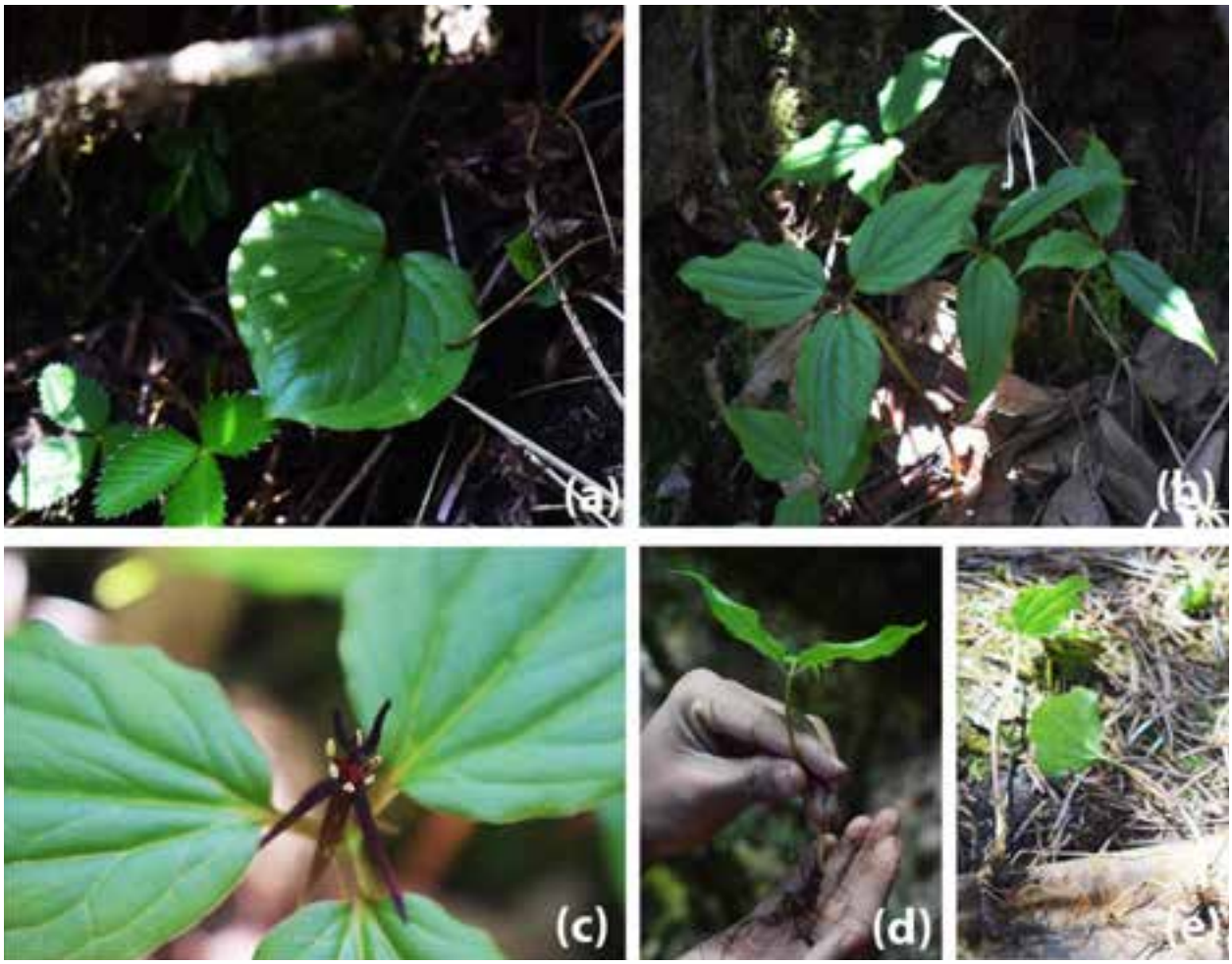

Image 1. *Trillium govanianum* Wall. ex D. Don: a–b—plants in habitat | c—flowers | d–e—rhizomes. © Bikash Kalita.

species under study in the state of Arunachal Pradesh, India. The present study also revealed that the species *T. govanianum* is one of the major associated species of *P. polyphylla* in the Mandala region. The details of information regarding the distribution of this species in the Sikkim Himalaya region are also limited. Hence, the present collection of the taxon from Arunachal Pradesh is a new record for the state.

Type: India, Himachal Pradesh, Sirmore, G. Govan sn. (E00318412 image!)

Herb, up to 30 cm tall, rhizome up to 2 cm thick, fibrous roots numerous. Leaves 3, petiole 0.3–1.5 cm long; oval to ovate or cordate, 3.5–11 × 3–11 cm, acute to acuminate, glabrous, reticulate venation. Flower solitary, terminal, pedicellate; pedicel 0.8–2.2 cm long, stout. Perianth segments, dark purple, narrowly lanceolate, outer segments broader, inner narrower. Stamens six, in two whorls, shorter than the perianth; filaments up to 4 mm long; anthers 4–5 mm long, basifixed, curved, longitudinally dehiscent. Ovary purple, 3–locular; styles 3, linear. Fruit berry, ovoid-globose, red, 1–2 cm in diameter; seeds many, oblong, small.

Flowering: April–May

Fruiting: May–June

Ecology: The species is mostly distributed under shady, moist, and low humid areas at an altitude 3,100–3,250 m along with *Paris polyphylla* Sm., *Senecio diversifolius* Wall., *Fragaria nubicola* Lindl. ex Lacaita

Distribution: India (Arunachal Pradesh, Mandala, West Kameng, 27.274° N, 92.258° E, elevation 3,154 m; Sikkim, Himachal Pradesh, Jammu & Kashmir, Uttarakhand); Afghanistan; Bhutan; China (Tibet [or Xizang] Guizhou); Nepal; Pakistan (Figure 1).

Specimen Examined: INDIA: Mandala, West Kameng, Arunachal Pradesh 27.274° N, 92.258° E, elevation 3,154 m, April 2022, B. Kalita (GUBH 20632; 07 September 2022).

Note: The species is listed as 'Endangered" in the IUCN Red List (3.1 version; Chauhan & Bisht 2020). The present investigation revealed that the occurrence of

the species is very rare, and the population is confined to only one locality in Arunachal Pradesh with a few individuals. The species shares the same habitat with *Paris polyphylla* in the high-altitude areas in the state, which is a fragile habitat. Therefore, for the conservation of this taxon along with other high-altitude medicinal plants, the habitat of this species needs to be declared a conservation site. A distribution map is also provided for the conservation management of this taxon.

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NOTE

Typhonium inopinatum Prain (Araceae): a new plant record to the flora of Uttarakhand, India

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The genus *Typhonium* Scott (Araceae) contains about 80 species distributed from India, southeastern Asia, to Australia (Mujaffar et al. 2013; Nguyen et al. 2022). In India, *Tyhponium* genus is recorded from the following states and union territories: Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Odisha, Puducherry, Punjab, Telangana, Tripura, Uttar Pradesh, Uttarakhand, and West Bengal (Mao et al. 2020; BSI 2024; India Flora Online 2024). The genus is represented by seven species, namely, *Typhonium bulbiferum* Dalzellet; *T. blumei* Nicolson; *T. flagelliforme* (Lodd.) Blume; *T. gracile* (Roxb.) Schott; *T. inopinatum* Prain; *T. roxburghii* Schott; *T. trilobatum* (L.) Schott (Mishra 2018; Mao et al. 2020). Two species of *Typhonium* (*T. listeri* Prain and *T. diversifolium* Wall. ex Schott) have now been transferred to the genus *Sauromatum* while *T. foliolosum* (Schott) Engl. has been synonymized with *T. diversifolium* Wall. ex Schott. In Uttarakhand, two species of *Typhonium*: *T. roxburghii* Schott; and *T. trilobatum* (L.) Schott and three species of *Sauromatum* including *S. brevipes* (Hook.f.) N.E.Br., *S. venosum* (Aiton) Kunth, and *S. diversifolium* (Wall. ex Schott) have been recorded to date (Uniyal et al. 2007).

During recent botanical explorations in and around Dehradun Valley a few specimens of the genus *Typhonium* were collected from Chandrabani, Dehradun; Indian Institute of Technology, Roorkee and Gurukula Kangri University, Haridwar. After a comparison of reproductive parts with all the species reported from India, it was identified as *Typhonium inopinatum* Prain. This species has earlier been reported from the states of Andhra Pradesh, Bihar, Maharashtra (Bhandara District and Marathwada), Madhya Pradesh, Telangana, Uttar Pradesh, and West Bengal (Kumar et al. 2014; Rasingam et al. 2017; Sonule et al. 2019). No previous records of this species were found from the state of Uttarakhand (Osmaston 1926; Kanjilal 1928; Babu 1977; Gaur 1999; Uniyal et al. 2007; Agarwal 2017). This species is reported as a new record for the state of Uttarakhand.

Taxonomic description

Typhonium inopinatum Prain in King & Prain, J. Asiat. Soc. Bengal Pt. 2. Nat. Hist. 67: 301. 1898 & Bengal

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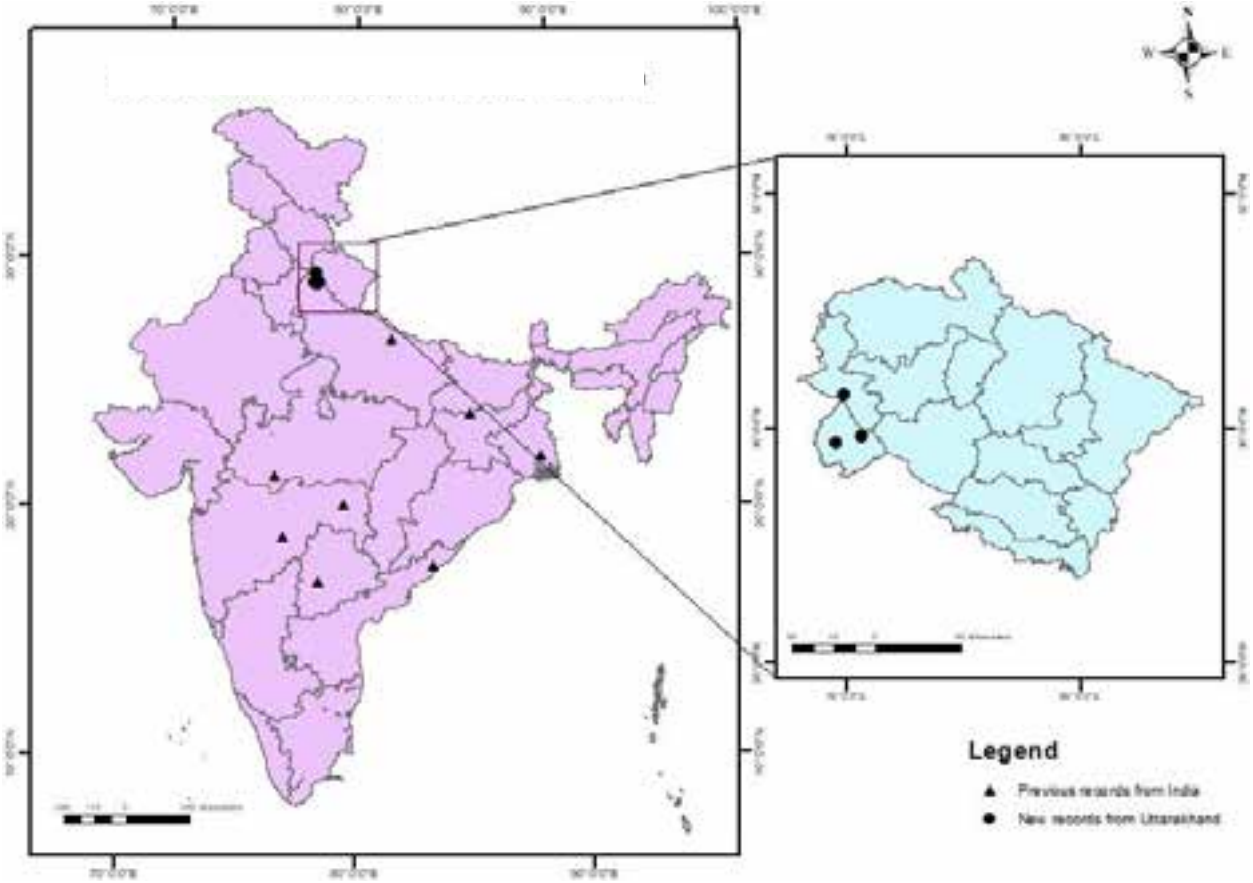

Figure 1. Records of *Typhonium inopinatum* Prain from India.

Pl. 1107. 1903; Engl. Pflanzenr. 73(IV. 23F): 116. 1920; Kumar et al. in Rheedea 24(2): 120. 2014; Rasingam et al. in Indian J. Forest. 40(4): 401– 402. 2017; Sonule et al. in Bioinfolet. 16(4): 242–243. 2019. *T. khandwaense* Mujaffar et al. Biosci. Disc. 4: 25. 2013.

Tuberous perennial herbs 10–45 cm tall; tubers globose, 1–3 × 0.8–1.5 cm; leaves 8–10, ovate varying to spear-shaped or triangular form, 5–14 × 4–10 cm; base hastate, acuminate at apex, margin entire, secondary veins 10–15 per side, petioles 15–30 cm long, green; inflorescence spadix, monoecious shorter than petioles, 1–2.5 cm. Spathe is broadly ovate to lanceolate, 8–10cm long, 2–3.5 cm broad, limb brownish outside, greenish-brownish inside, margin entire, margin, acuminate, involute, recurved, and coiled apically. Spadix 4.3–9 cm long; pistillate flower at base, sterile ones in the middle, preceded by naked zone, followed by staminate flowers towards the apex and a terminal zone appendix. Both pistillate and sterile flower zones are enclosed by basal tubes of spathe. Pistillate zone conical, 3–3.5 mm long, greenish; flowers sessile, 1–1.5 mm long; ovary ellipsoid, 1–1.3 mm long, glabrous; style very short; stigma disc-shaped, glabrous. Sterile flower zone yellow, 2–4.5 mm long; sterile flowers filiform, entire, decurved, each 2.5–4 mm long, partially covering pistillate flower zone. Naked zone 6–9 mm long. Staminate zone cylindric, 5–9 × 2–3 mm, pale yellow; flowers sessile, 0.5–1 mm long with 2 thecae; dehiscence by apical short slits or pores. Appendix 4–6 cm long, yellowish-brown (Image 1).

Life Cycle: *Typhonium inopinatum* Prain is a tuberous geophyte that is active for a short duration of 2 to 3 months. In Dehradun, the emergence of *Typhonium inopinatum* (Vegetative form) was observed during the first week of June; flowering was observed from the fourth week of June till the first week of October.

Habitat: In Dehradun *Typhonium inopinatum* Prain was found to be growing along the side of the Chandrabani main road and inside an empty plot under the canopy of *Syzygium cumini* (L.) Skeels, *Terminalia arjuna* (Roxb. ex DC.) Wight & Arn, *Mangifera indica* L., and *Monoon longifolium* (Soon.) B. Xue & R.M.K. Sanders, in association with *Laportea interrupta* (L.) Chew.

In IIT Roorkee it was seen growing along the margins

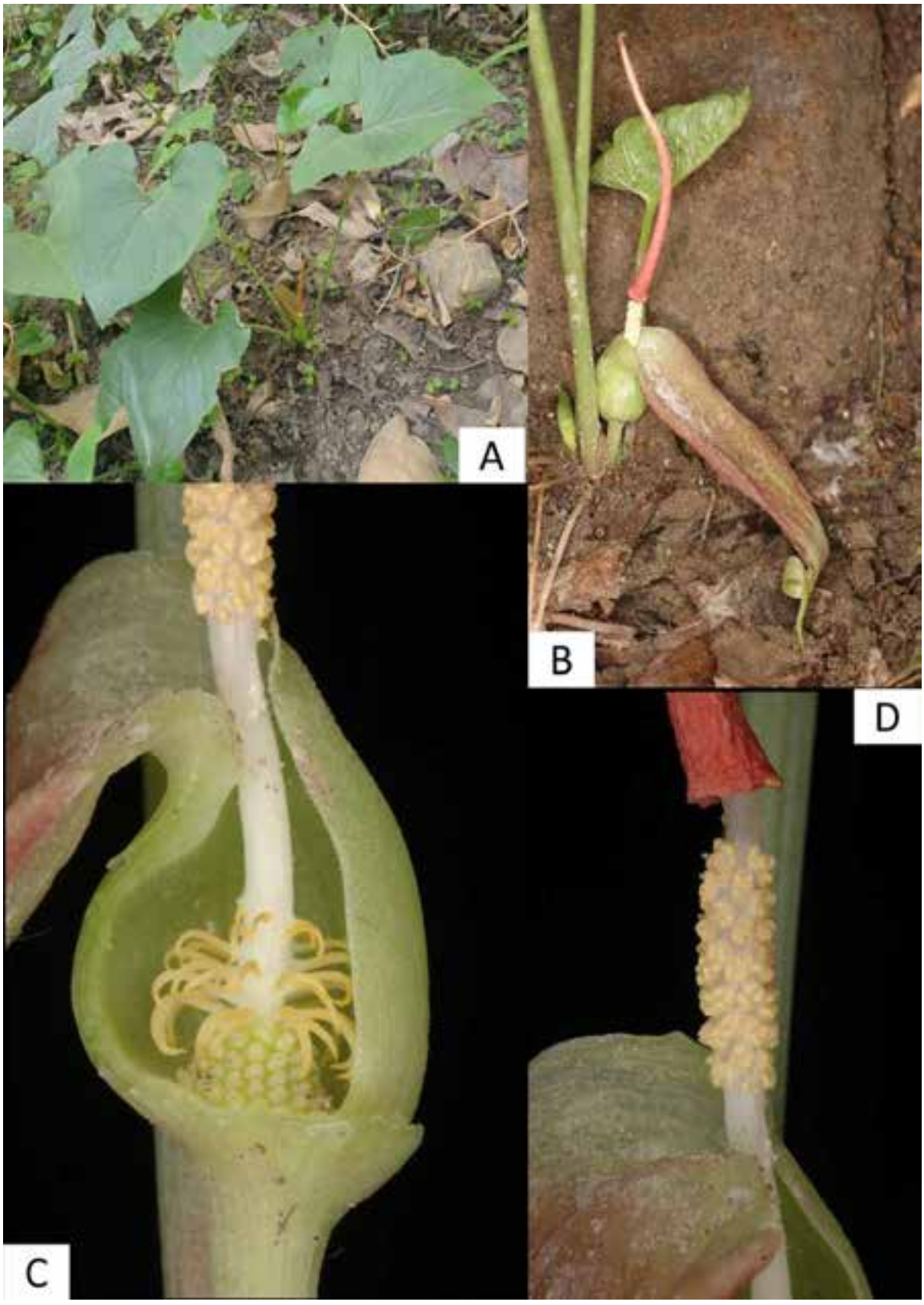

Image 1. *Typhonium inopinatum* Prain: A—Habit | B—Inflorescence | C— Female flower bottom, neutral flower middle, naked zone | D—Male flower and appendix. © Navendu Page.

Image 2. A—Lectotype of *Typhonium inopinatum* Prain collected by D. Prain from West Bengal | B—Lectotype of *Typhonium inopiantum* Prain collected by Haraukh from Bahrich, Uttar Pradesh.

of the football ground in association with *Mazus pumilus* (Burm.f.) Steenis, *Mimosa pudica* L., *Oplismenus burmanni* (Retz.) P. Beauv, and *Oxalis corniculata* L.

In Gurukula Kangri University it was found growing in front of the Zoology and Environmental Science Research Building in an open lawn associated with species such as *Cynodon dactylon* (L.) Pers., *Crinum asiaticum* L., *Mazus pumilus* (Burm.f.) Steenis, *Mimosa pudica* L., *Oplismenus burmanni* (Retz.) P.Beauv and *Oxalis corniculata* L.

These observations suggest that this species may be of frequent occurrence in the low lying plains and valleys adjacent to Shiwalik and Himalayan foothills of Uttarakhand and Himachal Pradesh. This species may have been overlooked or missed by previous botanical explorers due to its diminutive nature and the very short period during which it can be observed in vegetative or reproductive conditions.

Distribution: India (Andhra, Bihar, Maharashtra, Telangana, Uttar Pradesh, Uttarakhand (in this publication) and West Bengal (Figure 1).

Global distribution: Myanmar, Thailand.

Conservation status: Data Deficient.

Ethnobotnical uses: Tubers and leaves of *T. trilobatum*, *T. flagelliforme*, and *Typhonium inopinatum* are used by tribal people as a source of food and medicine (Panda et al. 2005). In the future, the pharmaceutical and R&D industries may employ it as a potent therapeutic plant.

Specimen examined: WII 22215, 22.viii.2022, India, Uttarakhand, Dehradun District, Wildlife Institute of India, 30.281 °N, 77.976 °E, 619 m, coll. Navendu Page & Sachin Rawat. CAL K000099897, X.1895. India, West Bengal, Botanical Garden, Calcutta, coll. D. Prain. (Image 2). K K000203516, 20.vi.1898. Uttar Pradesh, Bahraich district, coll. Haraukh (Image 2).

Additionally, live specimens were observed from the two localities Indian Institute of Technology, Roorkee, Uttarakhand (29.868 °N, 77.898 °E, 279 m) and Gurukula Kangri University, Haridwar, Uttarakhand (29.919 °N, 78.118 °E, 309 m). (Live specimens from the other two

locations are not cited as no specimens were collected, although images from the field with associated geographic coordinates are available as part of the image exif data, which we have uploaded on iNaturalist and can be verified).

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RESPONSE

Response to "First record of *Pieris napi* L. (Lepidoptera: Pieridae) from Kashmir Valley, India"

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I am writing to address several inaccuracies in the recent publication by Rasool & Mir (2024) on the occurrence of *Pieris napi* in Kashmir Valley, published in the *Journal of Threatened Taxa*. As an experienced lepidopterist with a focused study on the butterflies of the Jammu & Kashmir Union Territory, including a comprehensive checklist published in 2021, I find it imperative to clarify certain points raised in their study.

Firstly, the identification of the butterfly species in question is fundamentally flawed. The butterfly documented in their study appears to be *Pieris melete ajaka* (Moore, 1865), commonly known as the Himalayan Green-veined White, not *P. napi.* The misidentification likely stems from the authors' reliance on outdated literature and a lack of consultation with recent taxonomic revisions. *Pieris napi,* in all its subspecific variations, is predominantly found across Europe, western & northern Asia, but is not known to occur in India. This discrepancy highlights a critical need for the authors to revisit their identification methods and consult updated taxonomic resources.

It is important to note that the Indian subspecies *ajaka* were previously listed under *P. napi* Linnaeus, 1758 or European Green-veined White. However, they are now recognized under *P. melete* Moore, 1865, as updated in recent literature (Moore 1874; D'Abrera 1990; Varshney & Smetacek 2015; Kehimkar 2016; Gasse 2018; Anonymous 2024). For updated information, please refer to the ifoundbutterflies website (Anonymous 2024).

Previous literature consistently reports the distribution of *P. ajaka* in Kashmir (Moore 1874; D'Abrera 1990; Varshney & Smetacek 2015; Kehimkar 2016; Gasse 2018), including specific mentions of the Goorais valley (South 1902) and Budhal, Rajouri District in Jammu & Kashmir, India. These records, which I have also mentioned in my 2021 checklist, underscore the presence of *P. ajaka* in regions of Jammu & Kashmir and not *P. napi*.

Authors also have not checked the latest paper on *P. napi* group on India by Das et al. (2021).

I have mentioned the *P. melete ajaka* synonyms in the following list from the paper.

P. ajaka Moore, 1865 (Figs. 7, 8, 18, 23, 29, 34, 43, 52, 60, 68, 76, 84)

P. ajaka Moore, 1865: 490 (Type locality: "Lower Kunawur"). Winhard, 2000: 29.

Tshikolovets & Pagés, 2016: 93. Tadokoro et al., 2017: 90.

P. melete Ménétriés, 1857; Mackinnon & de Nicéville, 1898: 590.

P. napi race. *melete* var. *ajaka* Moore; Bingham, 1907: 173.

P. melete ajaka Moore; Verity, 1908–1911: 140, 166, 331.

P. ajaka f. *ajanta* Röber, 1907: 48.

P. melete ajaka Moore; Fruhstorfer, 1910: 140.

P. napi ajaka Moore; Evans, 1932: 67. Talbot, 1939: 420. Mani, 1986: 55.

P. napi f. *ajanta* Röber; Talbot, 1939: 420.

P. napi race. *ajaka* Moore; Wynter-Blyth, 1957: 432.

P. ajaka ajaka Moore; Eitschberger, 1983: 409.

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Additionally, the paper's assertion regarding the host plants of *P. napi* may be accurate; however, the depiction of the eggs in their study is incorrect. The eggs shown are dot-like, which is inconsistent with the eggs of the *Pieris* genus. *Pieris* eggs are tall, bottle-shaped, and strongly ribbed, a characteristic that is clearly absent in the images presented in the paper. This further calls into question the accuracy of the species identification in their research.

I would also like to address the authors' neglect in referring to updated literature concerning the range extension of butterfly species in the region. The published work by Sheikh et al. (2021) provides a detailed and updated checklist of butterfly species in the Union Territory of Jammu & Kashmir, which the authors have overlooked. Properly acknowledging and incorporating recent findings is essential for the credibility and accuracy of scientific research.

In conclusion, while the discovery of butterfly species in new regions is always exciting, it is crucial to ensure precise identification and thorough consultation of the latest literature. I urge the authors to revisit their findings and consider the points raised to enhance the accuracy and reliability of their research. It's already recorded from Jammu & Kashmir as *P. ajaka* or *P. melete ajaka,* (Parey & Sheikh 2021; Sheikh et al. 2021), Rasool & Mir (2023) identified this as *P. napi* in a podential predatory journal so this paper is baseless and misleading with wrong identification.

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Editor's note:

The article "First record of *Pieris napi* L. (Lepidoptera: Pieridae) from Kashmir Valley, India" by Rasool & Mir published in Volume 16, Issue 7 of the *Journal of Threatened Taxa* on 26 July 2024, has received a response based on the identification and reporting of the species. The arguments on the species identification is solely between the responder and the authors. Others are welcome to comment and participate in this post-publication peer-review.

In the article published by Rasool & Mir (2024), Pieris napi is presented as a first record for Jammu & Kashmir from Srinagar District with additional information. The same authors have reported *P. napi* in from Jammu & Kashmir in a potential predatory journal in January 2023. Since JoTT's Editorial policy does not recognise articles published in journals listed in Beall's List of Potential Predatory Journals and Publishers, the information along with additional notes is published in JoTT as first record.

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Rasool, F. & A.H. Mir (2024). First record of *Pieris napi* L. (Lepidoptera: Pieridae) from Kashmir Valley, India. *Journal of Threatened Taxa* 16(7): 25609–25612. https://doi.org/10.11609/jott.8233.16.7.25609-25612

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REPLY TO RESPONSE

Reply to Sheikh's Response to First record of *Pieris napi* L.

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It is an immense pleasure for us that our manuscript is gaining attention from entomologists nationwide and read with enthusiasm. As a result, some of them are responding to our published article entitled "First record of *Pieris napi* L. (Lepidoptera: Pieridae) from Kashmir Valley, India" [#8233], which was published on 26 July 2024 in the *Journal of Threatened Taxa*.

Firstly, it should be made clear that no one is an expert in any field and that humans are lifelong learners. Diversity is a vast issue that is constantly changing due to the discovery of hundreds of new species and the extinction of old ones after every blink.

We communicated this manuscript in October 2022, peer reviewed three times and taken almost one year and nine months to publish in this reputed journal.

Furthermore, we have some collaborated with taxonomists of Lepidoptera at international forum like Butterfly Research Center from Bhimtal and others for butterfly identification.

We were well aware of the most recent publications, and we cited all the sources that were pertinent to our study. Nevertheless, the scope of our research study was limited to Srinagar District's Dachigam National Park, a popular tourist destination with a global reputation, where undoubtedly more opportunities for the presence of new species is obvious. Hence, a good study site for upcoming researchers. Besides, all the references the querier had quoted were already reviewed thoroughly and have nothing to do with the subject of our investigation. It appears that they wish to draw attention to their own checklist (Sheikh et al. 2021) and receive a greater number of citations. It is highly recommended that they update their checklist as some species require modification.

Furthermore, our study is a new report and obviously not published before. It should be accepted by everyone in this context that new species do not wait to be discovered before being reported by professionals or experts only. We did sampling in the study area and have specimens available; if anybody is unsure, they can visit our lab anytime to view the samples.

Here we just highlight the differences between *P. napi* L. and *P. ajaka* (Moore) on certain grounds.

Butterfly databases: Butterflies of the World – Natural History Museum; Lepidoptera Barcode of Life; Scientific articles and research papers – published studies on Pieridae butterflies in journals like Journal of Lepidopterists' Society, Zoological Science, Entomological Research; Online encyclopedias and wikis: Encyclopedia of Life; Butterfly enthusiast websites; ifoundbutterflies website; Butterfly enthusiast forums; Butterfly Conservation; iNaturalist and much more.

Differences

Pieris napi and *P. ajaka* share some similarities as members of the Pieridae family, however, they differ in taxonomy, classification, appearance, habitat preferences, behavior, and ecological roles. *Pieris napi* has been considered a separate species by many authors who have provided distinguishing characteristic features (Richards 1940; Petersen 1949; Smith 1980; Forsberg & Wiklund 1989; Wiklund et al. 1991; Bissoondath & Wiklund 1996; Ohsaki & Sato 1999; Ferkau & Fischer 2006; Rayor et al. 2007; Chew 2009; Perveen & Ahmad

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2012; Perveen & Fazal 2013; Tadokoro 2015; Bibi et al. 2022; Ge et al. 2023). Here we cite a few taxonomic keys for the reader's perusal. Taxonomic keys by Perveen & Fazal (2013).

In addition to our published paper one can check more differences as European or Green-veined White ***Pieris napi***:

Habitat: Europe, Asia and northern Africa; the Himalayan region, including the northeastern states of India such as Arunachal Pradesh, Manipur, Assam, Himachal Pradesh, Meghalaya, Mizoram, Nagaland, and Uttarakhand, as well as Bhutan, Myanmar, China, Japan, North America, and Japan (Geiger & Shapiro 1992; Shaoji 2009; Gogoi 2013; Perveen & Fazal 2013; Lodh & Agarwal 2015; Tadokoro 2015; Tadokoro 2017).

Geographical distribution: Cool-temperate to cold wooded biomes of the northern hemisphere (Geiger & Shapiro 1992).

Habitus: wingspan 40–50 mm.

Upper wings: white with black tips and greenish-yellow veins.

Lower wings: yellowish-green with black spots.

Habitat: meadows, gardens, and woodland edges.

Food source: garlic mustard, cuckooflower and other Brassicaceae.

Resting host: *Stellaria media*, *Geranium* sp., and *Rubus* sp.

Himalayan Green-veined White or Ajaka White ***Pieris ajaka***:

Habitat: eastern Asia including China, Japan, & Korea and southern Asia,

Wingspan: 50–60 mm.

Upper wings: white with black tips and veins.

Lower wings: yellowish-green with black spots and a distinctive red or orange spot.

Habitat: woodland edges, grasslands, and mountainous areas.

Food source: various plants, including Japanese Angelica tree and Japanese Spikenard.

Taxonomy and classification

- Both *P. napi* and *P. ajaka* belong to the family Pieridae, which is known for its white and yellow butterflies. However, they are distinct species within this family.

Appearance

- *Pieris napi*, commonly known as the Green-veined White Butterfly, typically has white wings with greenish veins, which is a key identifying feature.

- *Pieris ajaka,* on the other hand, is often referred to as the Japanese White Butterfly or commonly known as Himalayan Green-veined White and may exhibit variations in wing coloration and patterns that differ from those of *P. napi*.

Habitat and distribution

- *Pieris napi* is widely distributed across Europe and parts of Asia, often found in meadows, and gardens.

- *Pieris ajaka* is primarily found in eastern Asia, particularly in Japan, and may prefer different habitats compared to *P. napi*.

Behavior and ecology

- Both species have similar life cycles, including egg, larval, pupal, and adult stages, but they may have different host plants for their larvae.

- *Pieris napi* larvae typically feed on plants in the mustard family, while *P. ajaka* may have a different set of host plants.

Natural enemies

- Both species face threats from natural predators and parasites, but the specific enemies may vary based on their geographical locations and habitats.

Conservation status

- The conservation status of these species can differ based on their populations and the environmental pressures they face in their respective regions.

Based on the existing literature and our research, it can be concluded that *P. napi* differs greatly from *P. ajaka* and cannot be considered a single species as the querier had intended. The querier would like to divert our attention to their checklist (Sheikh et al. 2021) where they reported *P. ajaka* Moore, 1865 from Rajouri District of Jammu region of J&K and not any record of *P. napi*. We report *P. napi* solely in Dachigam National Park, although we had 30 more study sites in Kashmir Valley. We are working on the updated checklist as additional species require modifications and the updated version seems to be the need of the hour.

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Tinged black veins on the upper side, veins of underside of hindwings are dusted with pale greenish-yellow and have conspicuous black color, tip of fore wing is black with a distal black spot in between veins 3 and 4.....***P. napi***

Black areas of forewing tip are heavily marked and no under hindwings tend to be yellowed..... **Female**
Heavy marking in forewing tip are absent.....**Male**
Undersides of both fore and hind wings are pale yellow, borders dusted with gray scales.....***P. ajaka***
Upper forewing with prominent black spots, veins heavily defined in black colour, noticeable black spot between veins 3 and 4.....**Female**
Upper forewings contain black weak markings, black spot is absent between veins 3 and 4.....**Male**
Ge et al. (2023) provided identification keys for males as well as females. Although they considered *P. napi* as a complex, however they did not include *P. ajaka* within this complex.

Male identification keys of *P. napi* are.
Hindwing distinctly yellowish on the underside, with dark stripes along veins completely absent; Forewing with the 3rd discal spot present on the upperside ..... ***P. napi muchei*** (Summer form)
Forewing with the 3rd discal spot present (East Kazakhstan) ..... ***P. napi sauro***
Tegumen with its terminal part moderately sclerotised as almost lobe-shaped convex..... ***P. napi bryonides***
Terminal part of tegumen without lobe-shaped convex ..... ***P. napi muchei*** Spring form

Female identification keys of *P. napi* are.
Medium size; hindwings yellowish on the underside; dark stripes along veins completely absent on the upperside.....
.....***P. napimuchei*** Summerform
Wings with brownish suffusion on the upperside extremely strong developed; dark suffusion almost filling the discocell of forewings (East Kazakhstan)..... ***P. napi sauron***
Forewing with the 3rd discal spot distinctly present (N. Tian-Shan, Dzhungarsky Alatau, the Alai and Sayan) ..... ***P. napi bryonides***

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