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Research Article

The Correlation of Avifauna Diversity and Its Habitat: An Observation Study at Mount Kawi Slope Waterfall, East Java

Lutfita Fitriana*, Nia Kurniawan, Amin Setyo Leksono

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, Malang 65145, Indonesia

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**Corresponding author:*
E-mail: ardaning@ugm.ac.id

ABSTRACT

Avifauna inhabiting mountain forest ecosystems on Java Island face severe threats from anthropogenic disturbances. Despite this, the diversity of avifauna in specific areas, such as the *Hutan Lindung Pegunungan Putri Tidur* (HLPPT) on the slopes of Mount Kawi, remains poorly monitored. This study focuses on assessing avifauna diversity and communities in the tourist area of Mount Kawi slope waterfalls, situated on both the southeast side in Malang Regency and the north side in Batu City. The research, conducted from January to March 2022, examined eight waterfall locations (*Baung, Glotak, Luksongo, Parangtejo, Manten, Tengah, Rondo*, and *Sumberpitu*) using the roaming method with Visual Encounter Survey (VES) and Audiovisual Encounter Survey (AES) techniques. Data analysis included considerations of conservation status, local distribution, feed specialists, diversity indices (Taxa Richness, Shannon-Wiener Diversity Index (H'), Simpson Index (D), Evenness Index (E)), and Important Value Index (IVI) as an assessment of avifaunal diversity. Researchers employed Microsoft Excel and Principal Component Analysis (PCA) to determine preferences for each character diversity index and abiotic factors in each location. Across the site, 84 species from 33 families were identified. Notably, seven species were classified as at risk (4 near-threatened, two vulnerable, and one endangered), and nine avifauna were protected. The correlation of avifauna diversity to biotic and abiotic factors was positive. These results provide essential data for further conservation management, emphasizing the protection of the forest area, tourists, waterfalls, and slopes of Mount Kawi. Additionally, studying spatial and temporal distribution is crucial for future avifauna species re-inventory efforts.

Keywords: Avifauna Diversity and Community, Habitat Assessment, Highlands, Inventory, Mount Kawi Slopes

Introduction

East Java has numerous tourist spots and waterfalls, each boasting its attractions, such as the beauty of nature, and some with adventurous spots. One of the waterfalls is situated on the slopes of Mount Kawi, specifically on the southeast side of Malang Regency and the north side of Batu City. The area is a protected forest ecosystem, commonly known as the Hutan Lindung Gunung Putri Tidur (HLPPT), comprising several mountain clusters, including Mount Kawi, *Butak*, and *Panderman*. The HLPPT area is managed by the forestry company of Malang Forest Management Unit (*Kesatuan Pengelolaan Hutan* (KPH) Malang). In 2021, KPH collaborated with a social foundation engaged in forest and wildlife conservation, namely Protection of Forest and Fauna (Profauna) Indonesia, to strengthen the function of protected forests in the HLPPT area. The Profauna community monitoring team's results in 2021 stated that the HLPPT is one of the remaining highland forests with good natural conditions, especially on the slopes of Mount Kawi.

However, the protected forest area is under

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threat. One of the threats is forest clearing for agriculture and wildlife hunting using network guns, which the local community has developed into a natural tourist attraction, a waterfall tourist attraction. The large number of visitors serves as a source of income for residents and the management of the waterfall area, but it also poses problems for the surrounding nature. Scattered garbage, noise, and water pollution can alter the quality of the waterfall's habitat. Noise pollution is one of the most critical factors contributing to the decline in the diversity and abundance of avifauna. Sound has contributed to species relying on acoustic signals for mating, predator sensing, and other activities [1].

Additionally, widespread deforestation leads to declines, population narrowing, and avifauna diversity in various landscapes. The natural habitats' environment differs from those visited by many people, causing differences between habitats. The difference between the two determines the variety of animals that can live in it. One causes the short interaction distance between avifauna and humans [2].

Avifauna, a group of bird types with diverse morphological characteristics, broad cruising ability, and adaptability to various landscapes [3], relies on trees for perching, food sources, and nesting. Land-use conversion systems have disrupted avifauna activities for foraging and reproduction [4]. Avifauna can be a suitable bioindicator of environmental quality due to its potential ability to respond to and observe environmental changes. Avifauna is widely accepted as a bioindicator for recognizing ecosystems degraded by anthropogenic activities.

There is a need to increase conservation awareness and species data collection to preserve avifauna in nature. So far, avifauna conservation in Indonesia is still limited and focused on designated government conservation areas, such as nature reserves, wildlife reserves, and national parks. However, avifauna with protected status are still found outside conservation areas, such as forests, settlements, rice fields, etc., without available information about avifauna diversity and its habitat. Nevertheless, it is necessary to provide primary data on avifauna conservation management based on diversity, conservation status, feed specialists, community structure, and the correlation between them. The results of this study are expected to be used as a primary reference to support habitat management in conservation activities and as an evaluation of avifauna diversity in waterfall tourism areas on the slopes of Mount Kawi.

Material and Methods

Study area

The research locations on the slopes of the Mount Kawi waterfall tourist area were on two sides, namely the southeast side of Malang Regency and the north side of Batu City (Figure 1). Data collection was obtained from eight waterfall locations, including 1) Baung Waterfall, 2) Glotak Waterfall, 3) Luksongo Waterfall, 4)

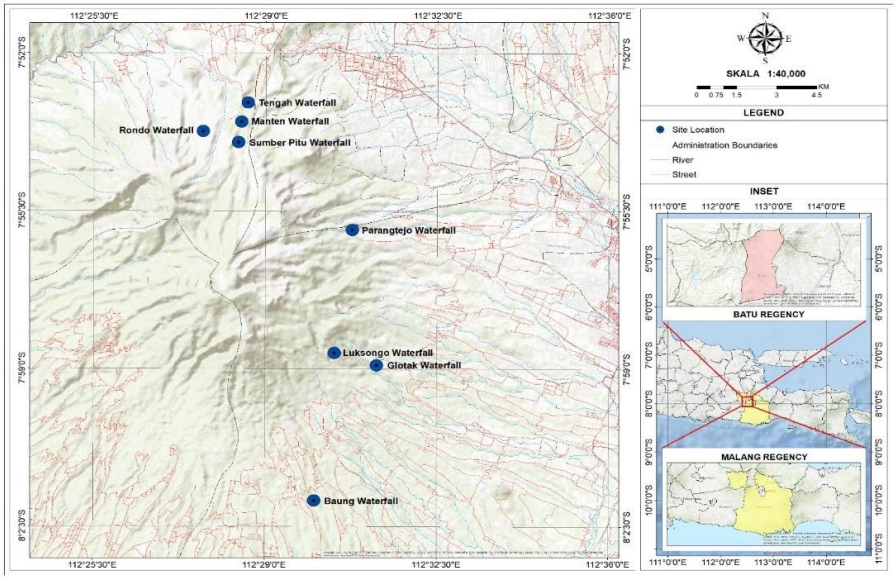

Figure 1. Location map of waterfall on Mount Kawi Slope showing the eight (8) study sites

Table 1. Description of the study location in the tourist area of Mount Kawi Slope Waterfall, East Java

Study site	Location	Waterfall tourism name	Elevation range (masl)	Description
1	Malang Regency	Baung	Approximately 800 masl	Land use change for rice fields and plantations found
2	Malang Regency	Glotak	Approximately 1010 masl	Land use changes for tourism and plantations found
3	Malang Regency	Luksongo	Approximately 1300 masl	No land use changes were found
4	Malang Regency	Parangtejo	Approximately 1200 masl	Land use changes for tourism and plantations found
5	Batu City	Manten	Approximately 1820 masl	No land use changes were found
6	Batu City	Tengah	Approximately 1560 masl	No land use changes were found
7	Batu City	Rondo	Approximately 1450 masl	Land use changes for tourism and plantations found
8	Batu City	Sumberpitu	Approximately 1760 masl	Land use changes for tourism areas and plantations found

Parangtejo Waterfall, 5) Manten Waterfall, 6) Tengah Waterfall, 7) Rondo Waterfall, and 8) Sumberpitu Waterfall. These waterfalls were classified as highland areas due to their altitude of 700 meters above sea level. Furthermore, each area was classified as still natural, indicating no change in land use. Specific descriptions of the eight locations are provided in Table 1.

Field observation and species identification

The study was conducted from January to March 2022 in the morning from 06:00 to 10:00 WIB. The cruising method [5] was employed, utilizing Visual Encounter Survey (VES) and Audiovisual Encounter Survey (AES) techniques along the observer's path [6]. Observations were conducted using binoculars (Binocular Swift 10 × 50 D) and a prosumer 60× optical zoom camera (Nikon Coolpix B600 and Nikon Coolpix B700). Audio recordings were made with an audio recorder (Sony ICD-PX440). Avian diversity was assessed by recording tree habitus within a 5 × 5 m plot. Insect diversity was observed using the cruising method throughout the Visual Encounter Survey (VES) technique along the observer's path, employing insect nets and prosumer 60× optical zoom cameras (Nikon Coolpix B600 and Nikon Coolpix B700).

The researchers referenced the Field Guidebook Series of Birds in Sumatra, Jawa, Bali, and Kalimantan (*Seri Buku Panduan Lapang Burung-Burung di Sumatera, Jawa, Bali, dan Kalimantan*) [7] to identify avifauna. Additionally, the application Burungnesia v.3.0 [8] and sound confirmations from the Xenocanto database [9] were used as research instruments. The field guidebook of Java Mountain Flora (*Flora Pegunungan Jawa*) [10] served as a reference for tree identification, and the guidebook of Key to Insect Determination (*Kunci Determinasi Serangga*) [11] was used for insect categorization. These instruments provided physical data on microclimates, including altitude location and air temperature, representing the interaction of abiotic factors with the landscapes and avifauna.

Data analysis

Avifauna data were grouped by taxa for each location and classified by feed types, including insectivores, granivores, frugivores, nectarivores, and carnivores [7]. Each species was identified based on conservation status according to the International Union for Conservation of Nature (IUCN) [12], Government Regulation No. 106 of the Ministry of Environment and Forestry [13], and local distribution categorization, distinguishing migrants and settlers based on the Burungnesia v.3.0 application. Taxa for each site were used to group vegetation and insect data.

Data on avifauna, vegetation, and insects were further analyzed for community structure using Microsoft Excel, with descriptive statistics derived from diversity indices, namely Taxa Richness, Shannon-Wiener index (H'), Simpson's Dominance index (D), Evenness index (E), and Importance Value Index (IVI) [14, 15]. The preferences of each characteristic, diversity index,

and abiotic factor for each location were analyzed using Principal Component Analysis (PCA) in PAST 4.09 software.

Results and Discussion

Avifauna and community diversity in waterfall tourism area

There were 831 animals belonging to 84 species and 33 families in eight water tourism areas on the slopes of Mount Kawi, East Java. The number of families and individuals in each location varied. The location with the most families was 24 in Tengah and Manten Waterfall, while the lowest was 14 in Parangtejo Waterfall. Regarding the number of individuals, Luksongo Waterfall had the highest count, with 146 individuals, and Parangtejo had the lowest count, with 70 animals (Table 3). The disparity in avifauna diversity in the area resulted from different types of vegetation and the availability of food resources in each location. This impacted the lives of most avifauna families, and the comprehensive documentation of each family is presented in Figure 2.

The IUCN conservation status revealed that 77 species were considered least concerned (LC). In comparison, four species (*Pycnonotus bimaculatus, Chrysophlegma mentale, Psilopogon javensis, Loriculus pusillus, Rubigula dispar, Chrysocolaptes strictus, Nisaetus bartelsi, Hydrornis guajanus, Psilopogon armillaris, Psilopogon javensis, Arborophila javanica, Loriculus pusillus, Nisaetus bartelsi, Spilornis cheela, Ictinaetus malaiensis, Pernis ptilorhynchus*) were classified as protected birds under Indonesia national law (Table 2). Regarding local distribution, 3 species (*M. cinerea, F. mugimaki, P. ptilorhynchus*) were migratory,

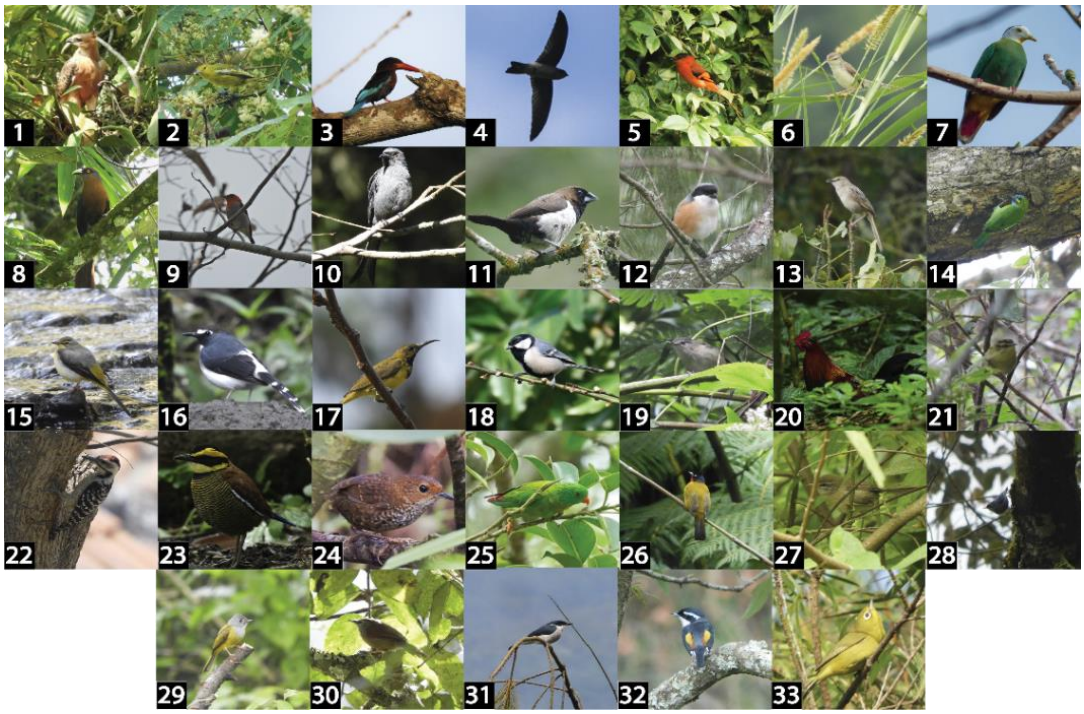

Figure 2. Documentation of avifauna species for each family in the tourist area of Mount Kawi Waterfall, East Java: (1) *N. bartelsi* [Accipitridae], (2) *A. tiphia* [Aegithinidae], (3) *H. cyanoventris* [Alcedinidae], (4) *C. linchi* [Apodidae], (5) *P. Miniatus* [Campephagidae], (6) *P. inornata* [Cisticolidae], (7) *P. melanospilus* [Columbidae], (8) *P. curvirostris* [Cuculidae], (9) *D. trochileum* [Dicaeidae], (10) *D. Leucophaeus* [Dicruridae], (11) *L. leucogastroides* [Estrildidae], (12) *L. schach* [Laniidae], (13) *M. Palustris* [Locustellidae], (14) *P. australis* [Megalaimidae], (15) *M. cinerea* [Motacillidae], (16) *E. Velatus* [Muscicapidae], (17) *C. jugularis* [Nectariniidae], (18) *P. major* [Paridae], (19) *M. sepiaria* [Pellorneidae], (20) *G. Gallus* [Phasianidae], (21) *P. trivirgatus* [Phylloscopidae], (22) *D. analis* [Picidae], (23) *H. guajanus* [Pittidae], (24) *P. pusilla* [Pneopygidae], (25) *L. pusillus* [Psittaculidae], (26) *R.dispar* [Pycnonotidae], (27) *H. flavolivaceus* [Scotocercidae], (28) *S. Frontalis* [Sittidae], (29) *C. Celyonensis* [Stenostiridae], (30) *C. melanothorax* [Timaliidae], (31) *H. Hirundinaceus* [Vangidae], (32) *P. flaviscapis* [Vireonidae], (33) *O. sepium* [Zosteropidae].

while the rest were sedentary (Table 2). These migratory avifauna originated from the North Asian Peninsula and are presumed to migrate to avoid the winter season in their original habitat from November to February [16]. The slopes of Mount Kawi waterfall provided an ideal resting place for these migratory avifauna to stop and find food.

Table 2. List of avifauna in waterfall tourist areas, categorized by conservation status, local distributor, and feed specialization. In summary, as follows: Conservation status: IUCN Status = least concerned (LC), near threatened (NT), endangered (EN), vulnerable (VU); National law status = protected (P), non-protected (NP); Local distribution = migrant (M), resident (R); Feeding specialization = carnivores (C), insectivores (I), granivores (G), frugivores (F), nectarivores (N).

Taxa	Common name	IUCN Status	National law status	Local distribution	Feeding specialization				
					C	I	F	G	N
Acipridae									
Nisaetus bartelsi	Javan-hawk eagle	EN	P	R	√				
Spilornis cheela	Crested-serpent eagle	LC	P	R	√				
Ictinaetus malaiensis	Black eagle	LC	P	R	√				
Pernis ptilorhynchus	Crested-honey buzzard	LC	P	M	√				
Aegithinidae									
Aegithina tiphia	Common Lora	LC	NP	R		√			
Alcedinidae									
Halcyon cyanoventris	Javan kingfisher	LC	NP	R	√	√			
Todiramphus chloris	Collared kingfisher	LC	NP	R	√	√			
Apodidae									
Collocalia linchi	Cave swiftlet	LC	NP	R		√			
Campephagidae									
Pericrocotus cinnamomeus	Small minivet	LC	NP	R		√			
Pericrocotus flammeus	Scarlet minivet	LC	NP	R		√			
Pericrocotus miniatus	Sunda minivet	LC	NP	R		√			
Coracina larvata	Sunda cuckoo shrike	LC	NP	R		√			
Lalage sueurii	White-shouldered Triller	LC	NP	R		√			
Lalage nigra	Pied Triller	LC	NP	R		√			
Cisticolidae									
Prinia inornata	Plain Prinia	LC	NP	R		√			
Orthotomus sepium	Olive-backed tailorbird	LC	NP	R		√			
Orthotomus sutorius	Common tailorbird	LC	NP	R		√			
Columbidae									
Macropygia unchall	Barred cuckoo-dove	LC	NP	R			√	√	
Macropygia emiliana	Ruddy cuckoo-dove	LC	NP	R			√	√	
Macropygia ruficeps	Little cuckoo-dove	LC	NP	R			√	√	
Spilopelia chinensis	Eastern spotted dove	LC	NP	R				√	
Treron griseicauda	Grey-cheeked green-pigeon	LC	NP	R		√	√	√	
Chalcophaps indica	Grey-capped emerald dove	LC	NP	R		√	√	√	
Ptilinopus melanospilus	Black-naped fruit-dove	LC	NP	R			√	√	
Ptilinopus porphyreus	Pink-headed fruit-dove	LC	NP	R			√	√	
Cuculidae									
Cacomantis merulinus	Plaintive cuckoo	LC	NP	R		√			
Cacomantis variolosus sepulcralis	Brush Cuckoo	LC	NP	R		√			
Chrysococcyx xanthorhynchus	Violet cuckoo	LC	NP	R		√			
Centropus bengalensis	Lesser Coucal	LC	NP	R		√			

Dicaeidae								
Dicaeum trigonostigma	Orange-bellied flowerpecker	LC	NP	R		√	√	
Dicaeum trochileum	Scarlet-headed flowerpecker	LC	NP	R		√	√	√
Dicaeum sanguinolentum	Blood-breasted flowerpecker	LC	NP	R		√	√	
Prionochilus percussus	Crimson-breasted flowerpecker	LC	NP	R		√	√	
Dicruridae								
Dicrurus leucophaeus	Ashy drongo	LC	NP	R		√		
Estrildidae								
Lonchura punctulata	Scaly-breasted munia	LC	NP	R				√
Lonchura leugastroides	Javan munia	LC	NP	R				√
Laniidae								
Lanius schach	Long-tailed shrike	LC	NP	R		√		
Locustellidae								
Locustella montis	Sunda grasshopper-warbler	LC	NP	R		√		
Megalurus palustris	Striated grassbird	LC	NP	R		√		
Megalaimidae								
Psilopogon armillaris	Flame-fronted barbet	LC	P	R		√	√	√
Psilopogon javansis	Black-banded barbet	NT	P	R		√	√	√
Psilopogon haemacepalus	Coppersmith barbet	LC	NP	R		√	√	√
Psilopogon australis	Yellow-eared barbet	LC	NP	R		√	√	√
Motaciliidae								
Motacilla cinerea	Grey Wagtail	LC	NP	M		√		
Muscicapidae								
Enicurus leschenaulti	White-crowned forktail	LC	NP	R		√		
Enicurus velatus	Sunda forktail	LC	NP	R		√		
Myophonus caeruleus	Blue whistling-thrush	LC	NP	R		√		
Ficedula mugimaki	Mugimaki flycatcher	LC	NP	M		√		√
Ficedula wastermanni	Little pied flycatcher	LC	NP	R		√		
Brachypteryx leuchophrys	Lesser shortwing	LC	NP	R		√		
Cyornis unicolor	Pale blue-flycatcher	LC	NP	R		√		
Eumyias indigo	Indigo Flycatcher	LC	NP	R		√		
Nectariniidae								
Cinnyris jugularis	Olive-backed sunbird	LC	NP	R		√	√	√
Paridae								
Parus major	Great tit	LC	NP	R		√		
Pellorneidae								
Malacocincla sepiaria	Horsfield's babbler	LC	NP	R		√		
Pellorneum capistratum	Rufous-browed babbler	LC	NP	R		√		
Phasianidae								
Gallus gallus	Red junglefowl	LC	NP	R	√	√	√	√
Arborophilia javanica	Chestnut-bellied partridge	LC	P	R		√	√	√
Phylloscopidae								
Phylloscopus grammiceps	Sunda Warbler	LC	NP	R		√		
Phylloscopus trivirgatus	Mountain warbler	LC	NP	R		√		
Picidae								
Dendrocopos analis	Freckle-breasted woodpecker	LC	NP	R		√		
Picoides moluccensis	Sunda pygmy woodpecker	LC	NP	R		√		
Chrysocolaptes strictus	Javan flameback	VU	NP	R		√	√	√
Chrysophlegma mentale	Checker-throated woodpecker	NT	NP	R		√		
Pittidae								
Hydrornis guajanus	Javan banded pitta	LC	P	R		√		
Pneopygidae								
Pneopyga pusilla	Pygmy wren-babbler	LC	NP	R		√		
Psittaculidae								
Loriculus pusillus	Yellow-throated hanging-parrot	NT	P	R			√	√
Pycnonotidae								
Rubigula dispar	Ruby-throated bulbul	VU	NP	R		√	√	√

Pycnonotus bimaculatus	Orange-spotted bulbul	NT	NP	R	√	√	√
Pycnonotus goiavier	Yellow-vented bulbul	LC	NP	R	√	√	√
Pycnonotus simplex	Cream-vented bulbul	LC	NP	R	√	√	
Ixos virescens	Sunda bulbul	LC	NP	R	√	√	
Scotocercidae							
Horornis flavolivaceus	Aberrant Bush-warbler	LC	NP	R	√		
Sittidae							
Sitta azurea	Blue nuthatch	LC	NP	R	√		
Sitta frontalis	Velvet-fronted nuthatch	LC	NP	R	√		
Stenostiridae							
Culicicapa ceylonensis	Grey-headed canary-flycatcher	LC	NP	R	√		
Timaliidae							
Pomatorhinus montanus	Chestnut-backed scimitar babbler	LC	NP	R	√	√	
Cyanoderma melanothorax	Crescent-chested babbler	LC	NP	R	√		
Stachyris thoracica	White-bibbed babbler	LC	NP	R	√		
Vangidae							
Hemipus hirundinaceus	Black-winged flycatcher-shrike	LC	NP	R	√		
Vireonidae							
Pteruthius flaviscapis	Pied shrike-babbler	LC	NP	R	√		
Zosteropidae							
Zosterops melanurus	Sangkar white-eye	LC	NP	R	√	√	√

The grouping of food specialists (Table 2) indicated that the feed specialization of carnivorous types included three families, with Accipi-tridae dominating. Insectivorous types encompassed 30 families, dominated by 6 (Muscicapidae, Campephagidae, Pycnonotidae, Picidae, Megalaimidae, and Cuculidae). Frugivore types included ten families, dominated by 4 (Dicaeidae, Pynnonotidae, Megalaimidae, and Columbidae). Granivorous types included nine families, dominated by 2 (Pycnonotidae and Columbidae). Nectarivores had two families, including Zosteropidae and Nectariniidae. Among the five feed specialist groups, insectivores exhibited the highest dominance compared to frugivores and granivores, while the carnivorous and nectarivorous feed specialist groups had the lowest dominance. This was attributed to the habitat in the tourist area of Mount Kawi slope waterfall, featuring numerous plantations owned by residents, such as coffee plantations, vegetable plantations, and rice fields, attracting insects and providing a source of nutrition for avifauna. Additionally, the secondary forests provided a canopy for avifauna to perch and consume their prey, creating suitable conditions (temperature and humidity) for insect abundance [17].

As measured by the Shannon-Wiener index (H'), the quality of biodiversity and avifauna communities indicates moderate values across all locations. The Simpson's index (D) ranges from 0.89 to 0.92, and the Evenness index (E) ranges from 0.83 to 0.92. Both diversity indices are categorized as stable (Table 3). The quality parameters of these indices depend on the actual conditions of avifauna communities at each location during a specific time. Daily patterns (space and time utilization) in search of food, resting, and other activities encompass the overall time allocation for each daily activity and its interaction with the habitat [18]. On the other hand, the dominance and evenness indices are generally influenced by factors such as prey abundance, low competition, and species occupying specific niches [19].

The Important Value Index (IVI) range reflects the actual conditions at each observation location. It shows that out of the 33 families, the Campephagidae family had the highest value across the eight observation locations, followed by Pycnonotidae and Columbidae (Table 4). The Campephagidae and Pycnonotidae families had a common strategy of living in colonies, except for species *C. indica, P. melanospilus, P. porphyreus, C. larvata, L. sueurii,* and *L. nigra,* which lived solitarily. However, Campephagidae had a narrower food specialization range, mainly focusing on insectivorous and frugivorous diets, compared to the Pycnonotidae and Columbidae families, which were more adaptive due to their

Table 3. Index Parameter Score of Avifauna Diversity for Each Location in the Waterfall Tourist Area: *Baung* (Ba), *Glotak* (Gl), *Luksongo* (Lu), *Parangtejo* (Pa), *Manten* (Ma), *Tengah* (T), *Rondo* (R), *Sumberpitu* (Sp).

Parameter	Location of Waterfall							
	Ba	**Gl**	**Lu**	**Pa**	**Ma**	**T**	**R**	**Sp**
Family Richness	20	17	23	14	24	24	22	21
Individuals	106	87	146	75	101	116	99	108
Shannon-Wiener (H')	2.65	2.61	2.82	2.42	2.84	2.65	2.75	2.77
Simpson's (D)	0.91	0.91	0.92	0.90	0.92	0.89	0.92	0.92
Evenness (E)	0.89	0.92	0.90	0.92	0.89	0.83	0.89	0.91

Table 4. Number of Important Value Index (IVI) of Avifauna Diversity

Number	Family	Important Value Index (IVI)	Ranking
1	Aegithinidae	4.14	18
2	Diceidae	4.09	19
3	Paridae	2.25	23
4	Pellorneidae	5.82	12
5	Capephagidae	19.55	1
6	Cisticolidae	8.55	8
7	Zosteropidae	2.92	22
8	Pycnonotidae	16.85	2
9	Muscicapidae	1.83	5
10	Dicruridae	2.54	24
11	Sittidae	3.62	21
12	Pittidae	2.22	26
13	Timaliidae	7.39	11
14	Apodidae	14.61	4
15	Picidae	5.37	14
16	Megalaimidae	8.41	9
17	Columbidae	16.41	3
18	Cuculidae	9.92	7
19	Alcedinidae	10.06	6
20	Accipitridae	7.62	10
21	Nectariniidae	4.44	17
22	Phasianidae	4.48	15
23	Pneopygidae	4.53	16
24	Estrildidae	2.20	27
25	Vangidae	5.58	13
26	Psittaculidae	1.95	28
27	Locustellidae	3.81	20
28	Motacillidae	1.32	31
29	Scotocercidae	1.40	29
30	Vireonidae	2.54	25
31	Laniidae	1.36	30
32	Stenostiridae	0.83	33
33	Phylloscopidae	1.06	32

broader range of food specialization, including insectivorous, nectarivorous, and frugivorous diets.

Diversity of vegetation and insects

The vegetation diversity consisted of 171 individuals belonging to 31 species and 17 families across eight areas of the Mount Kawi slope waterfall tourist site in East Java. The number of families and individuals varied at each location, with the highest count found in the Sumberpitu Waterfall area (ten families, 31 individuals) and the lowest count in the Rondo Waterfall area (six families, nine individuals)

(Table 5).

All locations' Shannon-Wiener index (H') values indicate a moderate category. The Simpson's index (D) ranged from 0.72 to 0.86, and the Evenness index (E) ranged from 0.85 to 0.97. Both indices fell into the stable category, indicating favorable habitat conditions. The potential of plants as food providers and nesting sites was closely linked to the breeding ability of avifauna. A bird species could have had abundant individuals in specific habitats, depending on specific tree species groups. This might have occurred because most bird activities occurred in trees, such as foraging, nesting, playing, and breeding [20].

The Importance Value Index (IVI) range indicates that out of the 17 families, the Moraceae family had the highest value, followed by Araucariaceae and Fagaceae across the eight observation locations (Table 6). These three families are plant types that provide food sources for avifauna, such as nectar from flowers, insects, seeds, and fruit. Therefore, they have the potential to offer abundant food sources for nectarivorous, insectivorous, frugivorous, and granivorous avifauna. Additionally, the Araucariaceae family is primarily utilized as perching and nesting sites.

The insect diversity consists of 1,741 individuals belonging to 81 species and 34 families across eight areas of the Mount Kawi slope waterfall tourist site in East Java. The number of families and individuals varies at each location. The highest number of families, 27, is found at the Luksongo Waterfall, while the lowest number of families, 17, is observed at the Baung and Parangtejo Waterfalls. The highest number of individuals, 232, is recorded at the Baung Waterfall, while the lowest number, 200, is found

Table 5. Index parameter score of vegetation diversity for each waterfall spot: *Baung* (Ba), *Glotak* (Gl), *Luksongo* (Lu), *Parangtejo* (Pa), *Manten* (Ma), *Tengah* (T), *Rondo* (R), *Sumberpitu* (Sp).

Parameter	Location of Waterfall							
	Ba	**Gl**	**Lu**	**Pa**	**Ma**	**T**	**R**	**Sp**
Family Richness	9	9	9	6	8	6	6	10
Individuals	27	28	28	14	16	17	9	31
Shannon-Wiener (H')	2.70	2.08	2.12	1.67	1.96	1.53	1.74	2.09
Simpson's (D)	0.86	0.86	0.87	0.79	0.84	0.72	0.81	0.84
Evenness (E)	0.94	0.95	0.96	0.93	0.94	0.85	0.97	0.91

Table 6. Number of Important Value Indexs for Vegetation Diversity

Number	Family	Important Value Index (IVI)	Ranking
1	Moraceae	26.91	1
2	Fagaceae	21.42	3
3	Myrtaceae	19.44	5
4	Combretacea	6.96	13
5	Meliaceae	16.24	9
6	Araucariaceae	24.12	2
7	Malvaceae	20.95	4
8	Lauraceae	7.47	11
9	Poaceae	3.62	14
10	Fabaceae	16.36	8
11	Muntingiaceae	2.46	17
12	Pinaceae	19.19	6
13	Meliaceae	2.47	16
14	Euphorbiaceae	12.83	10
15	Lamiaceae	17.07	7
16	Elaeocarpaceae	7.93	12
17	Apocynaceae	2.93	15

at the Parangtejo Waterfall (Table 7).

All locations' Shannon-Wiener index (H') values indicate a moderate category. The Simpson's index (D) ranges from 0.80 to 0.92, and the

Table 7. Index parameter score of insect diversity for each location in the waterfall tourist area: *Baung* (Ba), *Glotak* (Gl), *Luksongo* (Lu), *Parangtejo* (Pa), *Manten* (Ma), *Tengah* (T), *Rondo* (R), *Sumberpitu* (Sp).

Parameter	Location of Waterfall							
	Ba	Gl	Lu	Pa	Ma	T	R	Sp
Family Richness	17	20	27	17	24	22	22	22
Individuals	232	228	220	200	220	224	205	212
Shannon-Wiener (H')	2.52	2.35	2.70	2.41	2.93	2.28	2.80	2.45
Simpson's (D)	0.89	0.83	0.89	0.86	0.93	0.80	0.92	0.84
Evenness (E)	0.89	0.78	0.82	0.85	0.92	0.74	0.91	0.79

Table 8. Number of Important Value Indexs for Insect Diversity

Number	Family	Important Value Index (IVI)	Ranking
1	Acrididae	12.02	3
2	Tettigonioidea	2.26	28
3	Gryllidae	3.98	20
4	Chrysomelidae	8.70	5
5	Coccinellidae	9.28	4
6	Cicadellidae	2.48	26
7	Nymphalidae	17.42	2
8	Pieridae	7.39	7
9	Lycaenidae	3.78	22
10	Libellulidae	7.32	8
11	Euphaeidae	6.58	11
12	Chlorocyphidae	4.15	19
13	Syrphidae	4.62	16
14	Alydidae	6.91	9
15	Formicidae	32.71	1
16	Araneidae	5.44	14
17	Papilionidae	7.74	6
18	Lecithoceridae	3.37	23
19	Aleyrodidae	6.21	12
20	Pentatomidae	2.94	24
21	Calopterygidae	6.59	10
22	Coenagrionidae	1.55	32
23	Sparassidae	4.33	17
24	Bombyliidae	2.46	27
25	Stratiomyidae	6.12	13
26	Riodinidae	4.28	18
27	Erebidae	0.63	34
28	Apidae	1.61	31
29	Pyrgomorphidae	4.73	15
30	Cerambycidae	2.05	30
31	Curculionidae	3.81	21
32	Lonchodidae	1.38	33
33	Berytidae	2.29	25
34	Calliphoridae	2.24	29

Evenness index (E) ranges from 0.74 to 0.91. Both indices indicate stability. These parameters generally suggest an abundance of prey, low competition, and species inhabiting specific niches. The high diversity of insects was influenced by factors such as light penetration, leaf litter, and soil characteristics [21]. Specific insects could exhibit maximum activity, including nesting, mating, and obtaining food availability in specific habitats.

In the Importance Value Index (IVI), it is observed that out of 34 families, the Formicidae family had the highest value, followed by Nymphalidae and Acrididae across the eight observation locations (Table 8). This corresponds to the habitat conditions in the Mount Kawi slope waterfall area, where many flowering plants produce nectar and fruits, potentially providing nutrition for the Formicidae family and the Nymphalidae butterfly family. Additionally, the presence of plantations and rice fields supports the breeding of the Acrididae family as they easily obtain food sources such as grass [22], which is advantageous for insectivorous avifauna

Correlation of biotic and abiotic factors with avifaunal diversity

The preference of each diversity index character for avifauna, vegetation, insects, and abiotic factors for each location was analyzed using Principal Component Analysis (PCA). Characters with high values formed clusters together. The characters used in the cluster analysis and biplot included diversity indices such as Taxa Richness, Shannon-Wiener index (H'), Simpson's index (D), Evenness index (E), and abiotic factors such as elevation and air temperature.

The clustering result in Figure 3 showed the presence of four waterfall groups with different similarity values. The first group consisted of Luksongo, Parangtejo, Rondo, and Tengah Waterfalls, which had similar high elevations and low temperatures. Meanwhile, the third group included Glotak and Baung Waterfalls, which had similar low elevations and moderate air temperatures. Each group had distinct characteristics. The group characteristics can be observed in the biplot analysis in Figure 4.

Based on the Biplot analysis, the first group was characterized by moderate elevation (E) and air temperature (AT), which negatively correlated with avifauna diversity but positively correlated with insect taxa richness (TRIs), insect Evenness index (Eis) and vegetation Evenness Index (Eveg). This group consisted of Luksongo, Parangtejo, Rondo, and Tengah Waterfalls. The second group, consisting of Manten and Sumberpitu Waterfalls with high elevation, exhibited a positive correlation with the avifauna diversity index (H'Av), Avifauna Evenness index (Eav), Insect taxa richness (TRIs), and Vegetation Evenness Index (Eveg). The third group, represented by *Glotak* and *Baung* Waterfalls with low elevation,

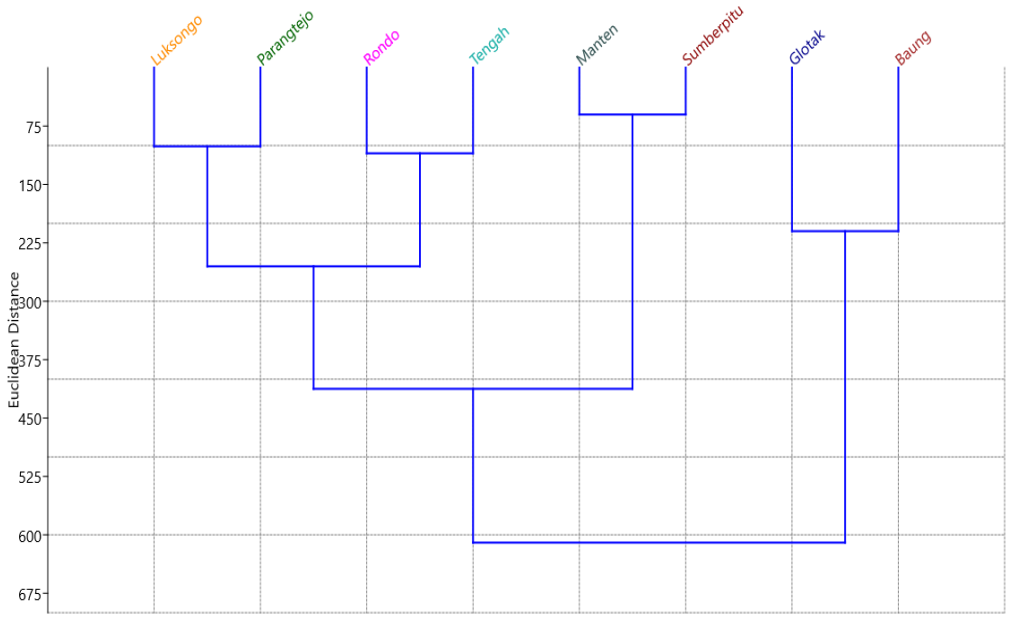

Figure 3. Cluster Analysis of Avifauna Diversity from Eight Waterfalls Spots

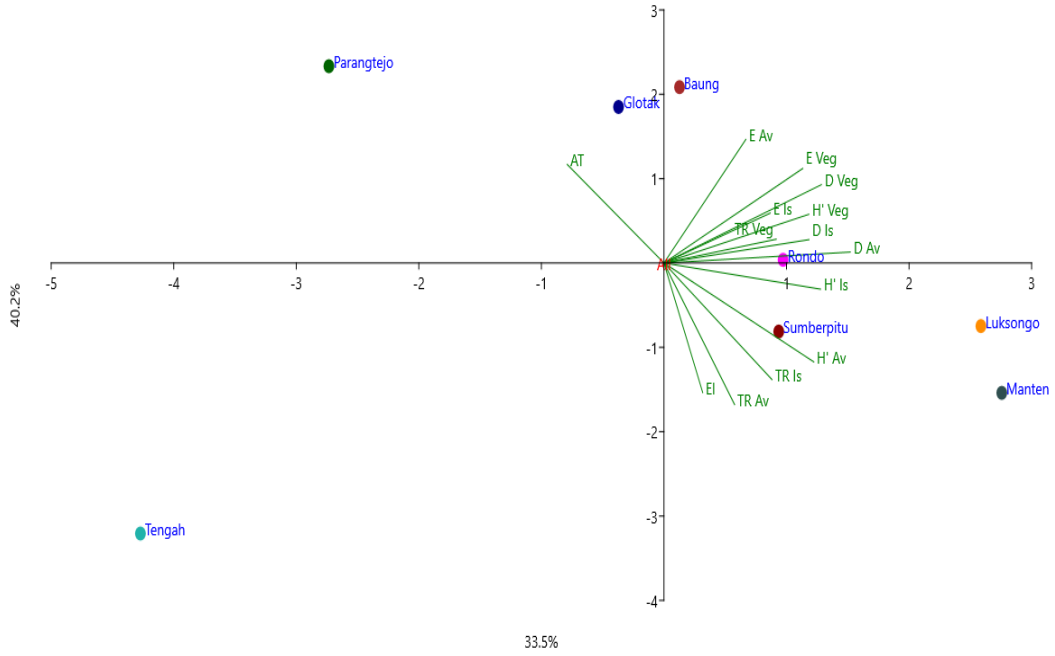

Figure 4. Biplot Analysis between Biotic and Abiotic Factors with Characters of Avifauna Diversity Index in Eight Waterfall Spots. Air Temperature (AT), Elevation (El), Taxa Richness Avifauna (TRAv), Shannon-Wiener Diversity Index Avifauna (H'Av), Simpson's Index Avifauna (DAv), Evenness Index Avifauna (EAv), Taxa Richness Vegetation (TRVeg), Shannon-Wiener Diversity Index Vegetation (H'Veg), Simpson's Index Vegetation (Dveg), Evenness Index Vegetation (EVeg), Taxa Richness Insect (TRIs), Shannon-Wiener Diversity Index Insect (H'Is), Simpson's Index Insect (DIs), Evenness Index Insec (EIs).

showed a negative correlation with avifauna taxa richness (TRAv) but a positive correlation with insect Evenness index (EIs) and vegetation Evenness index (EVeg). Habitats with more significant vegetation variation tend to have higher avifauna diversity. The presence of avifauna in certain trees or plants was due to the availability of food and shelter for their activities [23]. Additionally, diverse tree species could provide various food sources such as fruits, seeds, nectar, and insects.

The composition of multiple tree species in a forest stand resulted in rapid leaf litter decomposition and the growth of various understory plants. The abundance of understory vegetation served as a food source for numerous soil-dwelling insects, nourishing insectivorous avifauna. Additionally, artificial wetlands, such as rice fields and flowing rivers near the waterfalls, served as foraging areas for carnivorous and granivorous avifauna. The proximity of different habitats supported specific food sources for various avifauna families.

Conclusion

A total of 84 species from 33 families were successfully identified. Seven species were classified as at risk, with four near-threatened (NT), 2 vulnerable (VU), and one endangered (EN). Additionally, 9 avifauna species were protected. Evaluation based on the diversity index indicated the urgent need to improve habitat quality at each location to enhance avifauna communities.

There was a positive correlation between avifauna diversity and abiotic and biotic factors. This study provides fundamental data for future conservation management in the protected forest area of the Mount Kawi slope waterfall tourist site. Spatial and temporal distribution studies are also essential for species inventory in the future.

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