

Diurnal raptors of Eastern Himalayan foothills: Taxonomic and functional diversity attributes

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Abstract Raptors are crucial indicators of ecosystem health, and thus, requires research attention. Despite an upsurge in Indian ornithology, raptors remain poorly studied, particularly in Northeast India. Here, we measured the taxonomic and functional diversity of raptors in Manas National Park, Assam. The study was conducted between 2018–2022. We surveyed 39 standard transects and recorded 776 individuals of raptors belonging to 30 species in different habitats: forest, open and mosaic. The taxonomic alpha diversity was highest in mosaic habitat and lowest in the forest habitat. Crested Serpent Eagle (*Spilornis cheela*) was the most abundant raptor in open and forest habitats, while Collared Falconet (*Microhierax caerulescens*) was dominating in mosaic habitats. Of the recorded raptor species, 66.67% were classified as residents, and 33.37% were winter migrants. We also measured the functional alpha diversity of raptors using the data collected from AVONET database. We used ten functional traits and evaluated the functional alpha diversity indices. The functional richness was the highest in open habitats and functional divergence was the highest in mosaic habitats, also functional evenness was the highest in open habitats and lowest in mosaic habitats. We suggest intensified research on raptors in the region, to identify and address critical research question which facilitates the conservation of these apex predators.

Keywords: birds of prey, richness, abundance, functional traits, Assam

Összefoglalás A ragadozómadarak az ökoszisztéma egészségének kulcsfontosságú mutatói, ezért fokozott figyelmet kell fordítani kutatásukra. Az indiai ornitológia fellendülése ellenére a ragadozómadarakat továbbra is kevésbé tanulmányozzák, különösen Északkelet-Indiában. Jelen tanulmányban a ragadozómadarak taxonómiai és funkcionális diverzitását mértük fel az asszámi Manasz Nemzeti Parkban. A vizsgálatot 2018 és 2022 között végeztük. 39 transektet vizsgáltunk, és 30 faj 776 egyedét regisztráltuk különböző élőhelyeken: erdőben, nyílt és mozaikos területeken. A taxonómiai alfa-diverzitás a mozaikos élőhelyen volt a legmagasabb, az erdei élőhelyen pedig a legalacsonyabb. A nyílt és az erdei élőhelyeken a kontyos kígyász (*Spilornis cheela*) volt a leggyakoribb ragadozómadár, míg a mozaikos élőhelyeken az indiai verébsólyom (*Microhierax caerulescens*) dominált. A regisztrált ragadozómadár-fajok 66,67%-a állandó, 33,37%-a pedig téli vonuló volt. A ragadozómadarak funkcionális alfa-diverzitását is kiszámoltuk az AVONET adatbázisból gyűjtött adatok alapján. Tíz funkcionális tulajdonságot használtunk, és kiértékeljük a funkcionális alfa-diverzitás indexeit. A funkcionális fajgazdagság a nyílt élőhelyeken, a funkcionális diverzitás pedig a mozaikos élőhelyeken, valamint a funkcionális egyenletesség a nyílt élőhelyeken volt a legmagasabb, de a mozaikos élőhelyeken a legalacsonyabb. Javasoljuk a ragadozómadarak intenzívebb kutatását a régióban, hogy meghatározzuk és körüljárjuk azokat a kritikus kutatási kérdéseket, amelyek elősegítik a csúcsragadozók védelmét.

Kulcsszavak: fajgazdagság, funkcionális jellegek, gyakoriság, ragadozómadarak, Asszam

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Introduction

Raptors or birds of prey are one such avian group which serve as excellent indicators of environmental health (Donázar *et al.* 2016) and habitat quality (Sergio *et al.* 2008), and also are key ecosystem service providers (O'Bryan *et al.* 2018). The presence of raptors in an area advocates high level of biodiversity (Sergio *et al.* 2006, 2008). These birds play a key role in maintaining ecological stability of an area (Sergio *et al.* 2008). Raptors, being apex predators in trophic levels with large home ranges and low population density, are more susceptible to anthropogenic stress compared to other birds (Newton 1979, Owens & Bennett 2000, Santangeli *et al.* 2019). Moreover, habitat alteration (Bierregaard 1998, Watson 1998) and contamination of the environment (Newton 1979) further add to their survival threats. *Gyps* vultures in the Indian subcontinent suffered a tragic decline of 99% during the 1990s, owing to the use of a veterinary drug “diclofenac” for cattle (Prakash *et al.* 2003, 2012, 2019, Green *et al.* 2004, Oaks *et al.* 2004). Other than vultures, diclofenac toxicity was also observed in a study (Sharma *et al.* 2014), which highlights the vulnerability of these raptors to contamination. Other anthropogenic threats to raptors include habitat alterations (Thiollay 1998, Goriup & Tucker 2007), killing (Symes 2012, Dalvi & Haralu 2014, Brochet *et al.* 2019), poisoning (Oaks *et al.* 2004, Galligan *et al.* 2014, Ogada *et al.* 2016), electrocutions (Lehman 2001, Angelov *et al.* 2013, Kagan 2016, Mojica *et al.* 2018), collisions (Cusa *et al.* 2015), road kills (Klippel *et al.* 2015), and climate change (Franke 2017, Iknayan & Beissinger 2018, McClure *et al.* 2018).

Species richness and abundance of raptor communities are highly influenced by habitat heterogeneity and prey availability (White 1974), as habitat types (Guisan *et al.* 2017) and their utilization (Morrison 2012) largely determine the species-habitat interactions in an area. The species-habitat relationship also determine the migration of species in different regions (Gavashelishvili & McGrady 2006, Hansson & Åkesson 2014), which again affect the distribution of species across a geographical area (Carnicer *et al.* 2012). Raptors occur in low densities and have a wide range (Newton 1979, Fuller & Mosher 1981) which makes them difficult to study. However, considering the role of the raptor species in ecosystem functioning, it is of high importance to study the functional role of these birds in ecosystem functioning and diversity. With the advancement of the different measurement tools/indices in the field of biodiversity studies, now we are able to efficiently measure such role. In this context, protected areas are important zones of interest as other ecosystem elements are less disturbed in these areas.

Although ornithology in India has flourished over time, raptors remain poorly studied in general, compared to other bird groups. The research trend is highly skewed, with 60% publications devoted to only ten species (Mahananda *et al.* 2022). Raptor studies in Northeastern India is very scarce relative to other parts of the country (Mahananda *et al.* 2022), even though the region is rich in raptors and other birds. Hence the present study emphasized on the species diversity and functional diversity of diurnal raptors in Manas National Park, Assam.

Material and Methods

Study area

The study was carried out in Manas National Park, which is located between 26.623° – 26.822° N and 90.808° – 91.251° E in the foothills of the Eastern Himalayas, in Baksa and Chirang districts of the state of Assam, India (*Figure 1*). The park covers an area of 850 km², and is situated at the junction of Indo-Gangetic, Indo-Malayan and Indo-Chinese biogeographic realms (BirdLife International 2003), and is a part of Brahmaputra Valley biogeographic province, harboring Assam valley semi-evergreen forests and Terai-duar wet alluvial savanna grasslands (Champion & Seth 1968). It is also considered as an important bird area with diverse avifauna including globally threatened species (BirdLife International 2024).

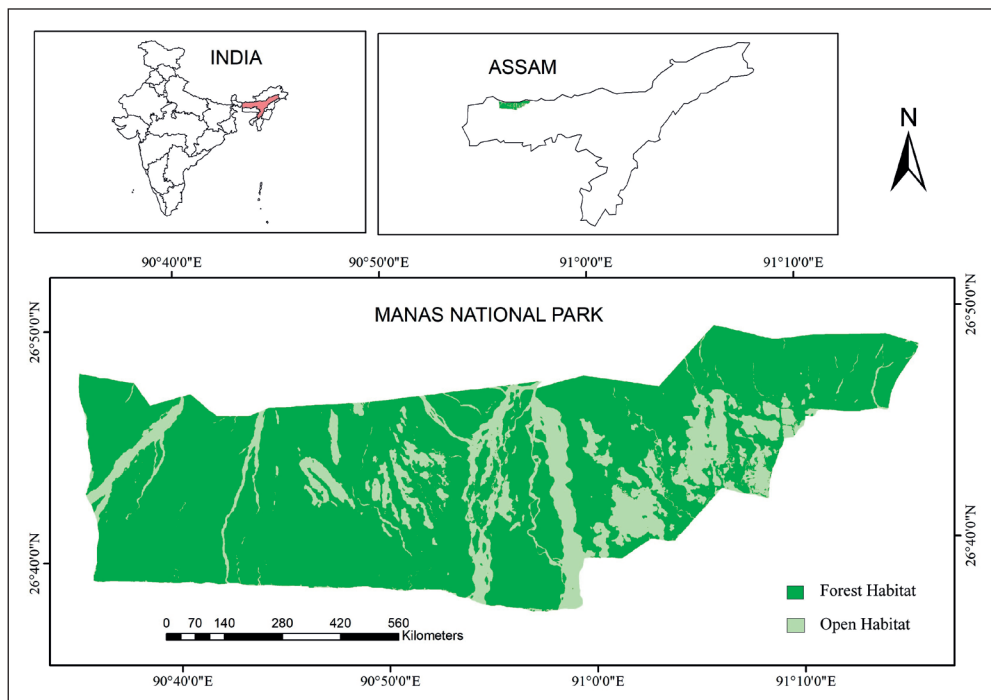


Figure 1. Map of Manas National Park showing the forest and open habitats

1. ábra A Manasz Nemzeti Park térképe az erdei és nyílt élőhelyek feltüntetésével

Sampling design

The selected study area was divided into 2×2 km grids, so that each grid can be easily covered in a day. We established 39 line transects of 2 km each in the selected area in a semi random manner based on accessibility, which were usually provided by the roads and trails. The transects were designed to be included in different grids, without overlaps (*Figure 2*). We assigned the habitat types based on field observations. During the surveys whenever

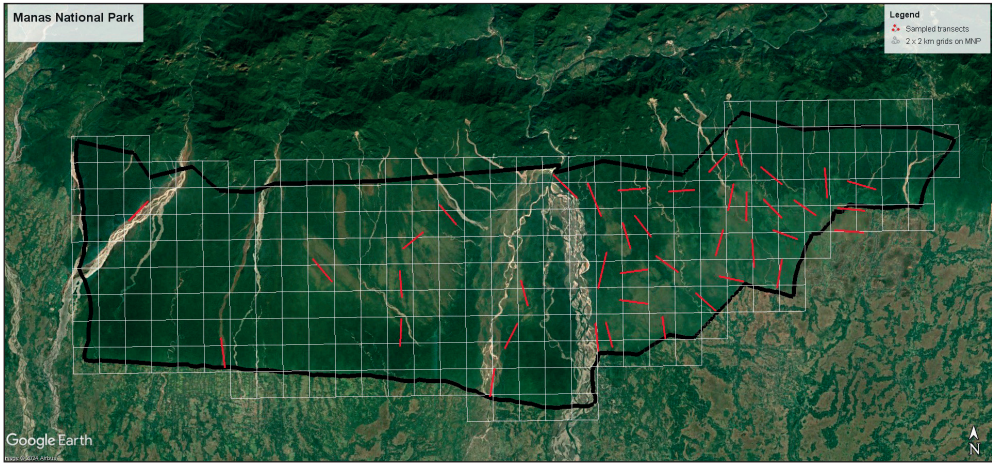


Figure 2. Map of Manas National Park showing line transects (red color) and 2×2 km grids

2. ábra A vonal transzektek (piros) és a 2×2 km háló elhelyezkedése a Manasz Nemzeti Park területén

Table 1. Geographical coordinates of the line transects and their habitat types
1. táblázat A vonal transzektek koordinátái és az élőhely típusa, amiben kijelöltük őket

Transects	Geographical Coordinates				Habitat type
	Start point		End point		
T1	26.66283	91.00211	26.68065	90.99679	Open
T2	26.70275	90.99093	26.72755	90.99740	Open
T3	26.75167	90.99344	26.77513	90.98272	Open
T4	26.78060	90.95674	26.76458	90.97502	Open
T5	26.74799	91.01010	26.73021	91.01576	Open
T6	26.72534	91.03540	26.71454	91.05259	Forest
T7	26.69552	91.00795	26.69299	91.02910	Open
T8	26.68429	91.04062	26.67032	91.04212	Mosaic
T9	26.68795	91.08163	26.70044	91.06551	Mosaic
T10	26.70822	91.10302	26.71159	91.08401	Mosaic
T11	26.72596	91.08106	26.74356	91.08708	Mosaic
T12	26.75673	91.09080	26.77494	91.09503	Mosaic
T13	26.78765	91.10153	26.80534	91.09695	Mosaic
T14	26.71789	91.11094	26.73734	91.10922	Mosaic
T15	26.70388	91.12840	26.72374	91.13232	Open
T16	26.73721	91.14433	26.74363	91.12553	Forest
T17	26.66295	90.83911	26.68202	90.84003	Mosaic
T18	26.69712	90.84017	26.71516	90.38857	Mosaic
T19	26.72992	90.84101	26.74180	90.85670	Mosaic
T20	26.76003	90.86889	26.74642	90.88217	Open

Transects	Geographical Coordinates				Habitat type
	Start point		End point		
T21	26.77056	91.00606	26.77183	91.02738	Forest
T22	26.76965	91.04493	26.77105	91.06501	Mosaic
T23	26.78294	91.07621	26.79618	91.08996	Forest
T24	26.71369	91.00808	26.71637	91.02924	Mosaic
T25	26.74961	91.10457	26.76912	91.10500	Open
T26	26.76423	91.11864	26.75105	91.13252	Open
T27	26.78638	91.11621	26.77488	91.13240	Open
T28	26.76397	91.14170	26.75344	91.15854	Mosaic
T29	26.76526	91.16718	26.78580	91.16572	Open
T30	26.77698	91.18292	26.77142	91.20505	Mosaic
T31	26.62916	90.90834	26.64841	90.91111	Open
T32	26.66182	90.91931	26.67956	90.92919	Mosaic
T33	26.69125	90.93683	26.70919	90.93155	Open
T34	26.75676	91.19618	26.75872	91.17481	Open
T35	26.74165	91.19497	26.74360	91.17382	Forest
T36	26.73888	91.03124	26.75361	91.01888	Mosaic
T37	26.74821	90.63066	26.76183	90.64536	Mosaic
T38	26.64831	90.70501	26.66867	90.70189	Mosaic
T39	26.70758	90.78655	26.72239	90.77199	Mosaic

the study encountered a raptor, it was classified into the following habitat categories: open habitats (grasslands, swamps, agricultural field and riparian areas, rivers and wetlands), forest habitats (closed canopy woodlands) and mosaic habitats (a matrix of open and forest habitats, etc.) (*Table 1*).

Data collection

The transect surveys were carried out between 2018–2022 (except the Covid 19 lockdown period). We drove on an open vehicle (Fuller & Mosher 1987) to the grid location and surveyed on foot. We recorded the species, its abundance and habitat type during the surveys. Each transect survey was repeated five times. The surveys were carried out from 06:00 to 12:00 hr during the peak soaring time of raptors (Thiollay & Meyburg 1988), in post monsoon and winters to accommodate the migratory raptors. Sampling was not performed in adverse weather conditions such as heavy rainfall and thunderstorms, due to difficulty in field survey. For functional diversity analyses, the functional traits data of raptors were obtained from the publicly available global database of AVONET (Tobias *et al.* 2022).

Data analyses

Species diversity and habitat similarity attributes

The species diversity was assessed obtaining the number of species and their abundance in all three habitat types (*Appendix A*). It was measured using the Shannon-Wiener index (H') (Shannon & Weaver 1949), which uses pooled number and abundance of each species in each habitat type, and also their evenness (J'). Species accumulation curve was plotted to evaluate the representativeness of the sampled species in the community. We also plotted individual-based rarefaction curves to compare species richness between habitats. We estimated the shared species richness between habitats using four similarity indices: Euclidean distance index, Bray-Curtis index (BC), Jaccard index (JI) and Morisita-Horn index (MH) (Magurran 2004). All the statistical analyses were executed in R 4.0.2 programming platform (R Core Team 2013). We applied the BiodiversityR (Kindt 2019) and VennDiagram (Chen & Boutros 2011) packages available within the R statistical programming framework.

Functional diversity attributes

The Functional data collected were analyzed using the R package “mFD” (Magneville *et al.* 2022), which uses three different frameworks i.e. groups of species, pairwise trait-based distances between species, and species coordinates in a multidimensional space. We used species occurrence data and raptor-traits data to measure different functional diversity indices.

Results

Species richness and diversity

The study recorded 30 species and 776 individuals of raptors belonging to 3 families within the three different habitats (*Appendix 1*). Of these, 66.67% were residents (20 species), and 33.37% were winter migrants (10 species). Species richness was observed as the highest in open habitat (28 species, $J' = 0.93$), followed by mosaic habitat (27 species, $J' = 0.94$), and lowest in forest habitat (20 species, $J' = 0.96$) (*Figure 3*). Shannon-Wiener Index was highest in mosaic habitat ($H' = 3.15$), followed by open habitat ($H' = 3.12$), and lowest in forest habitat ($H' = 2.72$). The rarefaction curve showed that raptor species reached its asymptote in all the three habitats indicating that the sampling was adequate (*Figure 4*).

Rank-abundance of raptors

A total of 776 individual raptors were recorded during the study, including 374 individuals in open habitat (48.1%), 326 in mosaic habitat (42%) and 76 individuals in forest habitat (9.7%). Collared Falconet (*Microhierax caerulescens*) was the dominating species in numbers in mosaic habitat, and Crested Serpent Eagle (*Spilornis cheela*) was the most abundant species

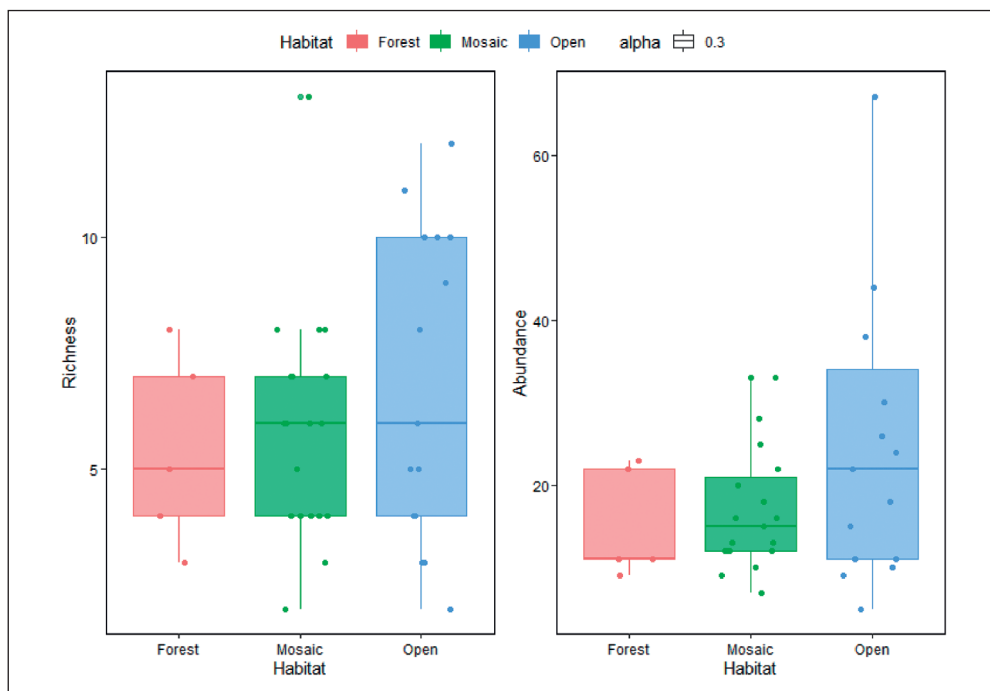


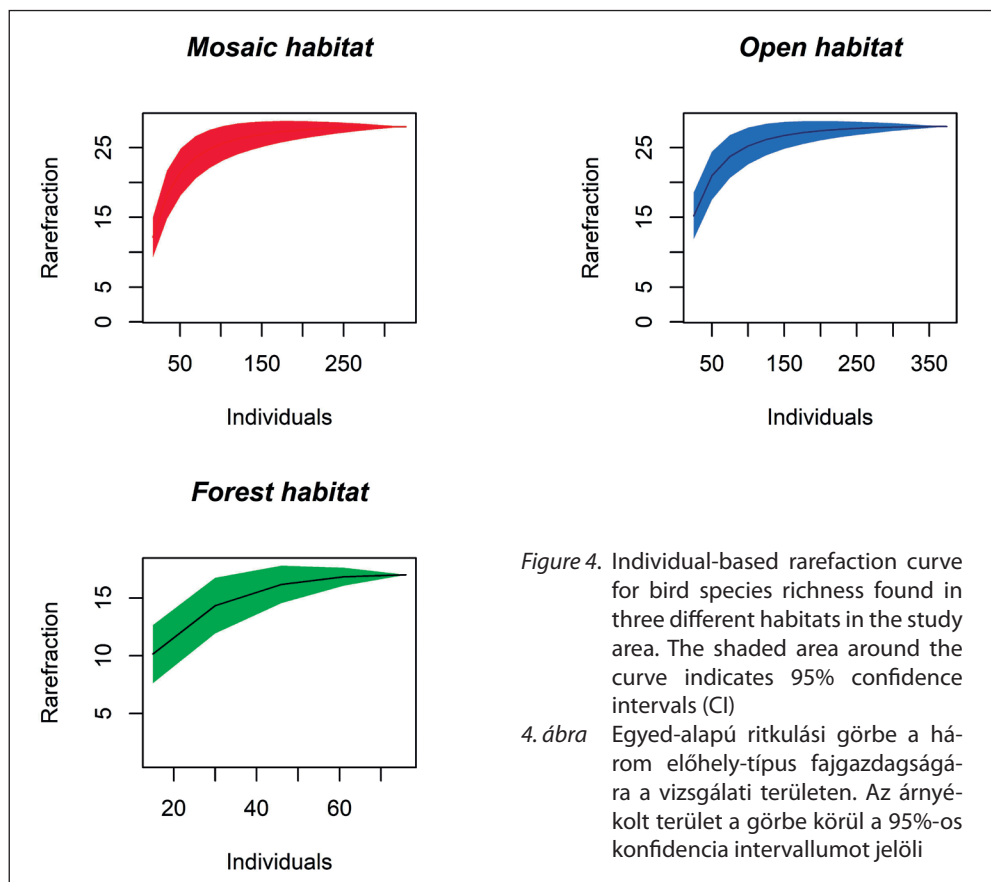
Figure 3. Richness and abundance of raptors in three habitats in the study area. The box is the interquartile range. The upper and lower edges of the box plots represent the 75% and 25% quartile of data, respectively. The horizontal line i.e. the median represents the 50% quartile. The vertical lines are the upper and lower whiskers

3. ábra A ragadozó madarak fajgazdagsága és gyakorisága a három élőhelytípusban a vizsgálati területen

in both open habitat and forest habitat. The raptors were more evenly distributed in mosaic habitat (Figure 5). Also, the Crested Serpent Eagle was the most abundant species in Manas National Park, followed by Collared Falconet (Figure 6).

Shared species richness and pairwise comparisons among habitats

During our survey, nineteen raptor species: Crested Serpent Eagle (*Spilornis cheela*), Changeable Hawk-eagle (*Nisaetus cirrhatus*) Black Eagle (*Ictinaetus malaiensis*), Booted Eagle (*Hieraaetus pennatus*), Short-toed Snake Eagle (*Circaetus gallicus*), Steppe Eagle (*Aquila nipalensis*), Greater Spotted Eagle (*Clanga clanga*), Black-winged Kite (*Elanus caeruleus*), Oriental Honey Buzzard (*Pernis ptilorhynchus*), Long-legged Buzzard (*Buteo rufinus*), Jerdon's Baza (*Aviceda jerdoni*), Shikra (*Accipiter badius*), Himalayan Vulture (*Gyps himalayensis*), Pied Harrier (*Circus melanoleucos*), Hen Harrier (*Circus cyaneus*), Peregrine Falcon (*Falco peregrinus*), Eurasian Kestrel (*Falco tinnunculus*), Red-necked Falcon (*Falco chicquera*), and Collared Falconet (*Microhierax caerulescens*) were found to occur in all the three habitats. Among the habitats, species richness was shared highest between mosaic (MO) and open (OP) habitats (27 species), followed by forest (FO) and open



(OP) habitats which shared 19 species, and forest (FO) and mosaic (MO) habitats also shared 19 species (Figure 7). Bray-Curtis index (BC) showed that there were higher dissimilarities between FO and OP, and Jaccard Index (JI) showed higher similarities between MO and OP (Table 2). The Morisita-Horn Index (MH) suggested that raptor compositional similarity was higher between FO and OP habitat, followed by FO and OP and FO and MO. Also, the Euclidean distance index (ED) showed greater similarity between FO and OP habitats, followed by FO and MO and lowest similarity between OP and MO habitats (Table 2).

Functional diversity

The functional alpha-diversity measured the variation is species composition in the three habitats based on 10 functional traits (Appendix 2, Table 3). The functional richness was highest in open habitats and lowest in forest habitats. The functional divergence was highest in mosaic habitat and lowest in forest habitat. Evenness in distribution of functional traits was highest in open habitats and lowest in mosaic habitats. A dendrogram was also plotted using linkage clustering of the 30 species based on their shared functional traits using Gower's distance which calculates the similarity between pairs of variables (Figure 7).

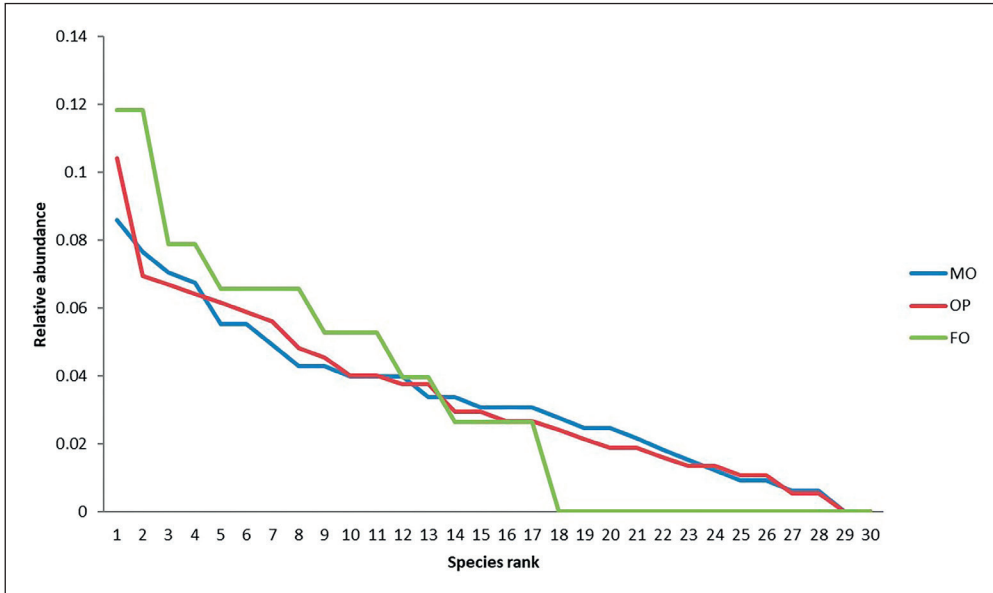


Figure 5. The rank-abundance curve showing the evenness of raptor species in each habitat type; MO = Mosaic habitat, OP = Open habitat and FO = Forest habitat

5. ábra Az egyes élőhelytípusokban a fajok egyenletességét mutató rang-abundancia görbe; MO = mozaik élőhely, OP = nyílt élőhely és FO = erdei élőhely

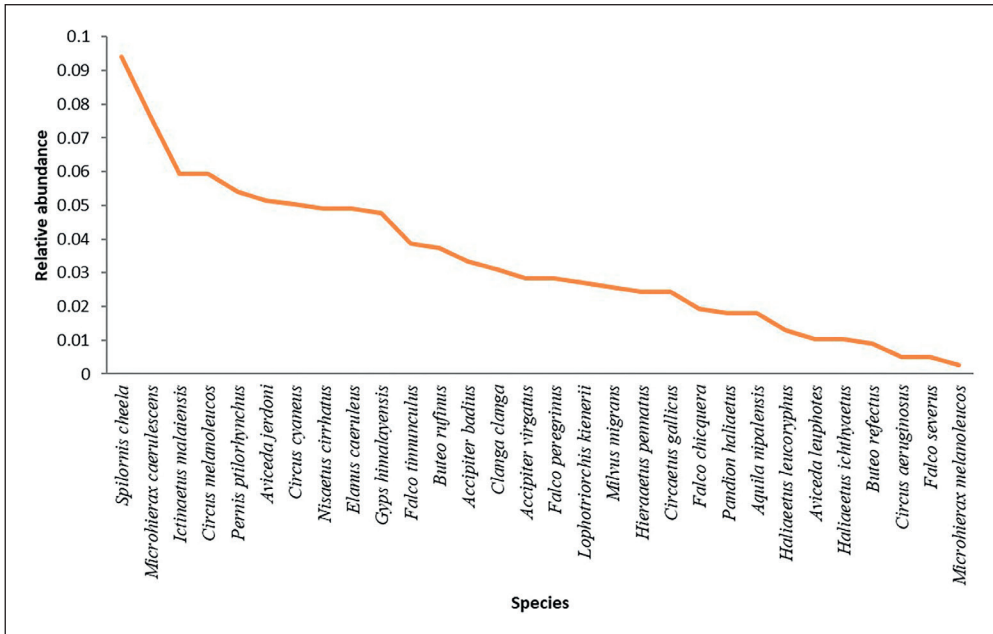


Figure 6. The relative abundance of species showing the most dominating raptor in Manas National Park

6. ábra A fajok relatív gyakorisága a legdominánsabb fajjal a Manasz Nemzeti Parkban

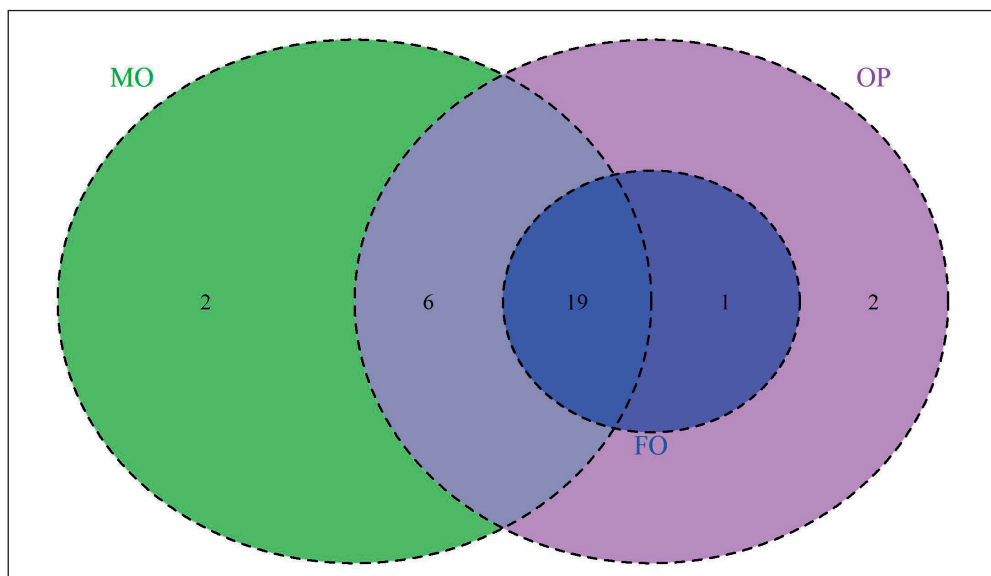


Figure 7. Venn diagram showing the number of shared species among the three different habitat types; MO: Mosaic habitat, FO: Forest habitat, OP: Open habitat

7. ábra Venn-diagram az egyes élőhely-típusok közös fajainak számával; MO: mozaik élőhely, OP: nyílt élőhely és FO: erdei élőhely

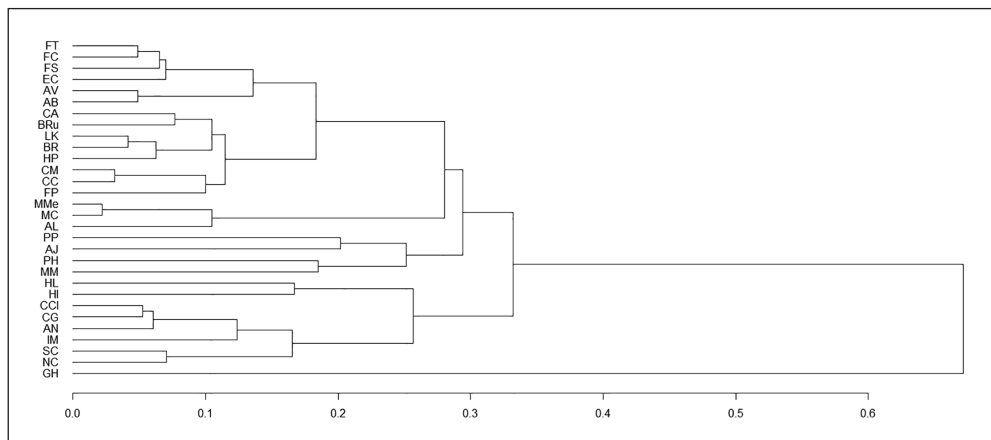


Figure 8. Cluster dendrogram showing the functional relationships shared by the 30 different species (FT: *Falco tinnunculus*, FC: *Falco chicquera*, FS: *Falco severus*, EC: *Elanus caeruleus*, AV: *Accipiter virgatus*, AB: *Accipiter badius*, CA: *Circus aeruginosus*, BRu: *Buteo rufinus*, LK: *Lophotriorchis kienerii*, BR: *Buteo refectus*, HP: *Hieraaetus pennatus*, CM: *Circus melanoleucos*, CC: *Circus cyaneus*, FP: *Falco peregrinus*, MMe: *Microhierax melanoleucos*, *Microhierax caeruleus*, AL: *Aviceda leuphotes*, PP: *Pernis ptilorhynchus*, AJ: *Aviceda jerdoni*, PH: *Pandion haliaetus*, MM: *Milvus migrans*, HL: *Haliaeetus leucoryphus*, HI: *Haliaeetus ichthyaetus*, CCI: *Clanga clanga*, CG: *Circus gallicus*, AN: *Aquila nipalensis*, IM: *Ictinaetus malaiensis*, SC: *Spilornis cheela*, NC: *Nisaetus cirrhatus*, GH: *Gyps himalayensis*)

8. ábra A 30 különböző faj funkcionális jellegei alapján készített klaszter dendrogram. A betűk a fajok tudományos nevének rövidítései

Table 2. Pairwise comparisons of the bird communities among three different habitats (MO = Mosaic, OP = Open and FO = Forest)

2. táblázat A madárközösségek páronkénti összehasonlítása a három élőhelytípusban (MO = mozaikos, OP = nyílt, FO = erdei)

Similarity Index	Euclidean		Bray-Curtis		Morisita-Horn		Jaccard	
Habitat	MO	OP	MO	OP	MO	OP	MO	OP
OP	34.89		0.211		0.034		0.866	
FO	56.79	70.02	0.621	0.671	0.108	0.143	0.607	0.607

Discussion

Our study recorded 30 species and 776 individuals of raptors in three different habitats in Manas National Park. During the study period we observed highest number (28) of raptor species in open habitats. According to the study by Sergio *et al.* (2005), open habitats provide better hunting opportunities due to increased visibility. Also, raptors in open habitats have a higher success rate in capturing prey in open areas than in closed habitats (Eduardo *et al.* 2007). The mosaic habitats also showed almost similar number of species as open habitats. Mosaic ecosystems also have abundant foods for predatory raptors, as observed in other works (Kumar *et al.* 2022). Additionally, the physical complexity of mosaic landscapes presents varied roosting and nesting prospects for raptors, acting as suitable habitats (Jullien & Thiollay 1996). This can also be attributed to several factors such as abundance of mammalian and ground-nesting bird preys in open areas which form a primary diet in many raptors (Pedrana *et al.* 2008, Carrete *et al.* 2009, Tinajero *et al.* 2017, Kumar *et al.* 2022).

The Crested Serpent Eagle was the most abundant species in both open and forest habitats, usually seen perched in the forest and soaring in open areas closer to the forest margin. The common occurrence of the species could be attributed to its dietary items which mainly comprises of snakes and other small reptiles available in both open and forest habitats (Naorogi 2006). The Collared Falconet was dominant species in the mosaic habitat in terms of abundance, which was observed in open spaces with isolated trees for perching. Our observation on the species is supported by other studies (Naorogi 2006). We found nineteen raptor species utilizing all the three habitats, which suggested a wide food spectrum of these raptors. The raptor species shared the highest similarities between open and mosaic habitats. The open and mosaic habitats were utilized mainly by buzzards, harriers, vultures and eagles. These habitats have open areas such as wetlands, grasslands and riparian areas, which consists of different prey items for raptors such as ground-nesting birds, reptiles, small mammals, and wetland birds. Also, open habitats in Manas National Park have been known to be breeding ground of harriers (Narayan & Rosalind 1991).

We recorded 10 winter migratory raptors, compared to 20 resident species (*Appendix A*). The winter migrants were reported mainly from open habitats, which serve as an ideal foraging space. Eagles such as Greater Spotted (*Clanga clanga*) and Steppe Eagles (*Aquila nipalensis*) were often seen soaring during clear sunny mornings till late afternoon foraging for preys above the open habitats. The buzzards were seen perched on the trees present in the open habitats by

the wetlands, looking out for rodents, lizards and insects. The harriers were observed to be flying low over the grassland and marshes to capture prey with a sudden striking speed. The Booted Eagle (*Hieraaetus pennatus*) often seen perched by the wetland and marshes, flushing waterbirds and reptiles until they are preyed upon. Pallas's Fish-Eagles (*Haliaeetus leucoryphus*) were observed along the Beki river towards the northeastern side of the study area. They were seen hunting for fishes in pairs and sometimes alone. Their occurrences were mainly due to the fact that this species migrates to the region during winter to breed (Naoroji 2006). Among the migrants, two species: Pallas's Fish-Eagle and Steppe Eagle were Endangered (IUCN 2024) (Appendix 1). The Pallas's Fish-Eagle is also among the high priority species in India as per Research and Conservation Priority Index (Mahananda *et al.* 2022). The occurrence of globally threatened migratory species in the area signifies it to be a raptor conservation priority area.

Data analyses based on functional attributes are important in identifying certain trends of species composition in a habitat. Raptor species diversity based on Shannon-Wiener index showed no major differences between the three habitats, contrastingly, functional diversity analyses showed some differences in the species compositions between the three habitats. The open habitats showed higher functional richness due to the greater number of species with different morphological and functional traits such as beak length, beak width, tarsus length, wing length, body mass and trophic niche (Table 3) involved in various functional roles (Legras *et al.* 2018). The open habitat harbored species like Crested Serpent Eagle which is a vertivore in terms of trophic niche, and also aquatic predators such as Pallas's Fish-Eagle to Collared Falconet which is an invertivore (Appendix 2), thus suggesting abundance of different prey items for most raptors in the habitat. The higher functional divergence in mosaic habitats suggests that the differently sized raptors in the habitat have variety of resources to choose from without competition. Thus, habitats with higher functional divergence indicates efficient use of resources by the raptors leading to better ecosystem function (Mason *et al.* 2005).

Table 3. Functional diversity indices based on 10 traits in different habitats
3. táblázat Funkcionális diverzitás indexek 10 jelleg alapján a három élőhelytípusban

Habitat	No. of species	Functional richness (F.ric)	Functional evenness (F.eve)	Functional dispersal (F.dis)	Functional divergence (F.div)
Mosaic	27	0.84	0.60	0.45	0.75
Open	28	0.98	0.69	0.45	0.72
Forest	20	0.44	0.63	0.40	0.67

We can conclude that Manas National Park harbors a decent population of both resident and migratory raptors. Our research findings might help as a baseline data to further study the nesting ecology and behavior of the breeding raptors, including the endangered ones. Also, the study area supports open habitat raptors like Short-toed Snake Eagle, Black-winged Kite, and Red-necked Falcon, which have a declining population trend (SoIB 2023) and may face conservation challenges in future. Long-term research and monitoring are important to develop conservation strategies for these raptors.

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References

- Angelov, I., Hashim, I. & Oppel, S. 2013. Persistent electrocution mortality of Egyptian Vultures *Neophron percnopterus* over 28 years in East Africa. – Bird Conservation International 23(1): 1–6. DOI: 10.1017/S0959270912000123
- Bierregaard, Jr. R. O. 1998. Conservation status of birds of prey in the South American tropics. – Journal of Raptor Research 32(1): 19–27.
- BirdLife International 2003. Important Bird Area factsheet: Manas National Park. – <https://datazone.birdlife.org/site/factsheet/manas-national-park-iba-india>
- Brochet, A.-L., van den Bossche, W., Jones, V. R., Arnardottir, H., Damoc, D., Demko, M., Driessens, G., Flensted, K., Gerber, M., Ghasabyan, M., Gradinarov, D., Hansen, J., Horváth, M., Karlons, M., Krogulec, J., Kuzmenko, T., Lachman, L., Lehtiniemi, T., Lorgé, P., Lötberg, U., Lusby, J., Ottens, G., Paquet, J.-Y., Rukhaia, A., Schmidt, M., Shimmings, P., Stipnieks, A., Sultanov, E., Vermouzek, Z., Vintchevski, A., Volke, V., Willi, G. & Butchart, S. H. M. 2019. Illegal killing and taking of birds in Europe outside the Mediterranean: Assessing the scope and scale of a complex issue. – Bird Conservation International 29(1): 10–40. DOI: 10.1017/S0959270917000533
- Carnicer, J., Brotons, L., Stefanescu, C. & Peñuelas, J. 2012. Biogeography of species richness gradients: linking adaptive traits, demography and diversification. – Biological Reviews 87(2): 457–479. DOI: 10.1111/j.1469-185X.2011.00210.x
- Carrete, M., Tella, J. L., Blanco, G. & Bertellotti, M. 2009. Effects of habitat degradation on the abundance, richness and diversity of raptors across Neotropical biomes. – Biological Conservation 142(10): 2002–2011. DOI: 10.1016/j.biocon.2009.02.012
- Champion, S. H. & Seth, S. K. 1968. A Revised Survey of the Forest Types of India. – Natraj Publishers, Dehradun
- Chen, H. & Boutros, P. C. 2011. VennDiagram: a package for the generation of highly-customizable Venn and Euler diagrams in R. – BMC Bioinformatics 12(1): 1–7. DOI: 10.1186/1471-2105-12-35
- Cusa, M., Jackson, D. A. & Mesure, M. 2015. Window collisions by migratory bird species: urban geographical patterns and habitat associations. – Urban Ecosystems 18: 1427–1446. DOI: 10.1007/s11252-015-0459-3
- Dalvi, S. & Haralu, B. 2014. Doyang reservoir: a potential IBA in Nagaland. – Mistnet 15: 24–28.
- Donázar, J. A., Cortés-Avizanda, A., Fargallo, J. A., Margalida, A., Moleón, M., Morales-Reyes, Z., Moreno-Opo, R., Pérez-García, J. M., Sánchez-Zapata, J. A., Zuberogoitia, I. & Serrano, D. 2016. Roles of raptors in a changing world: from flangships to providers of key ecosystem services. – Ardeola 63(1): 181–234. DOI: 10.13157/arla.63.1.2016.rp8
- Eduardo, C., Carvalho, A. & Marini, M. Â. 2007. Distribution patterns of diurnal raptors in open and forested habitats in south-eastern Brazil and the effects of urbanization. – Bird Conservation International 17(4): 367–380. DOI: 10.1017/S0959270907000822
- Franke, A. 2017. Priorities for Gyrfalcon research: food, weather, and phenology in a changing climate. – In: Anderson, D. L., McClure, C. J. W. & Franke, A. (eds.) Applied Raptor Ecology: Essentials from Gyrfalcon Research. – The Peregrine Fund, Boise, Idaho, USA, pp. 11–32. DOI: 10.4080/are.2017/001
- Fuller, M. R. & Mosher, J. A. 1981. Methods of detecting and counting raptors: a review. – Studies in Avian Biology 6: 235–264.

- Galligan, T. H., Amano, T., Prakash, V. M., Kulkarni, M., Shringarpure, R., Prakash, N., Ranade, S., Green, R. E. & Cuthbert, R. J. 2014. Have population declines in Egyptian Vulture and Red-headed Vulture in India slowed since the 2006 ban on veterinary diclofenac? – *Bird Conservation International* 24(3): 272–281. DOI: 10.1017/S0959270913000580.
- Gavashelishvili, A., McGrady, M. J. & Javakhishvili, Z. 2006. Planning the conservation of the breeding population of Cinereous Vultures *Aegypius monachus* in the Republic of Georgia. – *Oryx* 40(1): 76–83. DOI: 10.1017/S0030605306000081
- Goriup, P. & Tucker, G. 2007. Assessment of the merits of a CMS instrument covering migratory raptors in Africa and Eurasia. – Bristol UK: DEFRA
- Green, R. E., Newton, I. A. N., Shultz, S., Cunningham, A. A., Gilbert, M., Pain, D. J. & Prakash, V. 2004. Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. – *Journal of Applied Ecology* 41(5): 793–800. DOI: 10.1111/j.0021-8901.2004.00954.x
- Guisan, A., Thuiller, W. & Zimmermann, N. E. 2017. Habitat Suitability and Distribution Models: With Applications in R. – Cambridge University Press
- Hansson, L. A. & Åkesson, S. (eds.) 2014. Animal Movement Across Scales. – Oxford University Press
- Iknayan, K. J. & Beissinger, S. R. 2018. Collapse of a desert bird community over the past century driven by climate change. – *Proceedings of the National Academy of Sciences* 115(34): 8597–8602. DOI: 10.1073/pnas.1805123115
- Dalvi, S. & Haralu, B. 2014. Doyang reservoir: a potential IBA in Nagaland. – *Mistnet* 15: 24–28.
- IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. – <https://www.iucnredlist.org>
- Jullien, M. & Thiollay, J. M. 1996. Effects of rain forest disturbance and fragmentation: comparative changes of the raptor community along natural and human-made gradients in French Guiana. – *Journal of Biogeography* 23(1): 7–25. DOI: 10.1046/j.1365-2699.1996.00963.x
- Kagan, R. A. 2016. Electrocution of raptors on power lines: a review of necropsy methods and findings. – *Veterinary Pathology* 53(5): 1030–1036. DOI: 10.1177/0300985816646431
- Kindt, R. 2019. Package ‘BiodiversityR’. Package for community ecology and suitability analysis 2.12. – <https://cran.r-project.org/web/packages/BiodiversityR/index.html>
- Klippel, A. H., Oliveira, P. V., Britto, K. B., Freire, B. F., Moreno, M. R., Dos Santos, A. R., Banhos, A. & Paneto, G. G. 2015. Using DNA barcodes to identify road-killed animals in two atlantic forest nature reserves, Brazil. – *Plos One* (10)8: e0134877. DOI: 10.1371/journal.pone.0134877
- Kumar, S., Sohil, A., Kichloo, M. A. & Sharma, N. 2022. Landscape heterogeneity affects diurnal raptor communities in a sub-tropical region of northwestern Himalayas, India. – *Plos One* 17(4): e0246555. DOI: 10.1371/journal.pone.0246555
- Legras, G., Loiseau, N. & Gaertner, J. C. 2018. Functional richness: Overview of indices and underlying concepts. – *Acta Oecologica* 87: 34–44. DOI: 10.1016/j.actao.2018.02.007
- Lehman, R. N. 2001. Raptor electrocution on power lines: Current issues and outlook. – *Wildlife Society Bulletin* 29(3): 804–813.
- Magneville, C., Loiseau, N., Albouy, C., Casajus, N., Claverie, T., Escalas, A., Leprieur, F., Maire, E., Mouillot, D. & Villéger, S. 2021. mFD: an R package to compute and illustrate the multiple facets of functional diversity. – *Ecography* 2022(1): e05904 (ver. 1.0). DOI: 10.1111/ecog.05904
- Magurran, A. E. 2004. Measuring Biological Diversity. – Blackwell Publishing, Oxford
- Mahananda, P., Jelil, S. N. & Saikia, M. K. 2022. Raptor research in India: Inadequate data and species’ status uncertainty for many species. – *Journal of Raptor Research* 56(2): 201–211. DOI: 10.3356/JRR-21-00006
- Mason, N. W., Mouillot, D., Lee, W. G. & Wilson, J. B. 2005. Functional richness, functional evenness and functional divergence: the primary components of functional diversity. – *Oikos* 111(1): 112–118.
- McClure, C. J., Westrip, J. R., Johnson, J. A., Schulwitz, S. E., Virani, M. Z., Davies, R., Symes, A., Wheatley, H., Thorstrom, R., Amar, A. & Buij, R. 2018. State of the world’s raptors: Distributions, threats, and conservation recommendations. – *Biological Conservation* 227: 390–402. DOI: 10.1016/j.biocon.2018.08.012
- Mojica, E. K., Dwyer, J. F., Harness, R. E., Williams, G. E. & Woodbridge, B. 2018. Review and synthesis of research investigating Golden Eagle electrocutions. – *The Journal of Wildlife Management* 82(3): 495–506. DOI: 10.1002/jwmg.21412
- Morrison, M. L., Marcot, B. & Mannan, W. 2012. Wildlife-habitat Relationships: Concepts and Applications. – Island Press, Washington, DC.

- Narayan, G. & Rosalind, L. 1991. New record of the Pied Harrier *Circus melanoleucos* (Pennant) breeding in Assam Duars, with a brief review of its distribution. – Journal of the Bombay Natural History Society 88: 30–34.
- Naoraji, R. 2006. Birds of Prey of the Indian Subcontinent. 1st ed. – London, Christopher Helm
- Newton, I. 1979. Effects of human persecution on European raptors. – Journal of Raptor Research 13(3): 1.
- O'Bryan, C. J., Braczkowski, A. R., Beyer, H. L., Carter, N. H., Watson, J. E. & McDonald-Madden, E. 2018. The contribution of predators and scavengers to human well-being. – Nature Ecology & Evolution 2(2): 229–236. DOI: 10.1038/s41559-017-0421-2
- Oaks, J. L., Gilbert, M., Virani, M. Z., Watson, R. T., Meteyer, C. U., Rideout, B. A., Shivaprasad, H. L., Ahmed, S., Iqbal Chaudhry, M. J., Arshad, M. & Mahmood, S. 2004. Diclofenac residues as the cause of vulture population decline in Pakistan. – Nature 427(6975): 630–633. DOI: 10.1038/nature02317
- Ogada, D., Botha, A. & Shaw, P. 2016. Ivory poachers and poison: drivers of Africa's declining vulture populations. – Oryx 50(4): 593–596. DOI: 10.1017/S0030605315001209
- Owens, I. P. & Bennett, P. M. 2000. Ecological basis of extinction risk in birds: habitat loss versus human persecution and introduced predators. – Proceedings of the National Academy of Sciences 97(22): 12144–12148. DOI: 10.1073/pnas.200223397
- Pedrana, J., Isacch, J. P. & Bó, M. S. 2008. Habitat relationships of diurnal raptors at local and landscape scales in southern temperate grasslands of Argentina. – Emu-Austral Ornithology 108(4): 301–310. DOI: 10.1071/MU07075
- Prakash, V., Bishwakarma, M. C., Chaudhary, A., Cuthbert, R., Dave, R., Kulkarni, M., Kumar, S., Paudel, K., Ranade, S., Shringarpure, R. & Green, R. E. 2012. The population decline of *Gyps* vultures in India and Nepal has slowed since veterinary use of diclofenac was banned. – PLoS One 7(11): e49118. DOI: 10.1371/journal.pone.0049118
- Prakash, V., Galligan, T. H., Chakraborty, S. S., Dave, R., Kulkarni, M. D., Prakash, N., Shringarpure, R. N., Ranade, S. P. & Green, R. E. 2019. Recent changes in populations of Critically Endangered *Gyps* vultures in India. – Bird Conservation International 29(1): 55–70. DOI: 10.1017/S0959270917000545
- Prakash, V., Pain, D. J., Cunningham, A. A., Donald, P. F., Prakash, N., Verma, A., Gargi, R., Sivakumar, S. & Rahmani, A. R. 2003. Catastrophic collapse of Indian White-backed *Gyps bengalensis* and Long-billed *Gyps indicus* Vulture populations. – Biological Conservation 109(3): 381–390. DOI: 10.1016/S0006-3207(02)00164-7
- R Core Team 2020. R: A language and environment for statistical computing. – R Foundation for Statistical Computing, Vienna, Austria
- Santangeli, A., Girardello, M., Buechley, E. R., Eklund, J. & Phipps, W. L. 2019. Navigating spaces for implementing raptor research and conservation under varying levels of violence and governance in the Global South. – Biological Conservation 239: 108212. DOI: 10.1016/j.biocon.2019.108212
- Sergio, F. & Hiraldo, F. 2008. Intraguild predation in raptor assemblages: a review. – Ibis 150(1): 132–145. DOI: 10.1111/j.1474-919X.2008.00786.x
- Sergio, F., Newton, I. & Marchesi, L. 2008. Top predators and biodiversity: much debate, few data. – Journal of Applied Ecology 45(3): 992–999. DOI: 10.1111/j.1365-2664.2008.01484.x
- Sergio, F., Newton, I. & Marchesi, L. 2005. Top predators and biodiversity. – Nature 436(7048): 192–192. DOI: 10.1038/s41598-019-44159-6
- Sergio, F., Newton, I., Marchesi, L. & Pedrini, P. 2006. Ecologically justified charisma: preservation of top predators delivers biodiversity conservation. – Journal of Applied Ecology 43(6): 1049–1055. DOI: 10.1111/j.1365-2664.2006.01218.x
- Shannon, C. E. & Weaver, W. 1949. The Mathematical Theory of Communication. – University of Illinois Press, Urbana
- Sharma, A. K., Saini, M., Singh, S. D., Prakash, V., Das, A., Dasan, R. B., Pandey, S., Bohara, D., Galligan, T. H., Green, R. E. & Knopp, D. 2014. Diclofenac is toxic to the Steppe Eagle *Aquila nipalensis*: widening the diversity of raptors threatened by NSAID misuse in South Asia. – Bird Conservation International 24(3): 282–286. DOI: 10.1017/S0959270913000609
- SoIB 2023. State of India's Birds. 2023: Range, Trends, and Conservation Status. – The SoIB Partnership <https://stateofindiabirds.in/>
- Symes, C. T. & Kruger, T. L. 2012. The persistence of an apex avian predator, Verreaux's Eagle, *Aquila verreauxii* in a rapidly urbanizing environment. – South African Journal of Wildlife Research 42(1): 45–53. DOI: 10.3957/056.042.0109

- Thiollay, J. M. 1998. Distribution patterns and insular biogeography of South Asian raptor communities. – *Journal of Biogeography* 25(1): 52–72. DOI: 10.1046/j.1365-2699.1998.251164.x
- Thiollay, J. M. & Meyburg, B. U. 1988. Forest fragmentation and the conservation of raptors: a survey on the island of Java. – *Biological Conservation* 44(4): 229–250. DOI: 10.1016/0006-3207(88)90018-3
- Tinajero, R., Barragán, F. & Chapa-Vargas, L. 2017. Raptor functional diversity in scrubland-agricultural landscapes of northern-central-Mexican dryland environments. – *Tropical Conservation Science* 10: 1–18. DOI: 10.1177/1940082917712426
- Tobias, J. A., Sheard, C., Pigot, A. L., Devenish, A. J., Yang, J., Sayol, F., Neate-Clegg, M. H., Alioravainen, N., Weeks, T. L., Barber, R. A. & Walkden, P. A. 2022. AVONET: morphological, ecological and geographical data for all birds. – *Ecology Letters* 25(3): 581–597. DOI: 10.1111/ele.13898
- Watson, R. T. 1998. Preface: Conservation and ecology of raptors in the Tropics. – *Journal of Raptor Research* 32(1): 1–2.
- White, C. M. 1974. Current problems and techniques in raptor management and conservation. – *Transactions of the North American Wildlife Conference* 39: 301–312.

Appendix 1. Table showing the species and their abundance recorded in the study area, their migratory and IUCN status, and the functional traits used for functional diversity analyses (R: Resident, M: Migratory; LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered)

1. melléklet Táblázat a vizsgált területen észlelt fajokról és gyakoriságukról, vonulási és IUCN-státuszukról, valamint a funkcionális diverzitás-elemzésekhez használt funkcionális jellemzőkről (R: rezidens, M: vonuló; LC: nem fenyegetett, NT: mérsékelten fenyegetett, VU: sebezhető, EN: veszélyeztetett)

Sl.No	Species	English name	Mosaic habitat	Open habitat	Forest habitat	Migratory status	IUCN status
1	<i>Accipiter badius</i>	Shikra	8	14	4	R	LC
2	<i>Accipiter virgatus</i>	Crested Goshawk	13	9	0	R	LC
3	<i>Aquila nipalensis</i>	Steppe Eagle	8	4	2	M	EN
4	<i>Aviceda jerdoni</i>	Jerdon's Baza	14	22	4	R	LC
5	<i>Aviceda leuphotes</i>	Black Baza	3	5	0	R	LC
6	<i>Buteo refectus</i>	Himalayan Buzzard	3	4	0	M	LC
7	<i>Buteo rufinus</i>	Long-legged Buzzard	13	7	9	M	LC
8	<i>Circaetus gallicus</i>	Short-toed Snake Eagle	6	11	2	R	LC
9	<i>Circus aeruginosus</i>	Western Marsh Eagle	4	0	0	M	LC
10	<i>Circus cyaneus</i>	Hen Harrier	18	21	0	M	LC
11	<i>Circus melanoleucos</i>	Pied Harrier	22	24	0	R	LC
12	<i>Clanga clanga</i>	Greater Spotted Eagle	14	6	4	M	VU
13	<i>Elanus caeruleus</i>	Black-winged Kite	18	17	3	R	LC
14	<i>Falco chicquera</i>	Red-necked Falcon	11	2	2	M	NT
15	<i>Falco peregrinus</i>	Peregrine Falcon	10	10	2	M	LC
16	<i>Falco severus</i>	Oriental Hobby	2	2	0	R	LC
17	<i>Falco tinnunculus</i>	Eurasian Kestrel	11	14	5	M	LC
18	<i>Gyps himalayensis</i>	Himalayan Vulture	16	15	6	M	NT
19	<i>Ichthyophaga ichthyaetus</i>	Grey-headed Fish Eagle	0	8	0	R	NT
20	<i>Haliaeetus leucoryphus</i>	Pallas's Fish Eagle	0	10	0	M	EN

Sl.No	Species	English name	Mosaic habitat	Open habitat	Forest habitat	Migratory status	IUCN status
21	<i>Hieraetus pennatus</i>	Booted Eagle	7	7	5	R	LC
22	<i>Ictinaetus malaiensis</i>	Black Eagle	23	18	5	R	LC
23	<i>Lophotriorchis kienerii</i>	Rufous-bellied Eagle	10	11	0	R	NT
24	<i>Microhierax caerulescens</i>	Collared Falconet	28	26	5	R	LC
25	<i>Microhierax melanoleucos</i>	Pied Falconet	2	0	0	R	LC
26	<i>Milvus migrans</i>	Black Kite	5	15	0	R	LC
27	<i>Nisaetus cirrhatus</i>	Changeable Hawk Eagle	10	25	3	R	LC
28	<i>Pandion haliaetus</i>	Osprey	9	5	0	M	LC
29	<i>Pernis ptilorhynchus</i>	Oriental Honey Buzzard	13	23	6	R	LC
30	<i>Spilornis cheela</i>	Crested Serpent Eagle	25	39	9	R	LC

Appendix 2. Functional traits used for the functional diversity analyses (AVONET database)
2. melléklet A funkcionális diverzitás-elemzésekhez használt funkcionális jellemzők (AVONET adatbázis)

Species	Beak. Length_ Culmen	Beak. Length_ Nares	Beak. Width	Beak. Depth	Tarsus. Length	Wing. Length	Kipps. Distance	HanWing. Index	Mass	Trophic. Niche
<i>Accipiter badius</i>	20.6	12.1	8.8	11.6	43	186.7	62.5	32.9	131.2	Vertivore
<i>Accipiter virgatus</i>	21.2	11.7	7.6	10.2	49.8	167.7	46.7	27.4	117	Vertivore
<i>Aquila nipalensis</i>	54.1	32.4	17.7	25.2	95.1	559.6	225.2	40.5	2714.3	Vertivore
<i>Aviceda jerdoni</i>	45.5	21.7	12.9	15.9	34.7	302.8	76.9	25.6	363	Omnivore
<i>Aviceda leuphotes</i>	24.6	16.4	10.2	12.5	25	230.6	82	35.3	194	Invertivore
<i>Buteo reffectus</i>	33.4	20.4	11.8	16.1	64.9	346	125.7	36.3	759.1	Vertivore
<i>Buteo rufinus</i>	41.6	23.5	14	19.8	86.1	447.5	180.8	40.5	1166.2	Vertivore
<i>Circaetus gallicus</i>	47	35	15.5	24.6	90.9	537	216.8	40.5	1699.1	Vertivore
<i>Circus aeruginosus</i>	37.3	20.2	11.9	16.2	79.3	405.7	185.3	45.6	704.1	Vertivore
<i>Circus cyaneus</i>	30.1	16	9.7	13	72.1	352.4	158.9	44.7	393	Vertivore
<i>Circus melanoleucos</i>	29.9	15.5	9.4	13.1	72.5	352.6	179.8	50.5	336.3	Vertivore
<i>Clanga clanga</i>	50.2	31.2	15.6	23.2	96.8	510.6	192.2	37.9	2154.3	Vertivore
<i>Elanus caeruleus</i>	30.9	16	9.2	11.3	32.1	286.3	132.1	45.2	259.8	Vertivore
<i>Falco chicquera</i>	20	13.3	8.7	12	37.3	204.1	97.1	47.5	208	Vertivore
<i>Falco peregrinus</i>	31.1	18.4	13.7	15.4	45.1	314.7	165	52.2	760	Vertivore
<i>Falco severus</i>	23.7	13	9.3	11.3	28.5	217.4	128.8	58.6	200.6	Vertivore

Species	Beak. Length_ Culmen	Beak. Length_ Nares	Beak. Width	Beak. Depth	Tarsus. Length	Wing. Length	Kipps. Distance	HanWing. Index	Mass	Trophic. Niche
<i>Falco tinnunculus</i>	20.8	14.4	11	11.6	38.4	241.8	123.7	51	183.2	Vertivore
<i>Gyps himalayensis</i>	82.5	55.2	23.5	34	115.6	759.8	269.5	35.5	9798	Scavenger
<i>Ichthyophaga ichthyaetus</i>	66.1	36	16.8	25.7	81.7	471.2	134.6	29	1590	Aquatic. predator
<i>Haliaeetus leucoryphus</i>	63.6	39.1	19.3	28.3	95.3	566.6	241	42.8	2885.9	Aquatic. predator
<i>Hieraaetus pennatus</i>	33.8	19.1	10.1	17	65.3	361.8	151.3	42	823.8	Vertivore
<i>Ictinaetus malaiensis</i>	51.5	26.1	13.7	18.6	68.7	552.8	240.5	43.2	1028	Vertivore
<i>Lophotriorchis kienerii</i>	46.1	20.5	11.9	17.2	53.5	366.2	127.6	35.9	799	Vertivore
<i>Microhierax caerulescens</i>	14.4	9.8	8	9.1	21.7	102	39.7	39.2	38.7	Invertivore
<i>Microhierax melanoleucos</i>	15.2	10.4	8.7	10.2	24.3	111.4	45.3	40.4	64.2	Invertivore
<i>Milvus migrans</i>	40	22.4	13	17.4	51.4	457.4	219.9	48.1	734.1	Omnivore
<i>Nisaetus cirrhatus</i>	49.9	25.8	12.6	21.7	97.7	414.6	115.8	27.9	1475.1	Vertivore
<i>Pandion haliaetus</i>	47	27.7	17.3	19.6	49.8	468.4	204.8	44.9	1483.2	Aquatic. predator
<i>Pernis ptilorhynchus</i>	55.9	21.4	13.1	15.4	49	413.6	130.7	32	1141.1	Invertivore
<i>Spilornis cheela</i>	45.6	30.1	14.4	20.8	82.2	373.7	112.6	30.1	597.7	Vertivore

