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



Monitoring observations of the southernmost breeding population of Long-billed Vultures *Gyps indicus* (Scopoli, 1786) (Aves: Acciptriformes: Accipitridae) in the Nilgiri Biosphere Reserve, India

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Abstract: The Long-billed Vulture (LBV) population was systematically monitored across four nesting colonies in the Nilgiri Biosphere Reserve (NBR) throughout three extended breeding seasons. Breeding success rates between years ranged from 83.33% in 2018–2019 and 62.5% in 2020–2021. Nesting was monitored at the cliff sites, consistent with prior research. Overall population fluctuations were minimal, varying between 21 individuals in 2020–2021, 17 individuals in 2018–2019, and 16 individuals in 2019–2020. There was an apparent impact of forest fires and other human disturbance activities, and certain proactive conservation measures are proposed to help address these. There was indirect evidence of other threats including poison baits targeting wild carnivores and non-steroidal anti-inflammatory drugs (NSAIDs) being widely available for use in domestic livestock. The study endorses the approach of establishing vulture-safe zones, which focus on addressing the local threats. This includes raising awareness about wildfire management, controlling toxic NSAIDs availability that are harmful to vultures, discouraging the illegal use of poison-baits, and highlighting the necessity of monitoring threats posed by power infrastructure. Due to the high mobility of LBVs, all these threats need addressing through large-scale vulture safe zone work (up to 100 km radius) surrounding the breeding colonies to secure the LBV's long-term survival. These conservation actions are urgently needed.

Keywords: Conservation, Critically Endangered, forest fire, livestock, NSAID, poison, vulture safe zone.

Tamil Abstract: நீலகிரி உயிர்க்கோளக் காப்பகத்தில் உள்ள நீண்ட அலகு பிளந்தின்னிக் கழுக்குளின் எண்ணிக்கை மூன்று இனப்பெருக்க காலங்களில், நான்கு கூடு கட்டும் காலங்களில் முறையாக கண்காணிக்கப்பட்டது. ஆண்டுகளுக்கிடையேயான இனப்பெருக்க வெற்றி விகிதங்கள் 2018-2019 இல் 83.33% ஆகவும், 2020-2021 இல் 62.5% ஆகவும் இருந்தன. முந்தைய ஆராய்ச்சிக்கு இணங்க, குன்றின் தளங்களில் கூடு கட்டுவது கண்காணிக்கப்பட்டது. ஒட்டுமொத்த எண்ணிக்கை ஏற்ற இறக்கமாக இருந்தது. இது 2020-2021 இல் 21 ஆகவும், 2018-2019 இல் 17 ஆகவும் மற்றும் 2019-2020 இல் 16 ஆகவும் இருந்தது. காட்டுத்தீ மற்றும் பிற மனித இடையூறு நடவடிக்கைகளின் வெளிப்படையான தாக்கம் இருந்தது. மேலும் இவற்றை நிவர்த்தி செய்ய உதவும் சில பாதுகாப்பு நடவடிக்கைகள் இந்த ஆய்வில் முன்மொழியப்பட்டுள்ளன. வன்மம் காரணமாக வனவிலங்குகளுக்கு எதிராக விஷம் தடவுவது மற்றும் பிளந்தின்னிக் கழுக்குள்கு கேடு விளைவிக்கும் வலிநிவாரணிகள் (NSAIDs) கால்நடைகளுக்கு பயன்படுத்த பரவலாகக் கிடைக்கின்றன என்பதற்கான மறைமுக சான்றுகள் இருந்தன. உள்ளூர் அச்சுறுத்தல்களை நிவர்த்தி செய்து கழுகு-பாதுகாப்பான மண்டலங்களை நிறுவுவதற்கான அணுகுமுறையை இந்த ஆய்வு ஆதரிக்கிறது மேலும் காட்டுத்தீ மேலாண்மை பற்றிய விழிப்புணர்வை ஏற்படுத்துதல், கழுக்குள்கு தீங்கு விளைவிக்கும் வலிநிவாரணிகள் (NSAIDs) கள் கிடைப்பதைக் கட்டுப்படுத்துதல், வன்மம் காரணமாக வனவிலங்குகளுக்கு எதிராக விஷம் தடவுவது கட்டுப்படுத்துதல் மற்றும் மின் உள்கட்டமைப்பினால் ஏற்படும் அச்சுறுத்தல்களைக் கண்காணிப்பதன் அவசியத்தை எடுத்துரைத்தல் போன்ற மேற்கண்ட காரணிகளை பிளந்தின்னிக் கழுக்குள் பாதுகாப்பு மண்டலம் திட்டத்தின் மூலம் (100 கி.மீ சுற்றளவு) நிவர்த்தி செய்து நீண்ட அலகு பிளந்தின்னிக் கழுக்குள்கள் நீண்ட காலத்திற்கு பாதுகாக்க வேண்டும் என்று இந்த ஆய்வு எடுத்துரைக்கிறது மற்றும் இந்த பாதுகாப்பு நடவடிக்கைகள் அவசரமாக தேவை ஆகும்.

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Author contributions: SM—conceptualisation and writing; BH—design, writing and editing; PK—writing.

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INTRODUCTION

The decline in the population of *Gyps* vultures across the Indian subcontinent is largely attributed to accidental poisoning resulting from their consumption of carcasses contaminated with the non-steroidal anti-inflammatory drug (NSAID) diclofenac (Oaks et al. 2004; Swan et al. 2006). The Long-billed Vulture (LBV) *Gyps indicus*, is one of the three native resident *Gyps* species in India. The LBV breeds in southeastern Pakistan (Collar & Butchart 2013) and peninsular India south of the Gangetic plain up to Delhi (Risebrough 2004), eastward through Madhya Pradesh (Rasmussen & Anderton 2005), Telangana (Manchiriyala & Medichet 2014), Andhra Pradesh (Umapathy et al. 2009) and southwards to the Nilgiris (Subramanya & Naveen 2006; Venkitachalam & Senthilnathan 2015; Manigandan et al. 2023), nesting primarily on cliffs and occasionally ruins and has been observed only occasionally nesting in trees in Bikaner, Rajasthan (Rasmussen & Anderton 2005). The Nilgiris is the southern limit of the species. The spectrum of NSAIDs available in the veterinary market within the confines of the Nilgiri Biosphere Reserve (NBR), includes aceclofenac, ketoprofen, nimesulide, and flunixin, all known to be toxic to vultures (Mathesh et al. 2023) and this is a serious concern within the proposed vulture safe zone (VSZ) of southern India (Manigandan 2018). These observations prompted us to further monitor and understand the LBV population within the NBR.

While efforts toward vulture conservation have predominantly centered in the northern and eastern regions of India, with research and captive breeding programs targeted at saving the three Critically Endangered *Gyps* species—the White-rumped Vulture *Gyps bengalensis*, LBV, and Slender-billed Vulture *Gyps tenuirostris* (Prakash et al. 2003; Bowden et al. 2012; Ranade et al. 2023), such initiatives remain scarce in southern India. The prospect of establishing a similar captive breeding centre in the south is currently being deliberated both in Karnataka and in Hyderabad Zoo and is at various stages (MoEFCC 2020). Despite this, a conspicuous dearth of information persists for both the 'Endangered' Egyptian Vulture *Neophron percnopterus* (Byju & Raveendran 2022) and this 'Critically Endangered' species (LBV) within the precincts of the NBR. The present study aims to set some baseline information and evaluate recent LBV population trends, providing some breeding success data, and evaluating conservation challenges for this species in the Tamil Nadu landscape.

Study Area

The NBR (11.5731°N & 76.7558°E), was established in 1986 in the southern Western Ghats and connects the Western Ghats to the Eastern Ghats (Puyravaud & Davidar 2013). Our study was restricted to MTR and Sathya Mangalam Tiger Reserve (STR) of the NBR in Tamil Nadu (Figure 1). This biosphere reserve includes areas of Tamil Nadu, Kerala, and Karnataka states. Among the seven vulture species recorded within the NBR, four are resident—Egyptian Vulture *Neophron percnopterus*, Red-headed Vulture *Sarcogyps calvus*, White-rumped Vulture *Gyps bengalensis*, and Long-billed Vulture *Gyps indicus*; and three are scarce winter migrants—Cinereous Vulture *Aegypius monachus*, Himalayan Griffon Vulture *Gyps himalayensis*, and Eurasian Griffon Vulture *fulvus* (Manigandan et al. 2023).

METHODS

LBV nesting behavior was assessed by a combination of drawing upon prior research (Manigandan et al. 2023), local villager insights from indigenous inhabitants for potential nesting and roosting sites collected, local government officials, forest guards, and researchers of Government Arts College, Ooty along with the authors. Systematic visits were made between October and June, covering the known vulture breeding period in the landscape (Stotrabhashyam et al. 2015). During this period, each LBV nest site location was visited twice (15-day intervals) per month during breeding seasons and assessments were based on the frequency of bird visits to cliffs and on the presence of white droppings visible around the nesting site. These observations were repeated for three successive breeding seasons: 2018–2019, 2019–2020, and 2020–2021. The selection of observation timings, either in the morning (0600–1000 h) or the late afternoon (1700–2000 h) depended on the visibility thereby avoiding some misty mornings and evenings. These designated periods were determined both to optimize visibility due to haze and addressing safety concerns from elephant movement and sloth bears in the region. As LBVs are primarily cliff nesters, the survey focused on cliff searches and so could potentially have missed tree nesting pairs—although this seems unlikely as we have been collecting secondary information from forest dwellers from indigenous communities which has not revealed any tree-nesting of LBVs. Each nest site was given a reference number for inter-year tracking. Observations were made from carefully selected points that allowed clear observation of the nest contents

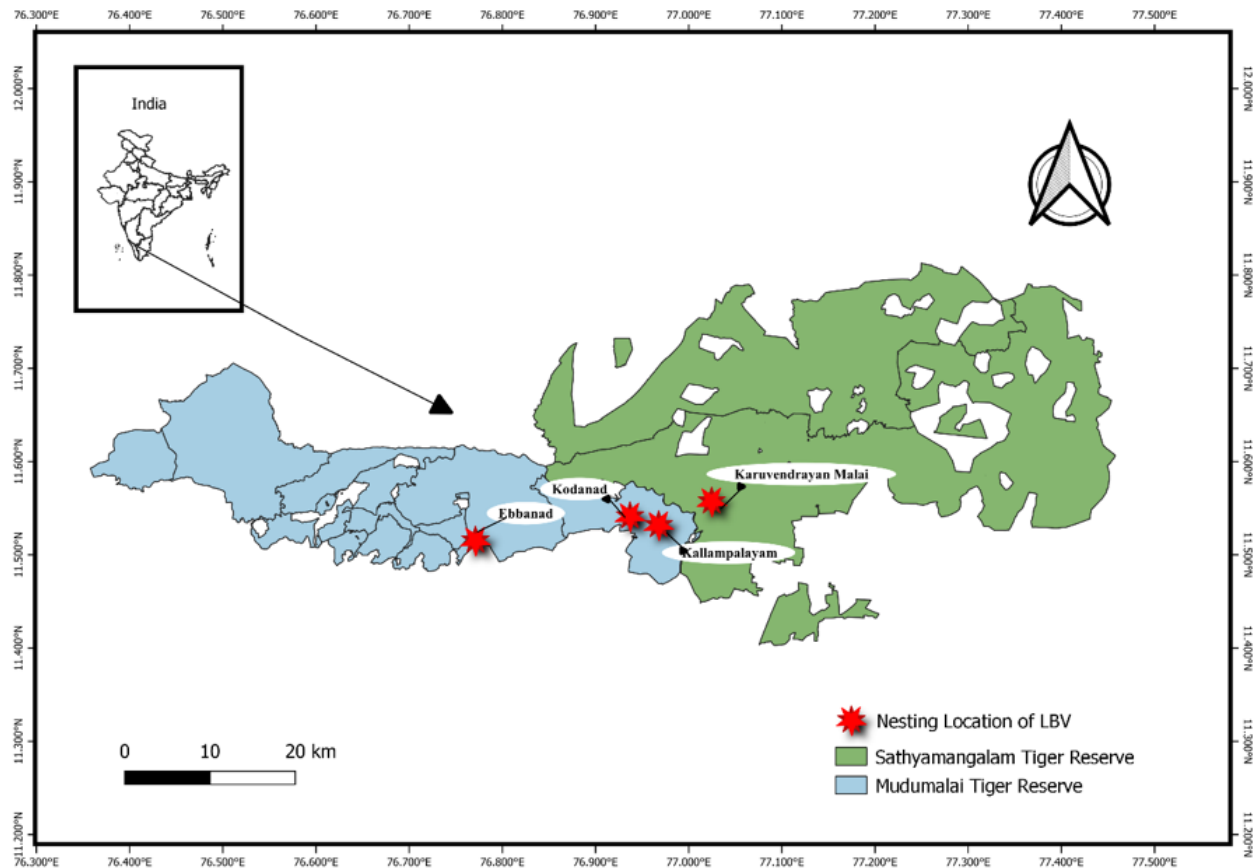


Figure 1. Study area and nesting locations of Long-billed Vultures (LBV) *Gyps indicus* in Nilgiri Biosphere Reserve.

and birds' behaviour. All observations were made using a spotting scope (Nikon Pro Staff 3 16–48 x 60) and binoculars (Nikon Monarch M5 12 x 42 binoculars) from about 100–250 m to minimize disturbance. Also, we noted any potential threats detected near nesting sites. We consulted published literature to assess the availability of NSAIDs in the area (Manigandan 2018). After analyzing the information, we went to nearby villages for further investigation of each of the threats to vultures. We investigated whether vultures had died of poisoning with the community stakeholders along with the details of the mortality of cattle. Between 2018 and 2020, we conducted surveys involving 208 pharmacy shops within the vulture safe zone area. These surveys were carried out covertly, with the help of local community posing as livestock owners. The objective was to assess the presence of NSAIDs that are harmful to vultures in these establishments.

RESULTS AND DISCUSSION

The study identified four distinct nesting colonies of the LBV (Table 1). All breeding sites were on rock cliffs adjacent to the river Moyar or its streams (Images 1, 2). No LBVs were found breeding on trees. The locations of all breeding sites detected together with habitat features, are presented in (Tables 1, 2). Breeding success across the colonies and between years averaged 70.83% (Table 3). The reasons for nest failures were not determined directly, but in the breeding season of 2018–2019, high breeding productivity of 83.33% was observed across all four nesting colonies combined. Subsequently, during the breeding season of 2019–2020, an overall breeding success rate of 66.66% was recorded in the three LBV nesting colonies collectively. However, the breeding success rate dropped to 62.5% in the season of 2020–2021. A new nesting site was found in the 2020–2021 breeding season, but this site did not yield successful breeding (Table 3). The LBV population monitoring revealed only minor fluctuations. The highest count of LBV individuals (21) was documented in the breeding

season of 2020–2021. The previous breeding seasons, 2018–2019 and 2019–2020 had maximum sightings of 17 and 16 individuals, respectively (Table 1).

From our field observations and interactions with local pharmacies, we confirmed that drugs that are harmful to vultures (Nimesulide, ketoprofen, aceclofenac, and flunixin) are still available in villages near the LBV nesting area. We conducted an inspection of nesting trees along major rivers like Moyar, Sigur, and Siriyur, in these areas, and potential nesting places to search for LBV nests. We also interacted with the forest department field staff to find out if there were any LBV nests in trees during our regular monitoring and found no tree-nesting of LBV in the study area. Notably, all identified nests of Kallampalayam and Ebbanad nesting sites were situated on east-facing cliffs.

The LBV population remained relatively stable over the three years. But notably, the Ebbanad nesting colony, in the years 2018–2019 harbored two nests, but only one nest in the subsequent breeding season. This decline was attributed to observed frequent disturbance by visitors from a nearby cottage frequented by tourists that resulted in the birds being repeatedly flushed and may have caused the birds to leave their nesting location. An illegally constructed cottage (Hitten Valley) was located 100–150 m away from the colony with a viewpoint arranged for the tourists. We observed people screaming and shouting during the daytime, followed by campfires in the night. Notably, in the breeding season

Table 1. Population trend of Long-billed Vulture *Gyps indicus* in three breeding seasons from 2018–2021.

Name of the nesting colonies	Long-billed Vulture population		
	2018–2019	2019–2020	2020–2021
Ebbanad	6	3	5
Kodanad	8	8	5
Kallampalayam	3	5	9
Karuvendrayan Malai	0	0	2
Total	17	16	21



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Image 1. Long-billed Vulture *Gyps indicus* in the Kallampalayam nesting site.



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Image 2. Landscape and Long-billed Vulture *Gyps indicus* nesting location of Kodanadu nesting site.

Table 2. Nesting habitat of Long-billed Vulture (LBV) *Gyps indicus* in the study area.

LBV nesting colony site	Protected area	Type of forest	Elevation (m)	GPS location		Distance from the nearest village
				Latitude N	Longitude E	
Ebbanad	MTR	Dry thorn and moist deciduous	1,064	11.515174°	76.770592°	1.88 km
Kodanad	MTR	Dry thorn and moist deciduous	1,661	11.538914°	76.911514°	2.27 km
Kallampalayam	MTR	Moist deciduous	854	11.532109°	76.967859°	3.11 km
Karuvendrayan Malai	STR	Moist deciduous	830	11.560016°	77.024215°	3.71 km

MTR—Mudumalai Tiger Reserve | STR—Sathya Mangalam Tiger Reserve.

of 2020–2021, after the closure of this cottage, the number of LBV nests increased (from one to two) in the Ebbanad nesting colony (Table 3). The Kodanad nesting colony encountered the impact of the 2019 forest fires as this nesting site has an approximate 50% grass cover in the area. This incident almost certainly caused the LBV pairs to abandon their nests as the nesting sites were surrounded by grassland, and the impact of flames reached the nests in December 2019. We recommend taking proactive steps to prevent fires. To reduce the impact of forest fires on vulture colonies, it is imperative to strategically plan pre-fire activities during non-breeding periods. The Kallampalayam nesting colony exhibited a positive trend, with 100% breeding success rate in 2020–2021. This success is likely due to the colony's limited exposure to forest fires and lower human disturbances, as no signs of human presence were detected near the nesting area during the study period.

Poison baits incident

The regular monitoring led to the discovery of a poison-bait mortality incident within the Karuvendrayan malai nesting colony. LBVs were observed incubating during November 2020; however, they were conspicuously absent from this nesting site in December 2020 and January 2021. This deviation from expected nesting behavior prompted further investigation. It was discovered that on 3 December 2020, four Asiatic Wild Dogs had succumbed to a poison-bait incident in the vicinity. Significantly, it was reported by locals that three vultures had also indirectly fallen victim to the poisoning, apparently a case of retaliatory killing of wild carnivores which had recently caused mortality in domestic livestock. Several locals were arrested for this incident by the forest department and this is subject to further investigation. Instances of vulture fatalities due to poison baits necessitate thorough investigations to ascertain the motivation and full circumstances relating

to the incidents, and it is often difficult to establish the full story. Identifying the sources and mechanisms of poisoning is essential to allow the implementation of targeted interventions to prevent further losses (Ogada et al. 2012).

Evidence of other threats

Interestingly, the fatality of a Himalayan Griffon Vulture was observed under powerlines, apparently a result of electrocution in NBR (Manigandan et al. 2021) with a burning smell of tissues reported although no tissue testing was done due to a lack of facilities.

The potential accessibility of harmful substances to vultures, specifically from toxic NSAIDs (Nimesulide, ketoprofen, aceclofenac, and flunixin) which were found to be available for use in cattle from local pharmacy outlets adds to the threat to vultures as the covert survey done during the period from the proposed VSZ (Manigandan 2018). Apart from the wider availability of safer drug meloxicam, other harmful drugs sold in the market such as ketoprofen and nimesulide is a major concern in vulture conservation of NBR, as this study concentrated on pharmacies in the districts of Nigiris, Erode, Tirupur and Coimbatore, adjacent to the VSZ. The collaborative efforts of the forest department and local NGOs in monitoring the availability of NSAIDs in pharmacy shops are commendable as they create awareness among the local community, pharmacy shop owners, and staff about the importance of vultures in society and the harmful effects of NSAIDs. However, pharmacy shop owners are only aware of diclofenac and not aware of other harmful drugs (Manigandan et al. 2023). To prevent the accidental poisoning of vultures, it is important to make sure that these substances are not accessed by vultures and above all that they are not used in livestock practices when affordable alternatives like meloxicam and tolfenamic acid are available. Villagers typically bury naturally deceased cattle, while livestock killed by wild animals, particularly those within

Table 3. Breeding success of Long-billed Vultures *Gyps indicus* from 2018–2021 (three seasons).

Name of the nesting colony	2018–2019					2019–2020					2020–2021					Overall %
	Total number of nests with eggs	Number of nests seen with hatchlings	Number of hatchlings successfully fledged	Hatching success percentage	Total number of nests under incubation	Number of nests seen with hatchlings	Number of hatchlings fledged	Hatching success percentage	Total number of nests under incubation	Number of nests seen with hatchlings	Number of hatchlings fledged	Hatching success percentage	Total number of nests under incubation	Number of nests seen with hatchlings	Number of hatchlings fledged	Hatching success percentage
Ebbanad	2	2	2	100	1	1	1	100	2	1	1	50	2	1	1	83.3%
Kodanad	3	2	2	66.66	3	2	2	66.66	2	1	1	50	2	1	1	61%
Kallampalayam	1	1	1	100	2	1	1	50	3	3	3	100	3	3	3	83.3%
Karuvendrayan Malai	-	-	-	-	-	-	-	-	1	0	0	0	1	0	0	0
Total	6	5	5	83.33	6	4	4	66.66	8	5	5	62.5	8	5	5	70.83%

the forest, are left in the open and available to vultures. If such incidents occur near the village, the animals are always buried.

CONCLUSION

To tackle the challenges faced by vulture conservation, the approach of the establishment of vulture-safe zones has been developed (Thapa et al. 2009; Mukherjee et al. 2014; Insua-Cao et al. 2022). Such conservation endeavors are playing a key role in safeguarding the remaining LBV population in NBR, along with the other nesting vulture species in the area, White-rumped Vulture (WRV). The conclusions from this three-year study suggest that vulture safe zone activities may best focus in this area on the following: a) optimizing fire management practices; b) controlling NSAID availability for veterinary use; c) investigating poison baits incidents; and d) monitoring the threat and safety of power infrastructure. Hence, a comprehensive vulture safe zone approach will be needed addressing all of these issues along with raising local awareness of the positive attributes of vultures. Local human disturbance may also be a further threat. The imperative lies in the coordinated commitment of researchers, government agencies, NGOs, and local communities to ensure the long-term survival of LBV populations. In conclusion, this monitoring study demonstrates how local threats can be determined through regular monitoring and follow-up, and how widescale vulture safe zone work is needed to secure the future of vulture populations.

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Articles

Unearthing calf burials among Asian Elephants *Elephas maximus* Linnaeus, 1758 (Mammalia: Proboscidea: Elephantidae) in northern Bengal, India

– Parveen Kaswan & Akashdeep Roy, Pp. 24615–24629

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

– Debosmita Sikdar, Shwetadri Bhandari & Sanjay Paira, Pp. 24630–24645

Avifaunal assemblage patterns in Bharathapuzha River Basin, Kerala, India

– Pazhayattuparambil Narayanan Anoop Raj, Avadhoot Dilip Velankar & Padmanabhan Pramod, Pp. 24646–24657

Desmids of Brahmaputra valley, a major southern Asian river basin

– Soumin Nath & Partha Pratim Baruah, Pp. 24658–24693

Communications

Distribution status and roost characteristics of Indian Flying Fox *Pteropus medius* Temminck, 1825 (Mammalia: Chiroptera: Pteropodidae) in Kurukshetra district, Haryana, India

– Ritu Devi & Parmesh Kumar, Pp. 24694–24706

Avifauna of four protected areas of Terai-Arc Landscape, India: significant records and a checklist of species

– Shariq Safi, Tanveer Ahmed, Junid Nazeer Shah, Meraj Anwar & Kamlesh K. Maurya, Pp. 24707–24729

Monitoring observations of the southernmost breeding population of Long-billed Vultures *Gyps indicus* (Scopoli, 1786) (Aves: Accipitriformes: Accipitridae) in the Nilgiri Biosphere Reserve, India

– S. Manigandan, H. Byju & P. Kannan, Pp. 24730–24736

Observations on Indian Skimmer *Rynchops albicollis* Swainson, 1838 (Aves: Charadriiformes: Laridae) breeding colonies in Middle Ganges stretch, India

Kumar Ankit, Mujahid Ahamad, Vivek Ranjan, Sanjay Kumar, Syed Ainul Hussain & Govindan Veeraswami Gopi, Pp. 24737–24745

Avifaunal diversity in urban greenspaces within Cotabato city, Mindanao Island, Philippines

– Joan Rhea Mae L. Baes, Peter Jan D. de Vera, John Paul A. Catipay, Marian Dara T. Tagoon & Elsa May Delima-Baron, Pp. 24746–24751

Waterbird count at Narathali waterbody, Buxa Tiger Reserve in northern Bengal for a decade (2009–2019) with a note on raptors

– Sachin Ranade & Soumya Sundar Chakraborty, Pp. 24752–24759

First confirmed reproduction by a translocated female Siamese Crocodile *Crocodylus siamensis* (Crocodylidae: Crocodilia) with observations of nest attendance and nest-associated fauna

– Steven G. Platt, Sounantha Boutxakittilath, Oudomxay Thongsavath, Samuel C. Leslie, Lonnie D. McCaskill, Randeep Singh & Thomas R. Rainwater, Pp. 24760–24768

Erode Ground Gecko *Cyrtodactylus speciosus* (Beddome, 1870) (Squamata: Gekkonidae) from peri-urban common-lands of Coimbatore, India, with comments on habitat associations

– S.R. Ganesh, N.A. Swaathi & Usha Ravindra, Pp. 24769–24774

Assessment of diversity of Odonata fauna in selected sites of Purba Bardhaman district, West Bengal, India

– Sulagna Mukherjee & Rabindranath Mandal, Pp. 24775–24785

A preliminary assessment of butterfly diversity from Mekhliganj town, Cooch Behar District, West Bengal, India

– Abhirup Saha, Prapti Das & Dhiraj Saha, Pp. 24786–24794

Utilization of *Afzelia africana* Sm. ex Pers. (Magnoliopsida: Fabales: Fabaceae) in Nigeria and its implications for conservation

– Samuel Oloruntoba Bamigboye, Muhali Olaide Jimoh, Falilat Abeni Lawal, Zainab Temitope Osiyemi, Charles Petrus Laubscher & Learnmore Kambizi, Pp. 24795–24803

Short Communications

Gastrointestinal parasites of the Indian Flying Fox *Pteropus medius* in Nagpur City: a seasonal study through faecal sample analysis

– Ruchika R. Sangale & Priya Gawande, Pp. 24804–24806

***Plagiochila javanica* (Sw.) Nees & Mont. (Marchantiophyta: Plagiochilaceae) rediscovered from the Western Ghats after 180 years**

– M.S. Sajitha, C.N. Manju, B. Mufeed, K.P. Rajesh & K.K. Rawat, Pp. 24807–24811

A new record of genus *Synedrus* Graham, 1956 with description of male of *Synedrus kasparyani* Tselikh, 2013 from India

– Mubashir Rashid & Arvind Kumar, Pp. 24812–24815

Note

***Hunteria zeylanica* (Retz.) Gardner ex Thwaites (Magnoliopsida: Gentianales: Apocyanaceae)—new addition and first genus record to the flora of Karnataka**

– G. Ramachandra Rao, Pp. 24816–24818

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