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Bird community structure and host plant in Sukamade Resort, Meru Betiri National Park, East Java, Indonesia

ABDU ROHMAN[1,♥], DICKY WAHYUDI[1], WACHJU SUBCHAN[1], JUMADIAWAN[2]

[1]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Jember. Jl. Kalimantan No. 37, Jember 68121, East Java, Indonesia. Tel.: +62-331-330738, ♥email: abdu.fkip@unej.ac.id

[2]Meru Betiri National Park. Jl. Sriwijaya No. 53, Jember 68123, East Java, Indonesia

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Abstract. *Rohman A, Wahyudi D, Subchan W, Jumadiawan. 2024. Bird community structure and host plant in Sukamade Resort, Meru Betiri National Park, East Java, Indonesia. Biodiversitas 25: 3295-3308.* Meru Betiri National Park (MBNP), East Java, Indonesia, is classified as a conservation area. Management of Biological Natural Resources (MBNR) refers to bird communities in a habitat. Damage to biological natural resources causes a high threat of bird vulnerability and extinction. Birds play a crucial role as indicators of the environment. This research aimed to determine the community structure of birds and host plants at the Sukamade resort. We recorded 49 bird species and 21 host plants. We are actively identifying location points according to habitat variations. Resort offices have the highest diversity (H ' = 2.774). The jungle track has the highest bird evenness index (E = 0.754). Parang Kulon has the highest dominance index (D = 0.162). *Pycnonotus goiavier* (pg) had the highest abundance found at each location. *Pavo muticus* (pm) is a protected species according to Indonesian national law. A total of 21 plants were documented as the dominant vegetation. Our research revealed that *Ficus benjamina* (FB) had the highest frequency of visits by pollinators, and the prevailing avian behavior observed was perching. The presence of *Haliaeetus leucogaster* (hl) nesting on *Artocarpus elasticus* (AE) trees was documented. Meanwhile, the Principal Component Analysis (PCA) results showed that four bird species, namely *Merops leschenaulti* (ml), *Rhyticeros undulatus* (ru), *P. goiavier* (pg), *Pycnonotus simplex* (ps), *Anthracoceros albirostris* (aa)) were correlated with two host plant species (*A. elasticus* (AE) and *Albizia chinensis* (AC)). Our results demonstrate a significant link between the presence of birds and host plants, underscoring their integral role in the ecology.

Keywords: Avifauna, diversity, flora, forest, point count method

INTRODUCTION

The Meru Betiri National Park (MBNP), East Java, Indonesia, is a designated conservation area for preserving and protecting forested regions. Management of Biological Natural Resources (MBNR) refers to bird communities in a habitat. Birds are wild animals that have adaptive abilities and ecological levels that influence environmental conditions and habitat types (Tu et al. 2020). Food availability influences bird species diversity in a habitat (Tanalgo et al. 2015; Gómez-Catasús et al. 2019). The diversity of vegetation in a habitat results in a higher diversity of bird species and vice versa (Cabral et al. 2021). Inadequate management of biological natural resources can significantly threaten bird populations. According to Kurnianto et al. (2014), the Merubetiri Wings dataset of MBNP includes thirty-three legally protected species, in accordance with Indonesian Regulation P.106/MENLHK/SETJEN/KUM.1/12/2018. Birds play a role in the ecosystem, including controlling insect populations (Railsback and Johnson 2014), helping in pollination (Dellinger et al. 2014), and seed dispersal (Carlo and Morales 2016). Illegal excessive use of managing biological natural resources (SDAH), human activities, and forest fires in the dry season can cause habitat damage and a decline in bird populations. Furthermore, birds play a crucial function as bioindicators of the environment (Mekonen 2017). Food specialization is correlated with the morphology of a bird's beak. One example is the great-billed bird, which has expertise in consuming seeds (Gomes et al. 2014). Sunbirds, scientifically known as *Nectarinia jugularis* (Linnaeus, 1766), exhibit a predilection for consuming honey (Iwanda et al. 2019). Therefore, bird diversity in an area can be used as a reference in SDAH.

The Sukamade Resort is characterized by its lowland forest ecosystem, which supports a rich and diverse avian population (Susilo 2018). The region remains undisturbed primarily, with high host plants. There is a correlation between the presence of birds and the type of flora they prefer. Birds favor fruit-bearing trees such as *Ficus* species (Rohman et al. 2020). Various insects, including Banyan and *Ficus* trees, inhabit trees (Mackay et al. 2018); particularly, the greater the variety of plants, the greater the variety of bird species (Paker et al. 2014). A positive correlation exists between the diversity of bird species and the quality of environmental conditions (Li et al. 2019). A higher vegetation density produces more bird species (Sanderson et al. 2022). The environmental factors strongly linked to bird diversity are surface area, presence of native shrub species, amount of shrub cover, and extent of bare soil area (Jakobsson and Lindborg 2017; Jähnig et al. 2018).

The term "host plant" refers to a specific type of plant that serves as a habitat and forms a mutually beneficial interaction with other organisms (Puspitarini et al. 2021). Organisms include symbiotic connections, such as mutualism, commensalism, and parasitism, to ensure their survival within the environment (Abdullahi et al. 2020; Gharehchopogh et al. 2020). Plants offer nourishment, refuge, nesting areas, places to rest, and opportunities for reproduction (McLellan et al. 2021). Plants can enhance bird populations by augmenting the abundance of prey and the structural intricacy of plant control (Mrazova et al. 2019; Banko et al. 2022).

Research data that explicitly investigates bird species' host plants in Sukamade Resort, MBNP, must be collected. Therefore, this research aims to determine bird communities' structure and host plants. Furthermore, this research is crucial for implementing specific measures for bird monitoring and recognizing the significance of the MBNP-protected area as a bird habitat. The research findings can serve as primary data for informing management and policy-making in the conservation area of Meru Betiri National Park.

MATERIALS AND METHODS

Study area

The research was conducted at Sukamade Resort, Meru Betiri National Park, Jember District, East Java Province, Indonesia. The observation area encompasses woodland adjacent to the shoreline. The point determination approach employs purposive sampling. It is determining location points based on habitat variations, including: Post-1. Camping ground, Post-2. The office of Sukamade Resort is located at Post-3 on the jungle trail, Post-4 on Parang Kulon, as seen in Figure 1. Post-1. Camping ground (8° 33' 35.701" S-113° 53' 16.598" E), Post-2. Sukamade Resort Office (8° 33' 31.399" S-113° 53' 11.699" E), Post-3. Jungle track (8° 33' 20.902" S-113° 52' 45.199" E), Post-4. Parang Kulon (8° 33' 25.801" S-113° 52' 41.099" E) (Figure 1).

Procedures

Data collection

The research was conducted from March to April 2022, with the bird observation area encompassing the forest adjacent to the beach. Data gathering employs the point count methodology (Bibby et al. 2000). The observation duration at each observation point is 20 minutes. This process also includes documenting the species and number of individuals observed on plate hosts and bird behavior in arboreal habitats, including foraging, nesting, and roosting. The bird observation commenced in the morning (06.00-09.00 am), with the peak of bird activity occurring in the afternoon from (03.00-05.00 pm). Bird observations were carried out three times for each point.

The tools employed included binoculars, and a Canon Power Shot SX540 HS camera. The identification process examined many birds' physical characteristics, including size, proportions, shape, bill, legs, and color pattern (MacKinnon et al. 2010; Taufiqurrahman et al. 2022). The sound recordings were identified using the BirdNET application (Birdnet.cornell.edu). The book 'Flora of the Javanese Mountains' by Van Steenis et al. (2010) was used to determine plant spesies.

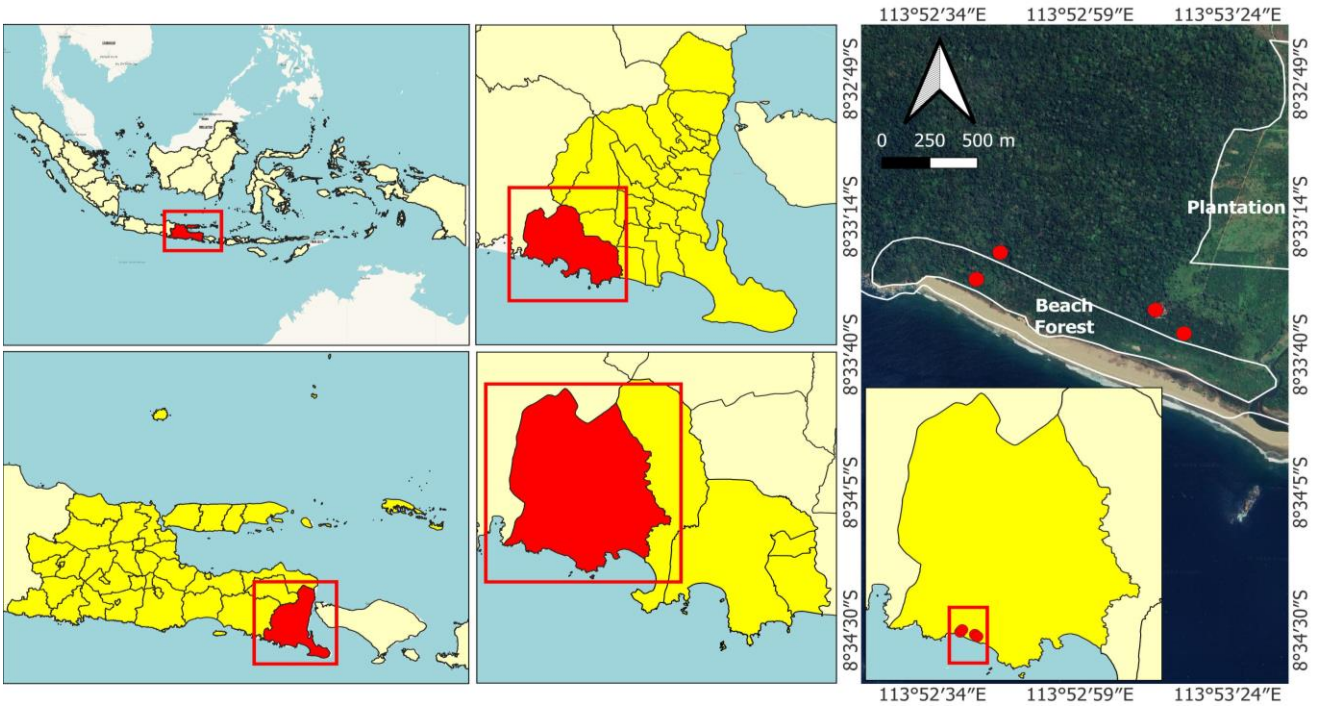

Figure 1. Study locations for bird research in the lowland forest ecosystem of Sukamade Resort, Meru Betiri National Park, Jember District, East Java Province, Indonesia

Data analysis

The conservation status assessment relied on the International Union for Conservation of Nature (IUCN). Red List of Threatened Species (www.iucnredlist.org), Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora (cites.org), Indonesian Regulation (P.106/MENLHK/SETJEN/KUM.1/12/2018). Bird activities on host plants include feeding, nesting, and perching.

Bird communities were analyzed using the Shannon-Wiener Diversity Index (H′), Evennes Index (E), and Simpson Dominance (C) (Magurran 2004). The Shannon-Wiener Index can be calculated using the formula:

$$H' = -\sum\{\left(\frac{ni}{n}\right) In \left(\frac{ni}{n}\right)\}$$

Where :
H' : Shannon-Wiener Diversity Index
ni : Number of individuals of type i
N : Number of individuals of all types

The Evenness Index (E) was used to determine the evenness in the number of individuals that make up a community (Magurran 2004) as follows:

$$E = \frac{H'}{Ln\ S}$$

Where :
E : Evenness Index
H' : Shannon-Wiener Diversity Index
S : Number of species found

Species dominance is determined using the Simpson's Index (Odum 1996) using the formula:

$$D = \sum_{i-l}^{s} (\frac{ni}{n})^2$$

Where :
D : Dominance Index
ni : Number of individuals of type i
N : Number of individuals of all types

The feeding specialization of birds is classified into several different categories: Carnivores (C), Insectivores (I), Fruit eaters (F), Granivores (G), and Nectarivores (N) (MacKinnon et al. 2010). This classification was done using a presence or absence matrix and the Jaccard similarity index, and the Unweighted Pair Group Method with Arithmetic mean (UPGMA) was used for grouping. The PAST4.09 software (Paleontological statistics) was utilized for this analysis. Researchers used Principal Component Analysis (PCA) to understand the relationship between bird abundance patterns (relative abundance data), describing the role and preferences of host plants using tree species, bird, and ecological role variables.

RESULTS AND DISCUSSION

Bird diversity

A total of 286 unique birds, belonging to 49 species from 30 families, were observed and documented at Sukamade Resort in Meru Betiri National Park. This information is summarized in Table 1. The Post-2 Resort Office was identified as the data collection location with the most species (28 species) and individuals (123). High bird diversity is influenced by the presence of host plant species, many of which produce fruit that attracts birds. The plants identified at this site exhibit significant variation in fruit size, reflecting specific adaptations to interactions with local fauna, particularly birds. *Toona sinensis* (A.Juss.) M.Roem. and *Ficus benjamina* L. produce small fruits that are ideally suited for consumption by small seed-eating birds. In contrast, *Sandoricum koetjape* (Burm.fil.) Merr., *Annona reticulata* L., *Neolamarckia cadamba* (Roxb.) Bosser, and *Plectocomia elongata* Mart. ex Blume produce medium-sized fruits that attract larger birds as a vital food source. *Artocarpus elasticus* Reinw. ex Blume, with its large fruits, provides substantial nutrition for large birds or those with strong beaks (Figure 6). This diversity in fruit size underscores the crucial role of birds in local ecology, especially in shaping the patterns of interaction between plants and avian species. Furthermore, minimal human activity at this location reduces potential disturbances. The limited human activity in these areas and low residential densities significantly minimize potential disruptions to the local ecosystem. The absence of intensive human interaction and restricted infrastructure development, including housing and public facilities, enable the natural environment to remain largely undisturbed. This dynamic not only aids in preserving biodiversity but also upholds the stability of ecosystems, which are particularly susceptible to disturbances caused by anthropogenic activities. The high bird diversity observed in Post-2 is associated with increased avian visits to trees (Figure 6.B). Ampoorter et al. (2020) emphasized that plant diversity serves as a crucial driver of trophic-level diversity, particularly for birds. Various habitat types significantly influence avian richness and evenness (Tu et al. 2020). Notably, Post-4 Parang Kulon recorded the fewest species, with only 16 species identified. This location is a forest adjacent to the beach. Mayo et al. (2015) highlighted that disturbances to bird populations are exacerbated by increased human presence. This was corroborated by the observed increase in tourist activity at Sukamade Beach during the turtle nesting season. The population peaked at Kantor Resort with 123 individuals and was lowest in Jungle Track with 36 individuals (Figure 2). *Pycnonotus goiavier* (Scopoli, 1786), *Psilopogon australis* (Horsfield, 1821), and *Eurystomus orientalis* (Linnaeus, 1766) a species that are present in all of the study sites. Furthermore, *Rhyticeros undulatus* (Shaw, 1812) exhibited the highest population density at Kantor Resort. Our study also identified an Endangered (EN) species, *Pavo muticus* (Linnaeus, 1766), legally protected under Indonesian national law (PermenLHKRI 2018). Based on the CITES conservation status, eight bird species identified are listed under Appendix II. Furthermore, according to Presidential

Regulation P.106 /MENLHK/SETJEN/KUM.1/12/2018 ten of the species are protected, including *Haliaeetus leucogaster* (Gmelin, 1788), *Spilornis cheela* (Latham, 1790), *Anthracoceros albirostris* (Shaw, 1808), *Buceros rhinoceros* (Linnaeus, 1758), *R. undulatus*, *Microhierax fringillarius* (Drapiez, 1824), *Psilopogon javensis* (Horsfield, 1821), *P. muticus*, *Hydrornis guajanus* (Müller & Pls, 1776), and *Loriculus pusillus* (G.R.Gray, 1859).

Table 1. List of bird species in Sukamade Resort of Meru Betiri National Park, Jember District, East Java Province, Indonesia

Family	English name	Scientific name	IUCN	CITES	National status	Relative abundance			
						Camping ground	Kantor Resort	Jungle track	Parang Kulon
Acciptridae	White-bellied Sea-eagle	*Haliaeetus leucogaster* (hl)	LC	A.II	P	0.02	0.06	0.00	0.04
Acciptridae	Crested Serpent-eagle	*Spilornis cheela* (sc)	LC	A.II	P	0.00	0.04	0.00	0.00
Aegithinidae	Common Iora	*Aegithina tiphia* (at)	LC	NA	NP	0.04	0.00	0.02	0.02
Alcedinidae	Javan Kingfisher	*Halcyon cyanoventris* (hc)	LC	NA	NP	0.00	0.02	0.00	0.00
Alcedinidae	Collared Kingfisher	*Todiramphus chloris* (tc)	LC	NA	NP	0.00	0.00	0.00	0.12
Artamidae	White-breasted Woodswallow	*Artamus leucoryn* (al)	LC	NA	NP	0.00	0.00	0.00	0.06
Bucerotidae	Oriental Pied Hornbill	*Anthracoceros albirostris* (aa)	LC	A.II	P	0.08	0.27	0.00	0.00
Bucerotidae	Rhinoceros Hornbill	*Buceros rhinoceros* (br)	VU	A.II	P	0.00	0.12	0.00	0.04
Bucerotidae	Wreathed Hornbill	*Rhyticeros undulatus* (ru)	VU	A.II	P	0.00	0.53	0.06	0.16
Campephagidae	Scarlet Minivet	*Pericrocotus flammeus* (pf)	LC	NA	NP	0.02	0.10	0.12	0.00
Campephagidae	Lesser Cuckooshrike	*Coracina fimbriata* (cf)	LC	NA	NP	0.00	0.02	0.00	0.00
Cisticolidae	Common Tailorbird	*Orthotomus sutorius* (os)	LC	NA	NP	0.02	0.02	0.00	0.00
Cisticolidae	Ashy Tailorbird	*Orthotomus ruficeps* (or)	LC	NA	NP	0.00	0.02	0.00	0.04
Columbidae	Grey-cheeked Green pigeon	*Treron griseicauda* (tg)	LC	NA	NP	0.00	0.00	0.00	0.06
Columbidae	Zebra Dove	*Geopelia striata* (gs)	LC	NA	NP	0.00	0.04	0.00	0.02
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis* (eo)	LC	NA	NP	0.02	0.04	0.06	0.02
Corvidae	Slender-billed Crow	*Corvus enca* (ce)	LC	NA	NP	0.10	0.06	0.00	0.04
Cuculidae	Red-billed Malkoha	*Zanclostomus javanicus* (zj)	LC	NA	NP	0.02	0.00	0.00	0.00
Dicaeidae	Scarlet-headed Flowerpecker	*Dicaeum trochileum* (dt)	LC	NA	NP	0.08	0.00	0.00	0.00
Dicruridae	Greater Racquettailed Drongo	*Dicrurus paradiseus* (dp)	LC	NA	NP	0.06	0.00	0.02	0.00
Estrildidae	Scaly-breasted Munia	*Lonchura punctulata* (lp)	LC	NA	NP	0.04	0.00	0.00	0.00
Estrildidae|	Javan Munia	*Lonchura leucogastroides* (ll)	LC	NA	NP	0.00	0.06	0.00	0.00
Eurylaimidae	Javan Broadbill	*Eurylaimus javanicus* (ej)	NT	NA	NP	0.02	0.00	0.02	0.00
Falconidae	Black-thighed Falconet	*Microhierax fringillarius* (mf)	LC	A.II	P	0.00	0.02	0.00	0.04
Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus* (ph)	LC	NA	NP	0.00	0.04	0.00	0.04
Megalaimidae	Yellow-eared Barbet	*Psilopogon australis* (pa)	LC	NA	NP	0.16	0.08	0.06	0.02
Megalaimidae	Black-banded Barbet	*Psilopogon javensis* (pj)	NT	NA	P	0.04	0.02	0.04	0.00
Meropidae	Chestnut-headed Bee-eater	*Merops leschenaulti* (ml)	LC	NA	NP	0.16	0.12	0.04	0.00
Muscicapidae	Oriental Magpie-Robin	*Copsychus saularis* (cs)	LC	NA	NP	0.02	0.00	0.00	0.00
Nectariniidae	Olive-backed Sunbird	*Cinnyris jugularis* (cj)	LC	NA	NP	0.00	0.02	0.00	0.00
Nectariniidae	Streaky-breasted Spiderhunter	*Arachnothera affinis* (aa)	LC	NA	NP	0.00	0.00	0.02	0.00
Nectariniidae	Brown-throated Sunbird	*Anthreptes malacensis* (am)	LC	NA	NP	0.04	0.00	0.00	0.00
Pellornidae	Horsfield's Babbler	*Malacocincla sepiaria* (ms)	LC	NA	NP	0.00	0.00	0.02	0.00
Phasianidae	Green Peafowl	*Pavo muticus* (pm)	EN	A.II	P	0.00	0.04	0.00	0.00
Picidae	Sunda Pygmy Woodpecker	*Dendrocopos moluccensis* (ym)	LC	NA	NP	0.00	0.02	0.00	0.00
Picidae	Common Flameback	*Dinopium javanense* (dj)	LC	NA	NP	0.00	0.02	0.00	0.00
Picidae	Freckle-breasted Woodpecker	*Dendrocopos analis* (da)	LC	NA	NP	0.00	0.00	0.00	0.02
Pittidae	Javan Banded Pitta	*Hydrornis guajanus* (hg)	LC	NA	P	0.00	0.00	0.04	0.00
Psittacidae	Yellow-throated Hanging-parrot	*Loriculus pusillus* (lp)	NT	A.II	P	0.00	0.00	0.02	0.00
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier* (pg)	LC	NA	NP	0.24	0.39	0.04	0.39
Pycnonotidae	Cream-vented Bulbul	*Pycnonotus simplex* (ps)	LC	NA	NP	0.06	0.06	0.08	0.00
Pycnonotidae	Sooty-headed Bulbul	Pycnonotus aurigaster (pa)	LC	NA	NP	0.00	0.12	0.00	0.00
Pycnonotidae	Black-headed Bulbul	*Brachypodius atriceps* (ba)	LC	NA	NP	0.00	0.00	0.02	0.00
Pycnonotidae	Black-crested Bulbul	*Pycnonotus dispar* (pd)	VU	NA	NP	0.02	0.00	0.00	0.00
Sittidae	Velvet-fronted Nuthatch	*Sitta frontalis* (sf)	LC	NA	NP	0.04	0.00	0.00	0.00
Sturnidae	Short-tailed Starling	*Aplonis minor* (am)	LC	NA	NP	0.00	0.00	0.02	0.00
Sturnidae	Asian Glossy Starling	*Aplonis panayensis* (ap)	LC	NA	NP	0.00	0.02	0.00	0.00
Tephrodornithidae	Black-winged Flycatcher-shrike	*Hemipus hirundinaceus* (hh)	LC	NA	NP	0.12	0.12	0.00	0.00
Turdidae	White-crowned Forktail	*Enicurus leschenaulti* (el)	LC	NA	NP	0.00	0.00	0.02	0.00

Note: IUCN: NE: Not Evaluated; DD: Data Deficient; LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CE: Critically Endangered; EW: Extinct in the Wild and Extinct. CITES: NA: Not Appendix; A.I: Apendik I; A.II: Apendik II. NS: National Status: P: Protected; NP: Not Protected (P.106 /MENLHK /SETJEN /KUM.1/12/2018)

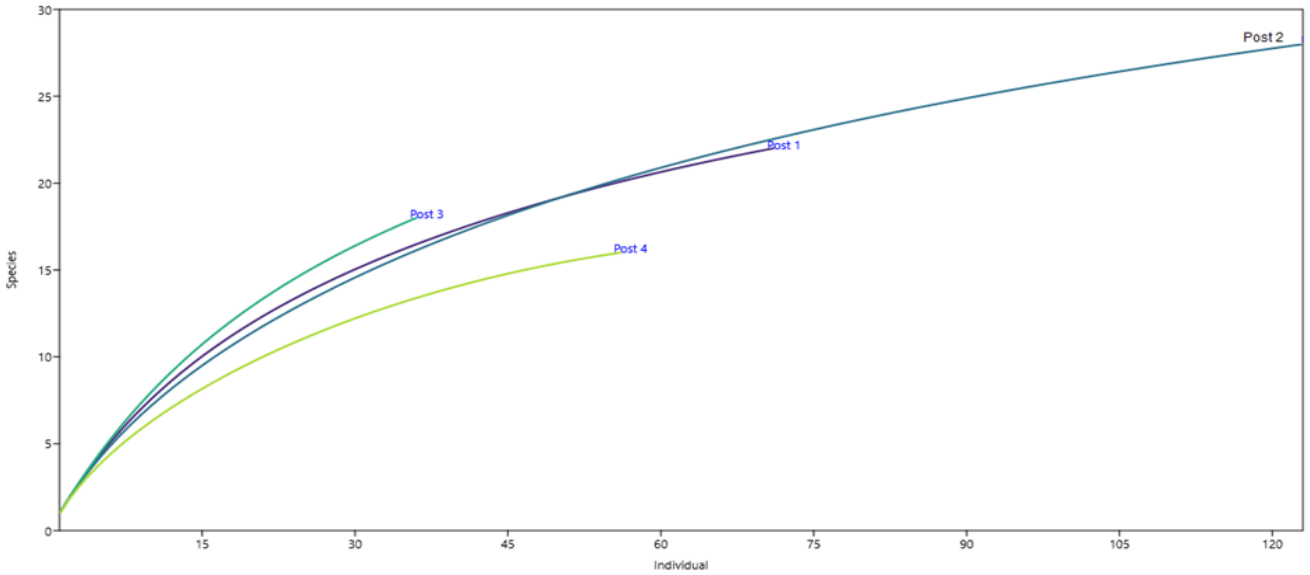

Figure 2. Bird rarefaction curves in four locations. Post-1 recorded 22 species with a total of 71 individuals; Post-2 recorded 28 species with a total of 123 individuals; Post-3 recorded 18 species with a total of 36 individuals; and Post-4 recorded 16 species with a total of 56 individuals

Figure 3 presents the results of data analysis using the Shannon-Wiener Diversity Index, Evenness Index, and Dominance Index to assess bird species at Sukamade Resort, Meru Betiri National Park. The resort office (Post-2) exhibits the highest diversity compared to other locations, with the highest diversity index recorded at 2.774. In contrast, Parang Kulon (Post-4) demonstrates the lowest diversity, with a Shannon index of 2.271. The resort office (Post-2) is situated at the periphery of the forest adjacent to the plantation area. According to Pandey et al. (2021), the richness and abundance of bird species are higher at the forest edge. Furthermore, the composition of bird communities varies according to habitat type, with their dietary specialization being a primary determinant. Ong'ondo et al. (2022) stated that the abundance and richness of forest specialist species and visitors are greater in natural forests. The jungle track exhibits the highest bird evenness index (0.754) compared to other locations. Bird distribution in this area shows a species evenness index value ranging from 0.564 to 0.754. An evenness index value close to 0 indicates low species evenness. Bird distribution at each post varies due to the influence of different vegetation and plant types; Tu et al. (2020) found that natural habitats can increase species evenness. According to Casas et al. (2016), forest habitat structure influences bird assemblages with its variable succession. The dominance index value for each post does not show a significant difference. Based on assessment criteria, the dominance index is classified as low, indicating that none of the bird species dominate across the four posts. A dominance index value close to one (1) signifies that a specific type or species dominates the community, while a value close to zero (0) indicates no dominant type or species. According to Blinkova and Shupova (2017), tree heterogeneity influences bird species diversity. The Dominance Index (C) inversely relates to the Evenness Index (E); when evenness is low, dominance is high, and conversely, when evenness is high, dominance is low.

Figure 4 presents data analysis calculations that utilize the relative abundance index of bird species at Sukamade Resort, Meru Betiri National Park. Complete data on the relative abundance of bird species can be seen in Table 1. Based on the pattern in Figure 4, it can be seen that *P. goiavier* (pg) and *R. undulatus* (ru) are the bird species with the highest abundance values. The *P. goiavier* species, which has the highest abundance value, is a bird from the Pycnonotidae family. It can be found in various habitats because it is very tolerant of environmental changes (Appanan et al. 2023). Taufiqurrahman (2023) revealed that the discovery of two individuals of *P. goiavier* at an altitude of 2,620 meters above sea level (masl) on the southwest side of the Wekas climbing route, Mount Merbabu National Park, indicates the existence of significant ecological adaptations of this species. Typically found in lowlands and secondary forests, the presence of *P. goiavier* at these relatively high elevations indicates its ecological flexibility, allowing this species to persist in various habitats. These findings also add essential data regarding the vertical distribution of *P. goiavier*, which can be helpful in conservation efforts and further studies of bird distribution patterns in tropical mountain areas.

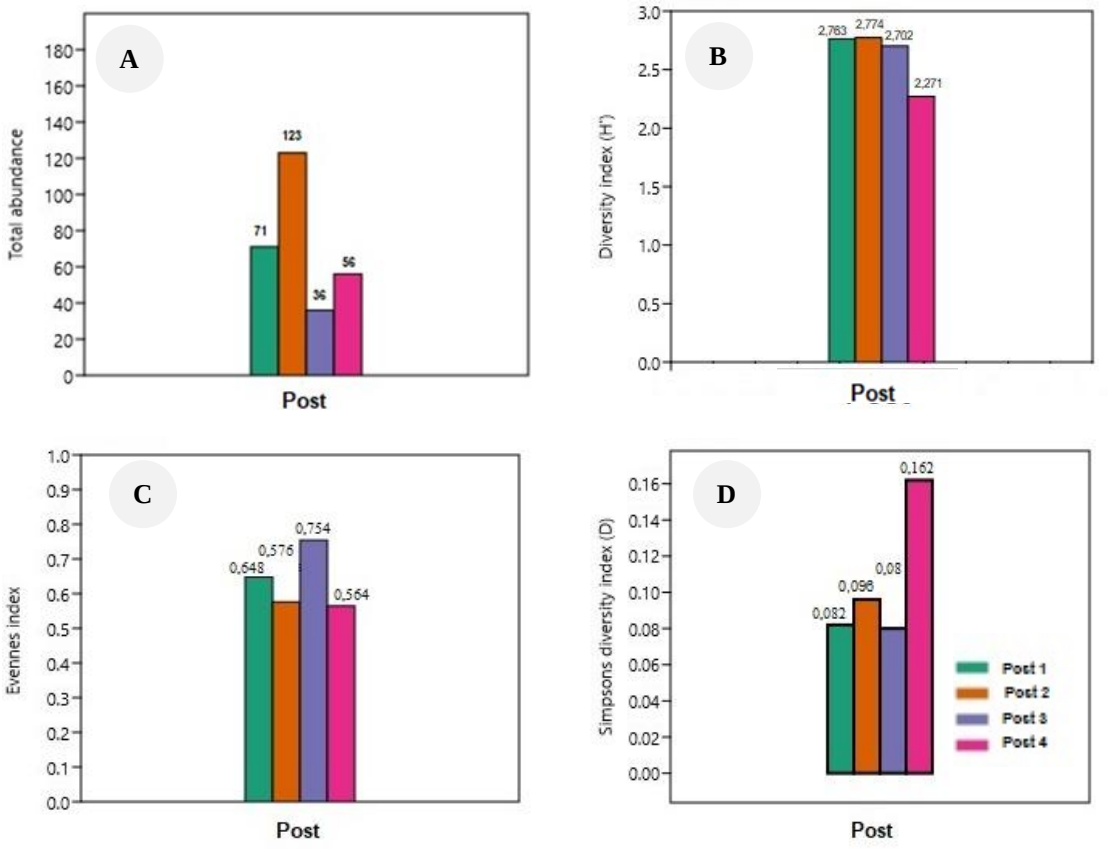

Figure 3. Data analysis using indices of bird diversity, evenness and dominance at Sukamade Resort, Meru Betiri National Park, Jember, Indonesia

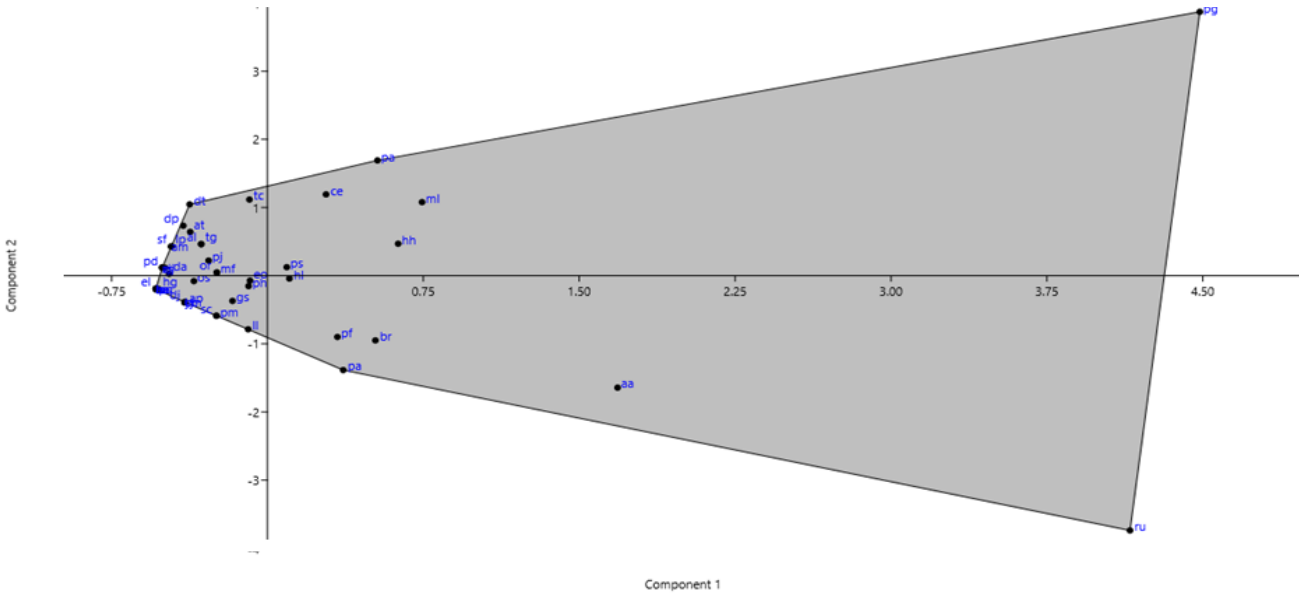

Figure 4. PCA analysis depicting the relative abundance pattern at Sukamade resort, Meru Betiri National Park, Jember, Indonesia. Note: List of bird name codes in Table 3

Table 2. Bird species and activities at the host plant at the Sukamade Resort, Meru Betiri National Park, Jember, Indonesia

Family host plant	Host plant	Bird species	Activity		
			Eat	Nesting	Perch
Annonaceae	*Annona reticulata* L.	*Psilopogon javensis* (Horsfield, 1821)	-	-	√
		Pericrocotus flammeus (J.R.Forster, 1781)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
		Geopelia striata (Linnaeus, 1766)	-	-	√
		Artamus leucoryn (Linnaeus, 1771)	-	-	√
		Psilopogon haemacephalus (P.L.S.Müller, 1776)	-	-	√
		Aplonis minor (Bonaparte, 1850)	-	-	√
Apocynaceae	*Alstonia scholaris* (L.) R.Br.	*Merops leschenaulti* (Vieillot, 1817)	√	-	√
		Corvus enca (Horsfield, 1821)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
		Geopelia striata (Linnaeus, 1766)	-	-	√
		Psilopogon haemacephalus (P.L.S.Müller, 1776)	-	-	√
		Eurystomus orientalis (Linnaeus, 1766)	-	-	√
		Artamus leucoryn (Linnaeus, 1771)	-	-	√
		Todiramphus chloris (Boddaert, 1783)	-	-	√
		Microhierax fringillarius (Drapiez, 1824)	-	-	√
		Haliaeetus leucogaster (Gmelin, 1788)	√	-	√
		Dendrocopos analis (Bonaparte, 1850)	-	-	√
Apocynaceae	*Voacanga grandifolia* (Miq.) Rolfe	*Anthreptes malacensis* (Scopoli, 1786)	√	-	√
Arecaceae	*Plectocomia elongata* Mart. ex Blume	*Orthotomus sutorius* (Pennant, 1769)	-	-	√
		Pycnonotus simplex (Lesson, 1839)	-	-	√
		Orthotomus ruficeps (Lesson, 1830)	-	-	√
Arecaceae	*Cocos nucifera* L.	*Coracina fimbriata* (Temminck, 1824)	-	-	√
Combretaceae	*Terminalia catappa* L.	*Psilopogon haemacephalus* (P.L.S.Müller, 1776)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Todiramphus chloris (Boddaert, 1783)	-	-	√
		Orthotomus ruficeps (Lesson, 1830)	-	-	√
		Haliaeetus leucogaster (Gmelin, 1788)	√	-	√
Euphorbiaceae	*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.	*Hemipus hirundinaceus* (Temminck, 1822)	-	-	√
		Pycnonotus aurigaster (Vieillot, 1818)	-	-	√
Fabaceae	*Samanea saman* (Jacq.) Merr.	*Dicrurus paradiseus* (Linnaeus, 1766)	-	-	√
		Sitta frontalis (Swainson, 1820)	√	-	√
		Merops leschenaulti (Vieillot, 1817)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Hemipus hirundinaceus (Temminck, 1822)	-	-	√
		Zanclostomus javanicus (Horsfield, 1821)	-	-	√
		Lonchura punctulate (Linnaeus, 1758)	-	-	√
Fabaceae	*Albizia chinensis* (Osbeck) Merr.	*Dicrurus paradiseus* (Linnaeus, 1766)	-	-	√
		Sitta frontalis (Swainson, 1820)	-	-	√
		Merops leschenaulti (Vieillot, 1817)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Hemipus hirundinaceus (Temminck, 1822)	-	-	√
		Zanclostomus javanicus (Horsfield, 1821)	-	-	√
		Lonchura punctulata (Linnaeus, 1758)	√	-	√
Lythraceae	*Lagerstroemia speciosa* (L.) Pers.	*Spilornis cheela* (Latham, 1790)	-	-	√
		Pavo muticus (Linnaeus, 1766)	-	-	√
Malvaceae	*Taliparitti tiliaceum* (L.) Fryxell	*Pycnonotus goiavier* (Scopoli, 1786)	-	-	√
		Geopelia striata (Linnaeus, 1766)	-	-	√
		Microhierax fringillarius (Drapiez, 1824)	-	-	√
		Aegithina tiphia (Linnaeus, 1758)	-	-	√
		Todiramphus chloris (Boddaert, 1783)	-	-	√
Meliaceae	*Dysoxylum amooroides* Miq.	*Copsychus saularis* (Linnaeus, 1758)	-	-	√
		Pycnonotus simplex (Lesson, 1839)	-	-	√
		Orthotomus sutorius (Pennant, 1769)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	√	-	√
		Merops leschenaulti (Vieillot, 1817)	-	-	√
		Psilopogon javensis (Horsfield, 1821)	-	-	√
		Anthracoceros albirostris (Shaw, 1808)	-	-	√
		Eurystomus orientalis (Linnaeus, 1766)	-	-	√
		Todiramphus chloris (Boddaert, 1783)	-	-	√

Meliaceae	*Toona sinensis* (A.Juss.) M.Roem.	*Pycnonotus simplex* (Lesson, 1839)	-	-	√
		Cinnyris jugularis (Linnaeus, 1766)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
		Psilopogon australis (Horsfield, 1821)	√	-	√
		Microhierax fringillarius (Drapiez, 1824)	-	-	√
		Psilopogon haemacephalus (P.L.S.Müller, 1776)	-	-	√
		Pycnonotus aurigaster (Vieillot, 1818)	-	-	√
		Eurystomus orientalis (Linnaeus, 1766)	-	-	√
		Anthracoceros albirostris (Shaw, 1808)	-	-	√
		Aplonis panayensis (Scopoli, 1786)	-	-	√
Meliaceae	*Sandoricum koetjape* (Burm.fil.) Merr.	*Aegithina tiphia* (Linnaeus, 1758)	-	-	√
		Dicrurus paradiseus (Linnaeus, 1766)	-	-	√
		Eurylaimus javanicus (Horsfield, 1821)	-	-	√
		Pycnonotus simplex (Lesson, 1839)	-	-	√
		Arachnothera affinis (Horsfield, 1821)	-	-	√
		Pericrocotus flammeus (J.R.Forster, 1781)	-	-	√
Moraceae	*Ficus benjamina* L.	*Merops leschenaulti* (Vieillot, 1817)	√	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
		Psilopogon australis (Horsfield, 1821)	√	-	√
		Anthracoceros albirostris (Shaw, 1808)	√	-	√
		Eurylaimus javanicus (Horsfield, 1821)	-	-	√
		Psilopogon javensis (Horsfield, 1821)	-	-	√
		Aegithina tiphia (Linnaeus, 1758)	√	-	√
		Pericrocotus flammeus (J.R.Forster, 1781)	√	-	√
		Hemipus hirundinaceus (Temminck, 1822)	-	-	√
		Pycnonotus simplex (Lesson, 1839)	√	-	√
		Pycnonotus dispar (Horsfield, 1821)	-	-	√
		Dicaeum trochileum (Sparrman, 1789)	√	-	√
		Buceros rhinoceros (Linnaeus, 1758)	√	-	√
		Rhyticeros undulatus (Shaw, 1812)	√	-	√
		Corvus enca (Horsfield, 1821)	-	-	√
		Haliaeetus leucogaster (Gmelin, 1788)	-	-	√
		Treron griseicauda (Bonaparte, 1855)	-	-	√
Moraceae	*Artocarpus elasticus* Reinw. ex Blume	*Pycnonotus aurigaster* (Vieillot, 1818)	-	-	√
		Eurystomus orientalis (Linnaeus, 1766)	-	-	√
		Dinopium javanense (Ljungh, 1797)	-	-	√
		Corvus enca (Horsfield, 1821)	-	-	√
		Anthracoceros albirostris (Shaw, 1808)	-	-	√
		Haliaeetus leucogaster (Gmelin, 1788)	-	√	√
		Psilopogon javensis (Horsfield, 1821)	-	-	√
		Loriculus pusillus (G.R.Gray, 1859)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Rhyticeros undulatus (Shaw, 1812)	-	-	√
Moraceae	*Ficus ampelas* Burm.f.	*Malacocincla sepiaria* (Horsfield, 1821)	-	-	√
		Psilopogon australis (Horsfield, 1821)	-	-	√
		Merops leschenaulti (Vieillot, 1817)	-	-	√
		Pycnonotus simplex (Lesson, 1839)	-	-	√
		Pycnonotus goiavier (Scopoli, 1786)	-	-	√
Pandanaceae	*Pandanus tectorius* Parkinson ex Du Roi	*Todiramphus chloris* (Boddaert, 1783)	√	-	√
Rubiaceae	*Neolamarckia cadamba* (Roxb.) Bosser	*Lonchura leucogastroides* (Moore, 1858)	-	-	√
		Pycnonotus aurigaster (Vieillot, 1818)	-	-	√
Sapindaceae	*Pometia tomentosa* (Blume) Teijsm. & Binn.	*Arachnothera affinis* (Horsfield, 1821)	-	-	√
		Rhyticeros undulatus (Shaw, 1812)	-	-	√
		Pericrocotus flammeus (J.R.Forster, 1781)	√	-	√
Tetramelaceae	*Trametes nudiflor* R.Br.	*Rhyticeros undulatus* (Shaw, 1812)	-	-	√

Ecological role using bird feeding specialization

According to their dietary specialization, four species are classified as carnivores, 21 as insectivores, and three as frugivores (Figure 5). Several species were observed to exhibit several dietary specializations, including two species that were both insectivorous and granivorous, as well as a species that was nectarivorous and probably insectivorous; 11 species mainly feed on insects and fruits. There are three species of animals: insectivores, frugivores, and granivores, and three species of carnivores and insectivores, as shown in Figure 2. The research on food specialization revealed that insectivores were the dominant group compared to the others. The National Park's ecosystem is conducive to insect life and exhibits significant biodiversity (Rohman et al 2022). Insects possess high nutritional value, particularly for avian species (Filho et al. 2021). The Sukamade area has a variety of plants that offer optimal habitat conditions, especially for bird activity. These plants are also magnets for insects, which are a food source.

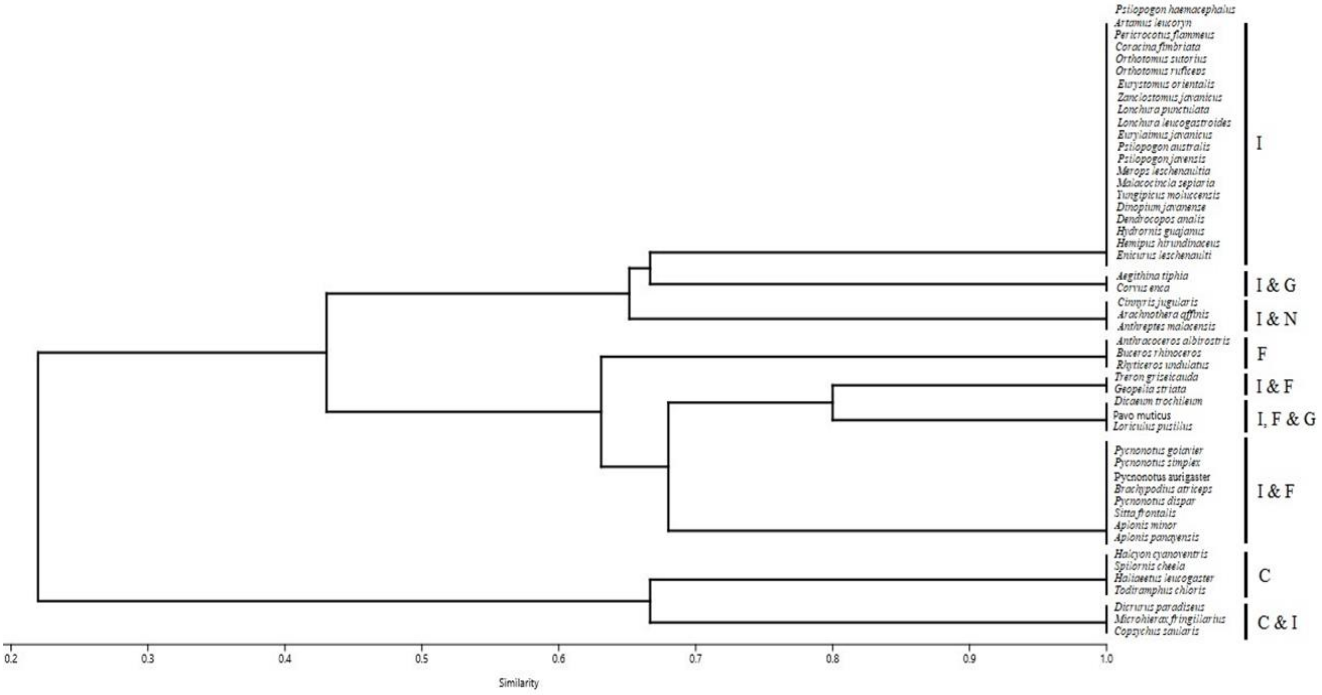

Figure 5. Clustering of feeding specialization based on the spesies of bird in the Resort Sukamade, Meru Betiri National Park, Jember, Indonesia. Abbreviation as follows: C: Carnivores; I: Insectivores; F: Frugivores; G: Granivores; and N: Nectarivores

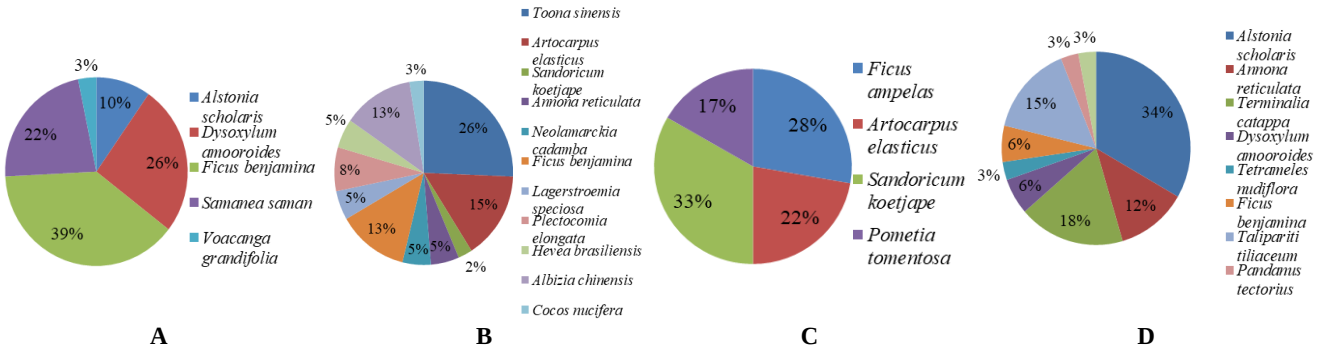

Figure 6. Percentage diagram of the number of bird species visiting preferred vegetation. A. Post-1 Camping ground; B. Post-2 Sukamade Resort Office; C. Post-3 Jungle track; D. Post-4 Parang Kulon

Bird preferences for host plants

Identifying prevalent vegetation in the four posts at Sukamade Resort revealed 21 plant species that birds prefer. These species belong to 14 different families, namely Annonaceae, Apocynaceae, Arecaceae, Combretaceae, Euphorbiaceae, Fabaceae, Lythraceae, Malvaceae, Meliaceae, Moraceae, Pandanaceae, Rubiaceae, Sapindaceae, and Tetramelaceae (Table 2). Bird perching is the most frequently observed behavior while nesting rarely occurs. Researchers observe roosting activity more often during the day compared to the morning and late afternoon. Additionally, birds frequently perch while moving from one tree to another, and researchers have included these observations in the data. We observed nesting activity in *Haliaeetus leucoryphus* (Pallas, 1771) on an *A. elasticus* tree. The active nest, situated on branches of the tree trunk, is located on a tree approximately 30 meters in height. We observed feeding activity in *M. leschenaulti*, *H. leucoryphus*, *A. malacensis*, *H. leucogaster*, *S. frontalis*, *L. punctulata*, *P. australis*, *M. leschenaulti*, *P. australis*, *A. albirostris*, *A. tiphia*, *P. flammeus*, *P. simplex*, *D. trochileum*, *B. rhinoceros*, *R. undulatus*, *T. chloris*, and *P. flammeus*.

Our research revealed that *F. benjamina* was the most frequently visited by birds as preferred vegetation. In contrast, visits were least frequent in five plant species (*V. grandifolia*, *T. catappa*, *P. tectorius*, *Tetrameles nudiflora* R.Br.) (Figure 6). The *F. benjamina* can grow to a height of up to 35 meters, exhibiting numerous branches. This tree is characterized by its distinctive hanging roots and supports a diverse insect community (Suênia-Bastos et al. 2021). When ripe, the tree produces abundant, round, red fruit,

attracting birds. According to Walther et al. (2018), *F. benjamina* bears fruit year-round, offering a stable food source for birds in tropical and subtropical forests. The host plant, *V. grandifolia*, a shrub that can reach a height of 5 meters, is infrequently visited. It features white flowers and elliptical fruit. Observational data (Table 2) indicate that only *A. malacensis* visits this plant. As a nectarivorous bird, *A. malacensis* attracts the plant due to its nectar-producing flowers, which serve as a food source. *P. tectorius* is a large, multi-stemmed shrub with a spreading canopy, typically reaching 3 to 7 meters high. This shrub is commonly found along the Sukamade coast. It produces white flowers arranged in clusters and relatively large fruit. Observational data reveal that only one bird species, *T. chloris*, visited this plant. Additionally, *P. tectorius* is frequently used by birds in the area for roosting. The *T. nudiflora* is characterized by its roots, which spread over the surface of soil and rocks, and its stem, which can reach up to 50 meters in height. The plant produces round fruit. Observational data (Table 2) indicate that only *R. undulatus* visited this host plant, likely attracted by the abundance of fruit and its potential as a nesting site.

The first post found that *F. benjamina* had the most excellent visitation rate across plant species, accounting for 39% of all visits (Figure 6.A). The *F. benjamina* was prevalent in all of the study sites. The *F. benjamina* is a plant that attracts birds in search of food (Pradana et al. 2018), while it serves as a source of nourishment for insects (Laarif and Bouslama 2022). Furthermore, it serves as a habitat for several insect species (Harbi et al. 2021), including *Trilocha varians* (Walker, 1855), known as ficus plant pests (Basari et al. 2019; Ramzan et al. 2021). Mardiastuti research reported bird visits to *F. benjamina* in a related study (Mardiastuti et al. 2021). The bird species that visit are Pycnonotidae, Columbidae, and Bucerotidae (Febriyanto et al. 2020). In addition, they disseminate ficus seeds (Quiroga et al. 2021).

At the Post-2 Sukamade Resort Office, *T. sinensis* is the plant species that attracts the most bird visits, with a rate of 26% (Figure 6.B). The *T. sinensis* produces several fruits per panicle, with varying numbers ranging from 38 to 646. The fruit contains a variable number of seeds, ranging from 1 to 35 (Pramono et al. 2016). Based on the observed percentage data on *T. sinensis*, it has been determined that *P. australis*, a specific bird species, is engaged in food-seeking. The bird's consumption is still being determined due to the brevity of the encounter. The *P. australis* is a member of the Megalaimidae family and prefers consuming fruits, seeds, and flowers (MacKinnon et al. 2010).

In the third Jungle track study, it was observed that *S. koetjape* had the most significant proportion of bird visits, accounting for 33% of all visits (Figure 6.C). The *S. koetjape* exhibits a profusion of branches and develops a compact canopy (Sritongchuay and Bumrungsri 2016; Susanto and Kartawinata 2022). Birds favor this vegetation. Furthermore, *S. koetjape* is a flowering plant primarily visited by stingless bees (Sritongchuay and Bumrungsri 2016). This interaction, in turn, attracts birds that seek out insects and nectar.

In Post-4, it was demonstrated that *A. scholaris* had the highest percentage, reaching 34% (Figure 6.D). *Alstonia scholaris* (L.) R.Br. attracts a large number of birds since it is known to serve as a host plant for a variety of arthropods, including different kinds of Lepidoptera (Dar et al. 2022). Furthermore, *A. scholaris* serves as a suitable and preferred vegetation, capable of attracting birds and increasing bird variety (Yuliawati et al. 2021).

Host plant and bird activity

The bird activities observed in the host plant were classified into three categories: feeding, nesting, and perching (Table 3). Perching and feeding are the most common bird activities found on *F. benjamina* trees, while nesting is only found on *A. elasticus* trees (Figure 7). The *H. leucogaster* is a bird that nests in this tree. Goncalves et al. (2019) identified 1,031 shrub species with the potential to serve as perches for birds. The mean height at which trees were perched ranged from 13.43±0.28 m to 15.93±0.45 m, as reported by Kaur and Kler (2018). Roosting behavior is crucial for forest avian species, frugivores, and insectivores due to their frequent eating, roosting, and breeding activities in these locations (Ortega-Álvarez et al. 2021). Observations of large-diameter trees with nest structures in the top crown rarely show nesting activity (Neema et al. 2021). The nesting preferences range from a minimum distance of 30 meters to a maximum distance of about 900 meters from the coastline. The highest elevation is 92 meters, while the lowest is 18 meters (Oyedele et al. 2020; Neema et al. 2021).

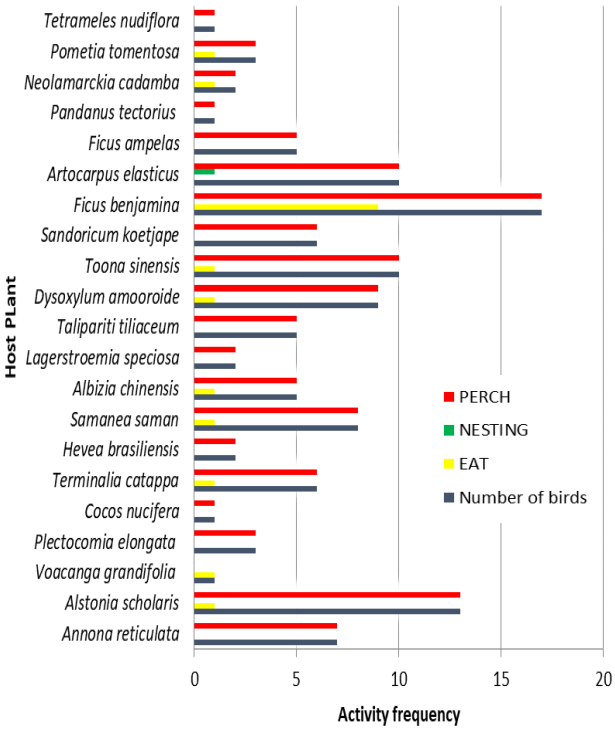

Figure 7. Bird species preferences for tree species as shown by the percentage of frequency of birds carrying out activities on several host plants

Table 3. Total individuals, ecological roles, and host plants

Bird species	Host plant																			Ecological role				
	AR	AS	VG	PE	CN	TC	HB	SS	AC	LS	TT	DA	TS	SK	FB	AE	FA	PT	NC	TN	INS	GRA	POL	FRU	PRE
H. leucogaster (hl)		2				2									2	9									√
S. cheela (sc)										3															√
A. tiphia (at)											1			2	4							√			
H. cyanoventris (hc)									2																√
T. chloris (tc)						1					2	2						1							√
A. leucoryn (al)	1	3																			√				
A. albirostris (aa)												1	1		32	1								√	
B. rhinoceros (br)															11									√	
R. undulatus (ru)															28	8		3		3				√	
P. flammeus (pf)														3	1				11		√				
C. fimbriata (cf)					1																√				
O. sutorius (os)				2								1									√				
O. ruficeps (or)				1		2															√				
T. griseicauda (tg)															1									√	
G. striata (gs)	1	2							2		2													√	
E. orientalis (eo)		2										1	1			3					√				
C. enca (ce)		2													3	1						√			
Z. javanicus (zj)								1														√			
D. trochileum (dt)															4									√	
D. paradiseus (dp)								3						2											√
L. punctulata (lp)								2													√				
L. leucogastroides (ll)																		3			√				
E. javanicus (ej)															1						√				
M. fringillarius (mf)		4											1					2							√
P. haemacephalus (ph)		1				4							5								√				
P. australis (pa)		9				1		2					3		5	11	1		2		√				
P. javensis (pj)	1											2	1		1	6					√				
M. leschenaulti (ml)		6						4	6			4			12		2				√				
C. saularis (cs)												1									√				
C. jugularis (cj)													1										√		
A. affinis (aa)														1									√		
A. malacensis (am)			2																				√		
M. sepiaria (ms)																	1				√				
P. muticus (pm)										2											√				
D. moluccensis (ym)									1												√				
D. javanense (dj)																1					√				
D. analis (da)		1																			√				
H. guajanus (hg)																					√				
L. pusillus (lp)																2						√			
P. goiavier (pg)	12	2									13	9	43		29		2							√	
P. simplex (ps)				3								1	2	12	6		2							√	
P. aurigaster (pa)							6						6			4			4					√	
B. atriceps (ba)															1									√	
P. dispar (pd)															1									√	
S. frontalis (sf)								3																√	
A. minor (am)	1																							√	
A. panayensis (ap)													1											√	
H. hirundinaceus (hh)							7	2	5						1						√			√	
E. leschenaulti (el)																					√			√	

Note: AR: *Annona reticulata*, AS: *Alstonia scholaris*, VG: *Voacanga grandifolia*, PE: *Plectocomia elongata*, CN: *Cocos nucifera*, TC: *Terminalia catappa*, HB: *Hevea brasiliensis*, SS: *Samanea sama*, AC: *Albizia chinensis*, LS: *Lagerstroemia speciosa*, TT: *Taliparitiliaceum*, DA: *Dysoxylum amooroides*, TS: *Toona sinensis*, SK: *Sandoricum koetjape*, FB: *Ficus benjamina*, AE: *Artocarpus elasticus*, FA: *Ficus amelas*, PT: *Pometia tomentosa*, NC: *Neolamarckia cadamba*, TN: *Tetrameles nudiflor*, INS: Insectivore, GRA: Granifora, POL: Pollinator, FRU: Frugivore, and PRE: Predator

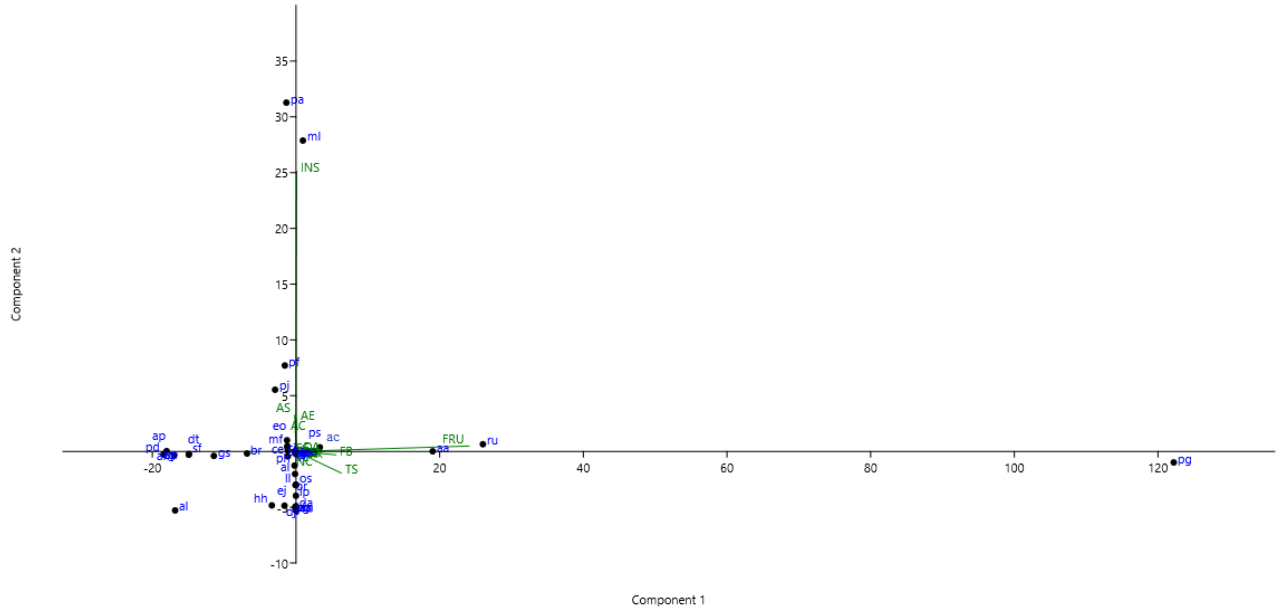

Figure 8. Principal Component Analysis (PCA) graph with the variables tree species, bird species, and the ecological role of birds. Ecological role: INS (Insectivore), POL (Pollinator), PRE (Predator), FRU (Frugivore)

Ecological role of birds using food specialization of various host plants

This data analysis utilizes bird species, host plants, and the ecological role of birds at each location (Figure 8; Table 3). Twenty-two bird species have an ecological role as insectivores. Sixteen species of birds are frugivores and six species of birds as predators. Four species of birds are granivores; three species of birds as frugivores. Based on the PCA pattern observed in Figure 8, the first quadrant indicates a correlation between *M. leschenaulti* (ml), *R. undulatus* (ru), *P. goiavier* (pg), *P. simplex* (ps), and *A. albirostris* (aa) with *A. elasticus* (AE) and *A. chinensis* (AC). *Merops leschenaulti* (ml) is a bird species that acts as an insectivore (INS). The *P. goiavier* (pg), *A. albirostris* (aa), *P. simplex* (ps) adalah frugiphora (Rumblat et al. 2016). The *R. undulatus* (ru) acts as a frugivore and insectivore (Ananda et al. 2022). Based on observations in Table 3, the bird species observed have different host plants. Insectivorous birds and fruit-eating birds are the most frequently observed species.

The *M. leschenaulti* occupies several trees: *A. scholaris* (AS), *S. saman* (SS), *A. chinensis* (AC), *D. amooroides* (DA), *F. benjamina* (FB), *F. amelas* (FA). Meanwhile, *P. goiavier* occupies *A. reticulata* (AR), *A. scholaris* (AS), *T. tiliaceum* (TT), *D. amooroides* (DA), *T. sinensis* (TS), *F. benjamina* (FB), *F. amelas* (FA) trees. The *A. albirostris* correlates with the trees *D. amooroides* (DA), *T. sinensis* (TS), *F. benjamina* (FB), and *A. elasticus* (AE). The *P. simplex* species occupies PE trees, *D. amooroides* (DA), *T. sinensis* (TS), *S. koetjape* (SK), *F. benjamina* (FB), *F. amelas* (FA).

As well as *R. undulatus* (ru) occupying *F. benjamina* (FB), *A. elasticus* (AE), *P. tomentosa* (PT), and *T. nudiflor* (TN) trees. The species *P. goiavier* (pg) is the bird with the most significant number of individuals. This species has a wide distribution area and is a commonly found type. It was recorded that *T. sinensis* had the highest visiting preference. Butterflies and bees are insects that visit blooming flowers in observation data. It is suspected that these insects are pollinating agents. *P. goiavier* hunts insects on flowers. The host plant, *F. benjamina*, is the second highest preference for visits. *F. benjamina* is a fruit tree with a dense canopy structure that provides various insects as a bird food source (Rumblat et al. 2016). Several red and purple fruit characteristics are generally more favorable than green fruit (Hazell et al. 2023).

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