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Wildlife existence and potential threats in Pelangi Forest Biosite of Ijen Geopark, East Java, Indonesia

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Abstract. *Siddiq AM, Kurnianto AS, Sulistiyowati H, Wijaya MT, Ratnasari T, Dewi N, Utami ET, Ayuningtyas TR. 2024. Wildlife existence and potential threats in Pelangi Forest Biosite of Ijen Geopark, East Java, Indonesia. Biodiversitas 25: 4487-4497.* A comprehensive study of the diverse wildlife and potential threats at the Pelangi Forest Biosite (Rainbow Forest Biosite, RFB) of Ijen Geopark, East Java, Indonesia was conducted in May 2023. Bird and primate observations were carried out using the point count method, while herpetofauna observation was conducted using the Visual Encounter Survey (VES). Data collection on potential threats to community activities in the RFB used a questionnaire survey method. Data analysis used the Diversity Index (H'), Existence factor (Ef), and scale-Likert for potential threats. The Pelangi Forest is home to an impressive 62 wildlife species, including six amphibian species, nine reptile species, 46 bird species, and one primate species. The value of wildlife species diversity in RFB, calculated using the Shannon-Wiener index, is remarkably high (H= 3.48). The wildlife species in the Pelangi Forest had an average existence value of 41.94%, indicating a moderate uniqueness level, with the Javan lutung (*Trachypithecus auratus* (É.Geoffroy Saint-Hilaire, 1812)) standing out with the highest Ef value (80%). According to Likert-scale analysis, potential threats to biodiversity in the RFB of Ijen Geopark are relatively low (23.54%). However, some crucial notes for evaluating the conservation plan, namely the illegal poaching or hunting of wildlife species, such as birds and large mammals, still occur. Therefore, implementing education-based tourism, such as birdwatching or wildlife observation, can increase awareness and knowledge about conservation for tourists and society.

Keywords: Existence, Ijen Geopark, Pelangi Forest, wildlife

INTRODUCTION

The Pelangi Forest of Sumberwringin is a unique and Special-Purpose Forest Area (SPFA) with a distinctive vegetation structure located in the Bondowoso region of East Java, Indonesia. Established in 1937, this area is home to around 3,879 collection trees composed of 59 species originating from 52 locations worldwide (Geopark Ijen 2023). The existing plant species are introduced to assess their suitability and usefulness as collection and conservation plants. One of the most striking plant species is the Pelangi Eucalyptus (*Eucalyptus deglupta* Blume), which boasts unique morphological characteristics of a stem surface color resembling a Pelangi (Orwa et al. 2009) and has a vulnerable conservation status (Hills 2019). Due to its ecological value and uniqueness, the Pelangi Forest has been designated as one of the biological sites (Biosite) or biological heritage under the management of the Ijen Unesco Global Geopark since 2023 (Geopark Ijen 2023).

Over the past 85 years, Pelangi Forest has been a tropical ecosystem with heterogeneous and diverse vegetation. This is indicated by the vegetation richness that made the forest, ranging from herbaceous habitus, shrubs, and trees (Geopark Ijen 2023). Therefore, the plant diversity in this area is thought to lead to complexity (Sulistiyowati et al. 2024). This supports the existence of wildlife species in the ecosystem around the slopes of Mount Raung and Ijen. Plant parts, such as leaves, fruits, seeds, and nectar, become food sources for herbivores (Stratford and Sekercioglu 2015; Sun et al. 2017; Maselou et al. 2019). Furthermore, tree vegetation provides canopy nesting or resting sites for birds, amphibians, reptiles, and primates (Valencia-Aguilar et al. 2013; Tsuji et al. 2017; Xu et al. 2022; Siddiq et al. 2024a). According to Brockerhoff et al. (2017), the forest canopy plays a role in biodiversity conservation. It provides various essential ecosystem services such as climate regulation, biomass production, water supply and purification, pollination, and habitat provision for forest species.

On the other hand, the existence of wildlife is also essential as a counterweight to the energy flow or productivity of an ecosystem. Bird groups (avifauna) have roles as pollinators (Anderson et al. 2016; Johnson 2022), seed dispersers (Partasasmita et al. 2017; Ohkawara et al. 2023), herbivory or prey control at lower trophic levels (Stratford and Sekercioglu 2015; Verduci et al. 2023). Furthermore, the group of amphibians and reptiles (herpetofauna) also coexist in niches with other group species; hence, most members of their species are nocturnal. Relatively large mammals play an equally important role, such as primates that are able to disperse large seeds in the

forest and control plant populations (Bufalo et al. 2016; McConkey 2018). However, information related to the existence and diversity of wildlife at the Pelangi Forest Biosite (Rainbow Forest Biosite, RFB) has never been reported scientifically.

Specifically, this study aims to explore wildlife existence in the RFB of Ijen Geopark using an ecological approach to assess the structure of biodiversity based on species composition, dominance, and diversity. Species composition will provide information on the list of biodiversity species from avifauna, herpetofauna, and mammal groups that compose the Pelangi Forest ecosystem. The dominance index represents the dominant-codominant species that comprise the Pelangi Forest structure. The diversity of species describes species richness with the relative abundance of communities that comprise the Pelangi Forest structure. These three components manifest the contribution of biodiversity as a producer of tangible-value products that can be calculated or measured.

Furthermore, the presence of wild animals can also be calculated using the total ecological value. This value is determined by considering three categories: Frequency or encounter (Fr), Conservation status (Cs), and expansion or Geographic distribution (Gd) of species. Each category is assigned a value, and the total ecological value is the sum of these values, providing a comprehensive measure of the presence of wild animals in the RFB (Sulistiyowati and Buot 2016; Siddiq et al. 2023). Finally, this study also aims to measure potential threats from society to wildlife in RFB. Thus, these results can be a comprehensive report for sustainable management by stakeholders.

MATERIALS AND METHODS

Study area

Geographically, Pelangi Forest is located west of Mount Ijen and Mount Raung at an altitude of 820 m above sea level. It encompasses an area of 23.75 ha, which is located in a permanent production forest. According to Geopark Ijen (2023), the climate classification (Schmidt and Ferguson) in the Pelangi Forest Area includes a type B climate with 2400 mm/year rainfall, the rainiest days in January, and decreases starting in June. Topographic conditions show an average slope ranging from 0 to 15% with brown andosol association soil type.

Data were collected in May 2023, including wildlife diversity that includes birds (avifauna), primates, amphibians, and reptiles (herpetofauna) and community activities inside the Pelangi Forest Area. Bird and primate data were taken at four representative sites, including site 1 (7°59'48.56"S, 114°0'8.78"E), site 2 (7°59'48.36"S, 114°0'15.05"E), site 3 (7°59'54.77"S, 114°0'10.42"E), and site 4 (7°59'55.67"S, 114°0'15.96"E) (Figure 1). While data on amphibians and reptiles were taken at four representative tracks, i.e., track 1 (7°59'48.93"S, 114°00'11.17"E to 7°59'48.83"S, 114°00'10.05"E), track 2 (7°59'48.76"S, 114°00'12.39"E to 7°59'51.12"S, 114°00'14.85"E), track 3 (7°59'52.41"S, 114°00'11.61"E to 7°59'55.24"S, 114°00'13.05"E), and track 4 (7°59'52.80"S, 114°00'11.52"E to 7°59'58.95"S, 114°00'15.20"E) (Figure 1).

Wildlife observation

The wildlife such bird and primate observations were conducted using the point count method (Thunhikorn et al. 2016), with each site lasting 20 minutes. Observations were made at 06.00-09.00 AM. The observation used Nikon Aculon binoculars, a Canon EOS 60D DSLR camera, and a Thamron 300 m telephoto lens. Furthermore, herpetofauna observation was carried out using the Visual Encounter Survey (VES) method (Boullhesen et al. 2021; Siddiq et al. 2024b) on a 400-meter trail. This observation was conducted twice, including at noon around 09.00 AM-1.00 PM and at night around 07.00-10.00 PM. The data collection process used several pieces of equipment, such as headlamps used in night observations, hocksticks used for snake handling, and a plastic ziplock for sample collection. Ecological data was collected, including species name, abundance, and frequency. Finally, for the identification and verification of birds using a guidebook for Greater Sundas (Taufiqurrahman et al. 2022), while the primates field guide to the primates of Indonesia (Supriatna 2022), the identification of herpetofauna using a guidebook (Das 2015; Alhadi et al. 2021).

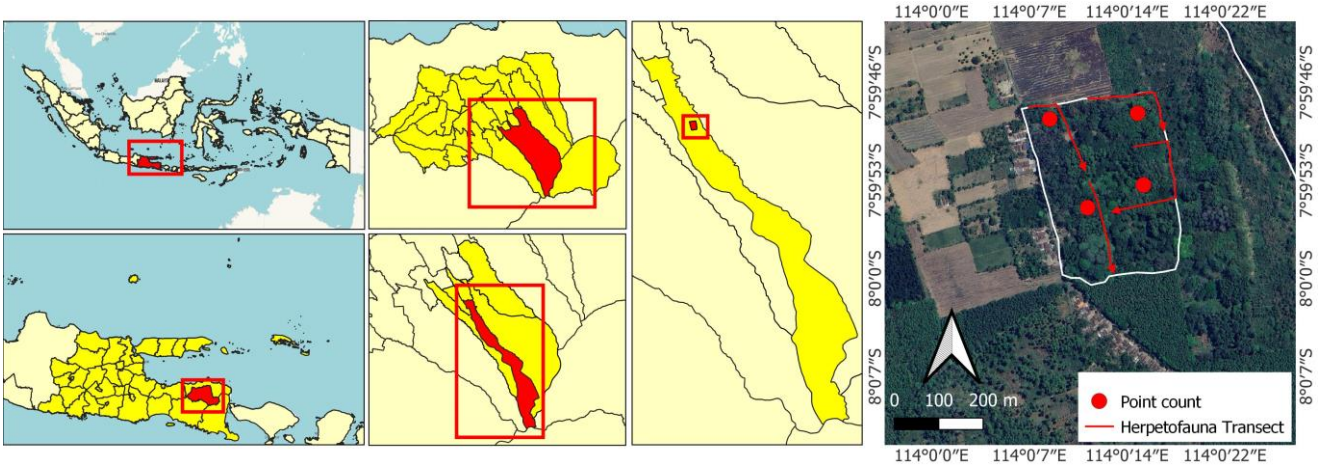

Figure 1. Study sites for wildlife existence at Pelangi Forest, Ijen Geopark, Bondowoso District, East Java Province, Indonesia

Potential threats investigation

Data collection on community activities in Pelangi Forest used a questionnaire survey method. The questionnaire was given to 50 active respondents around or inside the Pelangi Forest Area; 8 questions were related to potential threats carried out by society (Table 6). The questions included several social activities, such as tourism, research, logging, and poaching.

Data analysis

There are three approaches to analyzing wildlife Existence (Ef) at RFB, including species composition, Species Diversity Index, and uniqueness value. Species composition is determined descriptively and qualitatively based on the categories of class, families, species names, and local names. The species composition is also equipped with additional information on conservation status and geographic distribution based on the International Union for Conservation of Nature's Red List of Threatened Species (IUCN) (https://www.iucnredlist.org/), the Convention on International Trade in Endangered Species (CITES) (https://cites.org/eng), and the Minister of Environment and Forestry Regulation of Indonesia number:106 of 2018. Furthermore, the diversity species value is determined using the Shannon Wiener (H') Index using the Vegan package (Oksanen et al. 2018) in Rstudio (R) (R Core Team 2021). Meanwhile, the uniqueness value is calculated using three categories, i.e., Frequency or encounter (Fr), Conservation status (Cs), and expansion or Geographic distribution (Gd) of species (Sulistiyowati and Buot 2016; Siddiq et al. 2023) based on the following formula:

Ef = [Fr statuses+Cs statuses+Gd statuses / 3 × 5] × 100%

Whereas the Cs scale obtained from conservation status by IUCN Redlist status according to the provisions in Table 1.

Whereas the Gd scale obtained from geographical distribution by IUCN Redlist according to the provisions in Table 2. The wildlife Ef scores were then converted into weights and species uniqueness status as in Table 3.

Ultimately, the analysis for potential biodiversity threats from community activities used a modified Likert scale (Sugiyono 2011). The Likert scale calculation formula is as follows:

$S = T\ x\ P$n

Where:

S : Likert Scale

T : Total number of respondents to choose the answer

Pn : Likert score number options

Based on the results of the Likert scale calculation (S) on each question, it is continued with the summation of the entire Likert scale (S total). Furthermore, the interpretation of the results of the calculation of the entire Likert scale (S total) will be substituted in the formula:

$$Indeks\ \% = \frac{S\ total}{Y\ x\ 100}$$

Where: Y is the highest score.

The percentage (%) index obtained from each question is then taken as the average value, and the interaction level is determined based on the percentage scale (Referowska-Chodak 2019), as shown in Table 4.

Table 1. Scale of conservation statuses (Siddiq et al. 2023)

Conservation status	Scale of Cs
CR = Critically Endangered*	5
EN = Endangered	4
VU = Vulnerable	3
NT = Near Threatened	2
LC = Least Concern**	1

Note: *Including status of EW: Extinct in the Wild; PE: Probably Extinct; and PEW: Probably Extinct in the Wild; **: Including status of DD (Data Deficient) and NE (Not Evaluated)

Table 2. Scale of geographical distribution (Siddiq et al. 2023)

Area distribution	Scale of Gd
Local in Indonesia	5
Island in Indonesia	4
Indonesia Archipelago	3
Continent	2
World	1

Table 3. Status of the uniqueness value (Siddiq et al. 2023)

Ef (%)	Weight	Uniqueness level
81-100	5	Very high
61-80	4	High
41-60	3	Moderate
21-100	2	Low
0-20	1	None

Table 4. The percentage of threat levels at Pelangi Forest, East Java, Indonesia

Percentage	Threat levels
0	No Threats
1-33.33	1 (Low Threats)
33.34-66.66	2 (Moderate Threats)
66.67-100	3 (High Threats)

RESULTS AND DISCUSSION

Wildlife existence

Environmental conditions in the Pelangi Forest of Ijen Geopark show varying values in each plant block (Figure 2). There are four plant blocks, including *E. deglupta* block (temperature around 27.1°C-27.3°C; humidity around 76%-76.4%; sunlight around 655 lux-1725 lux), *Pterospermum javanicum* Jungh. block (temperature around 25.5°C-26.1°C; humidity around 78.8%-80.6%; sunlight around 336 lux-1423 lux), *Araucaria cunninghamii* subsp. *papuana* (Lauterb.) Silba block (temperature around 24.8°C-24.9°C; humidity around 87%-87.5%; sunlight around 397 lux-1798 lux), and *Dendrocalamus asper* (Schult.f.) Backer block (temperature around 24.8°C-25.8°C; humidity around 83.6%-83.9%; sunlight around 362 lux-688 lux). These conditions are still categorized as highland and provide suitable habitat for some wildlife species that prefer highland areas.

There are 62 wildlife species recorded in the Pelangi Forest, consisting of 6 amphibian species, nine reptile species,

46 bird species, and one primate species (Table 5). During the observations, there are 14 species (22.58%) that fall into the rare category because they were only found once in the total observations, including *Chalcorana chalconota* (Schlegel, 1837), *Pareas carinatus* (Wagler, 1830), *Spilornis cheela* (Latham, 1790), *Ictinaetus malaiensis* (Temminck, 1822), *Lalage sueurii* (Vieillot, 1818), *Macropygia emiliana* (Bonaparte, 1854), *Spilopelia chinensis* (Scopoli, 1786), *Treron griseicauda* (Bonaparte, 1855), *Geopelia striata* (Linnaeus, 1766), *Phaenicophaeus curvirostris* (Shaw, 1810), *Dicaeum trigonostigma* (Scopoli, 1786), *Aethopyga eximia* (Horsfield, 1821), *Otus lempiji* (Horsfield, 1821), and *Trachypithecus auratus* (É.Geoffroy Saint-Hilaire, 1812). The two species of diurnal raptors (*S. cheela* and *I. malaiensis*) are also included in the rare category at the RFB. These species are important indicators for assessing ecosystem complexity in RFB. These raptors are top consumers or predators (Fargallo et al. 2020); this shows that prey species in the RFB area are still relatively abundant. Both species were observed soaring, a flying activity involving circling the forest area to hunt prey.

According to endemism statuses, there are ten species endemics to Indonesia (*Microhyla achatina* (Tschudi, 1838), *Microhyla palmipes* (Boulenger, 1897), *C. chalconota*, *Gonocephalus kuhlii* (Schlegel, 1851), *Collocalia linchi* (Horsfield & F.Moore, 1854), *L. sueurii*, *M. emiliana*, *T. griseicauda*, *Dicaeum trochileum* (Sparrman, 1789), *Lonchura leucogastroides* (Moore, 1858)), six species endemics to Java and Bali (*Draco volans* (Linnaeus, 1758), *Cyrtodactylus marmoratus* (Gray, 1831), *Halcyon cyanoventris* (Vieillot, 1818), *Hydrornis guajanus* (Müller & Pls, 1776), *Heleia javanica* (Horsfield, 1821), *T. auratus*), and two species endemics to Java (*Ae. eximia*, *Ixos virescens* (Temminck, 1825)). One of the important notes is *Hy. Guajanus*, which was recorded in the forest ground at RFB. This species is an endemic bird of Java-Bali that is more active on the forest floor with dense forest canopy cover (Taufiqurrahman et al. 2022). However, this species has a global population decline trend due to hunting and habitat destruction (BirdLife International 2016). Therefore, this species is categorized as protected by the Indonesian government and restricted in international trade (Appendix II). This species was observed foraging on the forest floor with high frequency.

Bird groups have the highest species richness (46 species), particularly the family Cuculidae which consists of five species, including *C. merulinus*, *C. sonneratii*, *C. variolosus*, *Cu. saturates*, and *Ph. curvirostris*. The next three families with the second highest species richness of bird groups, with four species each, are Campephagidae (*L. nigra*, *L. sueurii*, *Pe. cinnamomeus*, and *Pe. flammeus*), Columbidae (*M. emiliana*, *Sp. chinensis*, *T. griseicauda*, and *G. striata*), and Nectariniidae (*Ae. eximia*, *An. malacensis*, *C. jugularis*, and *Ar. longirostra*). According to a richness comparison with other biosites at Ijen Geopark, RFB has bird species lower than in the Erek-Erek Geoforest (EEG) biosite, including 57 bird species (Siddiq et al. 2023). However, both biosites have different bird compositions; 30 bird species at RFB have not been found at EEG. Based on the Jaccard similarity index, it shows that RFB and EEG have different bird compositions or high habitat variation (R = 1, P = 0.1) (Figure 3). It was shown that each biosites has habitat characteristics that affect the composition of a wide variety of bird species.

Herpetofauna richness reveals that there are 15 species in the RFB, comprising nine reptiles and six amphibian species. The highest richness is in Agamidae, including *D. volans*, *G. kuhllii*, *B. jubata*, and *B. cristatella*. This family is diurnal and spends their time foraging and sunbathing in the scrub and trees (Smith et al. 2018). Related to this result, these species recorded sunbathing in the tree or arboreal. Further observation revealed that all herpetofauna species were found scattered in several habitat types in the RFB, such as leaf litter, soil surface, tree branches or leaves, and those close to puddles. On the other hand, primate species also exist in the RFB. Javan lutung (*T. auratus*) was recorded in a small group of six individuals. This species is occupied in the medium-upper canopy of trees in stratum C (5-20 m) with locomotion and foraging activities (Figure 4). This is by Siddiq et al. (2024a), revealing *T. auratus* occupying stratum C in the Bandealit coastal forest of Meru Betiri National Park as well. This stratum provides a dense canopy with high branches for *T. auratus* for locomotion and forage activities.

According to conservation statuses, several wildlife species are categorized as threatened and protected (Figure 5). First, referring to the IUCN Red List, there are 59 species (95%) least concerned, one species (2%) near threatened, and two species (3%) in vulnerable categories. Secondly, regarding CITES status, there are 58 non-appendix species (94%) and four species (6%) in Appendix II categories—finally, the Indonesian regulation under the Minister of Environment and Forestry Regulation of Indonesia number. Of the 106 in 2018, 55 species (89%) were not protected, and seven (11%) were protected categories. These results show that the RFB biosite is an essential habitat for several threatened and protected species. Even though it is not a conservation area, it provides appropriate habitat for these wildlife species.

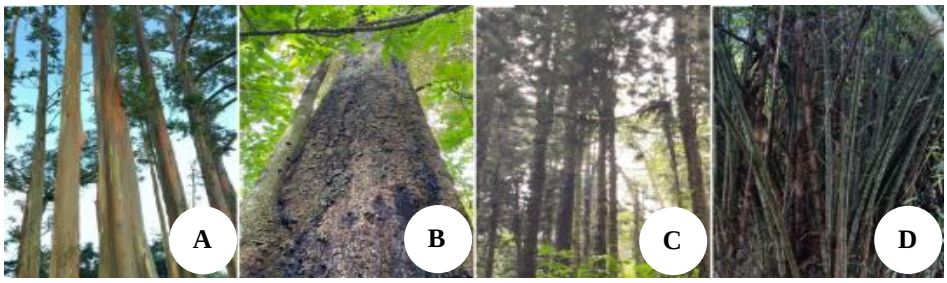

Figure 2. Pelangi Forest Biosite of Ijen Geopark, East Java, Indonesia: A. *Eucalyptus deglupta* block; B. *Pterospermum javanicum*; C. *Araucaria cunninghamii* subsp. *papuana* block; D. *Dendrocalamus asper* block

Table 5. Wildlife species composition at RFB, Ijen Geopark, East Java, Indonesia

Group	Family	Species	Local name	FS	Conservation Statuses		
					IUCN	CITES	NS
Amphibian	Dicroglossidae	*Fejervarya limnocharis* (Gravenhorst, 1829)	Boie's Wart Frog	C	LC	NA	NP
		Fejervarya cancrivora (Gravenhorst, 1829)	Java Wart Frog	C	LC	A.II	NP
	Microhylidae	*Microhyla achatina* (Tschudi, 1838)*	Javan Chorus Frog	C	LC	NA	NP
		Microhyla palmipes (Boulenger, 1897)*	Pengalengan Rice Frog	C	LC	NA	NP
	Rachoporidae	*Polypedates leucomystax* (Gravenhorst, 1829)	Java Whipping Frog	V	LC	NA	NP
	Ranidae	*Chalcorana chalconota* (Schlegel, 1837)*	Schlegel's Frog	R	LC	NA	NP
Reptile	Agamidae	*Draco volans* (Linnaeus, 1758)**	Common Flying Dragon	C	LC	NA	NP
		Gonocephalus kuhlii (Schlegel, 1851)*	Gonochepalus kuhl	U	VU	NA	NP
		Bronchocela cristatella (Kuhl, 1820)	Green Crested Lizard	C	LC	NA	NP
		Bronchocela jubata (Duméril & Bibron, 1837)	Bronchocela	C	LC	NA	NP
	Gekkonidae	*Cyrtodactylus marmoratus* (Gray, 1831)**	Marbled Bow-fingered Gecko	V	LC	NA	NP
		Hemidactylus frenatus (Duméril & Bibron, 1836)	Common House Gecko	U	LC	NA	NP
	Scincidae	*Eutropis multifasciata* (Kuhl, 1820)	Common Mabuya	V	LC	NA	NP
	Varanidae	*Varanus salvator* (Laurenti, 1768)	Common Water Monitor	U	LC	NA	NP
	Pareatidae	*Pareas carinatus* (Wagler, 1830)	Keeled Slug-eating Snake	R	LC	NA	NP
Aves	Accipitridae	*Spilornis cheela* (Latham, 1790)	Crested Serpent-eagle	R	LC	A.II	PR
		Ictinaetus malaiensis (Temminck, 1822)	Black Eagle	R	NT	A.II	PR
	Aegithinidae	*Aegithina tiphia* (Linnaeus, 1758)	Common Iora	C	LC	NA	NP
	Alcedinidae	*Halcyon cyanoventris* (Vieillot, 1818)**	Javan Kingfisher	O	LC	NA	NP
		Todiramphus chloris (Boddaert, 1783)	Collared Kingfisher	V	LC	NA	NP
	Apodidae	*Collocalia linchi* (Horsfield & F.Moore, 1854)*	Cave Swiftlet	V	LC	NA	NP
		Apus nipalensis (Hodgson, 1837)	House Swift	U	LC	NA	NP
	Campephagidae	*Lalage nigra* (J.R.Forster, 1781)	Pied Triller	C	LC	NA	NP
		Lalage sueurii (Vieillot, 1818)*	White-shouldered Triller	R	LC	NA	NP
		Pericrocotus cinnamomeus (Linnaeus, 1766)	Small Minivet	C	LC	NA	NP
		Pericrocotus flammeus (J.R.Forster, 1781)	Scarlet Minivet	U	LC	NA	NP
	Caprimulgidae	*Caprimulgus macrurus* (Horsfield, 1821)	Large-tailed Nightjar	C	LC	NA	NP
	Cisticolidae	*Orthotomus ruficeps* (Lesson, 1830)	Ashy Tailorbird	U	LC	NA	NP
		Orthotomus sutorius (Pennant, 1769)	Common Tailorbird	C	LC	NA	NP
	Columbidae	*Macropygia emiliana* (Bonaparte, 1854)*	Ruddy Cuckoo-Dove	R	LC	NA	NP
		Spilopelia chinensis (Scopoli, 1786)	Eastern Spotted Dove	R	LC	NA	NP
		Treron griseicauda (Bonaparte, 1855)*	Grey-cheeked Green-pigeon	R	LC	NA	NP
		Geopelia striata (Linnaeus, 1766)	Zebra Dove	R	LC	NA	NP
	Cuculidae	*Cacomantis merulinus* (Scopoli, 1786)	Plaintive Cuckoo	V	LC	NA	NP
		Cacomantis sonneratii (Latham, 1790)	Banded Bay Cuckoo	U	LC	NA	NP
		Cacomantis variolosus (Vigors & Horsfield, 1827)	Brush Cuckoo	U	LC	NA	NP
		Cuculus saturatus (Blyth, 1843)	Oriental Cuckoo	V	LC	NA	NP
		Phaenicophaeus curvirostris (Shaw, 1810)	Chestnut-breasted Malkoha	R	LC	NA	NP

	Dicaeidea	*Dicaeum trigonostigma* (Scopoli, 1786)	Orange-bellied Flowerpecker	R	LC	NA	NP
		Dicaeum trochileum (Sparrman, 1789)*	Scarlet-headed Flowerpecker	U	LC	NA	NP
	Estrildidae	*Lonchura leucogastroides* (Moore, 1858)*	Javan Munia	C	LC	NA	NP
	Hirundinidae	*Cecropis daurica* (Laxmann, 1769)	Red-rumped Swallow	U	LC	NA	NP
	Megalaimidae	*Psilopogon haemacephalus* (P.L.S.Müller, 1776)	Coppersmith Barbet	V	LC	NA	NP
	Monarchidae	*Hypothymis azurea* (Boddaert, 1783)	Black-naped Monarch	C	LC	NA	NP
	Nectariniidae	*Aethopyga eximia* (Horsfield, 1821)***	White-flanked Sunbird	R	LC	NA	NP
		Anthreptes malacensis (Scopoli, 1786)	Brown-throated Sunbird	C	LC	NA	NP
		Cinnyris jugularis (Linnaeus, 1766)	Olive-backed Sunbird	V	LC	NA	NP
		Arachnothera longirostra (Latham, 1790)	Little Spiderhunter	O	LC	NA	NP
	Pellorneidae	*Malacocincla sepiaria* (Horsfield, 1821)	Horsfield's Babbler	V	LC	NA	NP
	Picidae	*Dinopium javanense* (Ljungh, 1797)	Common Flameback	O	LC	NA	NP
		Dendrocopos analis (Bonaparte, 1850)	Freckle-breasted Woodpecker	C	LC	NA	NP
	Pittidae	*Hydrornis guajanus* (Müller & Pls, 1776)**	Javan Banded Pitta	U	LC	A.II	PR
	Podargidae	*Batrachostomus javensis* (Horsfield, 1821)	Javan Frogmouth	U	LC	NA	NP
	Pycnonotidae	*Pycnonotus aurigaster* (Vieillot, 1818)	Sooty-headed Bulbul	V	LC	NA	NP
		Pycnonotus goiavier (Scopoli, 1786)	Yellow-vented Bulbul	O	LC	NA	NP
		Ixos virescens (Temminck, 1825)***	Sunda Bulbul	U	LC	NA	NP
	Rhipiduridae	*Rhipidura javanica* (Sparrman, 1788)	Sunda Pied Fantail	U	LC	NA	PR
	Strigidae	*Otus lempiji* (Horsfield, 1821)	Sunda Scops-owl	R	LC	NA	PR
	Sturnidae	*Aplonis minor* (Bonaparte, 1850)	Short-tailed Starling	C	LC	NA	NP
	Vangidae	*Hemipus hirundinaceus* (Temminck, 1822)	Black-winged Flycather-shrike	C	LC	NA	NP
	Zosteropidae	*Heleia javanica* (Horsfield, 1821)**	Javan Grey-throated White-eye	U	LC	NA	PR
Primate	Cercopithecidae	*Trachypithecus auratus* (É.Geoffroy Saint-Hilaire, 1812)**	Javan lutung	R	VU	NA	PR

Note: *endemic to Indonesia; **endemic to Java-Bali; ***endemic to Java (Taufiqurrahman et al. 2022). Abbreviation as follows: FS: Frequency Status; V: Very Common; C. Common; U. Uncommon; O. Occasional; R. Rare; LC: Least Concern; NT: Near Threatened; VU: Vulnerable; NA: Not Appendix; A.II: Appendix II; NS: National Status; NP: Not Protected; PR: Protected

Based on the Shannon-Wiener diversity index, the value of wildlife diversity at RFB is categorized as high (H'=3.48). Species *C. linchi* had the highest abundance (86 individuals), followed by *Py. aurigaster* (24 individuals), *Pe. Cinnamomeus* (23 individuals), *M. sepiaria* (18 individuals), *L. leucogastroides* (16 individuals), and *H. hirundinaceus* (15 individuals), respectively. Dominated by *C. linchi*, also reported in Badung Bali (Yuni et al. 2022). In comparison, the species with the lowest abundance were *S. cheela*, *L. sueurii*, *Sp. chinensis*, *D. trochileum*, *Py. goiavier*, *Ch. Chalconota*, *V. salvator*, and *P. carinatus* with only one individual each. Several representative documentations of wildlife species are presented in Figure 6.

This diversity signifies the highest level of ecosystem equilibrium within RFB. Wildlife animals have a wide ecological function to control energy flows. The RFB plays a significant role in supporting diverse trophic levels, with all species in the RFB constituting important roles, such as primary, secondary, and tertiary consumers. It is also an important component of biodiversity, including nongame species, species richness, habitat diversity, rare species, rare habitats, and ecosystem function (Hagan and Whitman 2006). It is suspected that RFB also provides many resources for wildlife species to grow up and survive. This biosite has become a suitable habitat for several species, particularly herpetofauna groups that tend to settle in this area.

Furthermore, wildlife species in Pelangi Forest had an average existence value of 41.94% or showed a moderate uniqueness level. Species *T. auratus* (Figure 7) had the highest Ef value (80%), followed by *Ae. eximia* (66.67%), *G. kuhlii* (60%), *Ch. calconota* (60%), *T. griseicauda* (60%), *Ma. emiliana* (60%), *L. sueruii* (60%), *Ha. cyanoventris* (60%), *Ic. malaiensis* (60%), *P. carinatus* (53.33%), *He. Javanica* (53.33%), *O. lempiji* (53.33%), *I. virescens* (53.33%), *Hy. Guajanus* (53.33%), *D. triganostigma* (53.33%), *Ph. curvirostris* (53.33%), *Ge. Striata* (53.33%), *Sp. chinensis* (53.33%) and *S. cheela* (53.33%), respectively (Figure 5).

Javan lutung (*T. auratus*) is the only primate species recorded in the RFB of Ijen Geopark. This species has the highest uniqueness value (80%) due to its endemicity (Java-Bali) (Nijman 2021), low frequency in the RFB, and vulnerable conservation status. The species *T. auratus* has a vital role in the RFB as one of the seed dispersal agents. Tsuji et al. (2017) reported that *T. auratus* prefers feeding on leaves, flowers, and fruits whose seeds can be spread through locomotion behavior in its home range. On the other hand, globally, *T. auratus* poses a severe threat due to hunting and habitat destruction due to land conversion (Nijman 2021). The discovery of this endemic species in RFB shows that this Biosite provides the needed resources, such as food, shelter, and socializing areas.

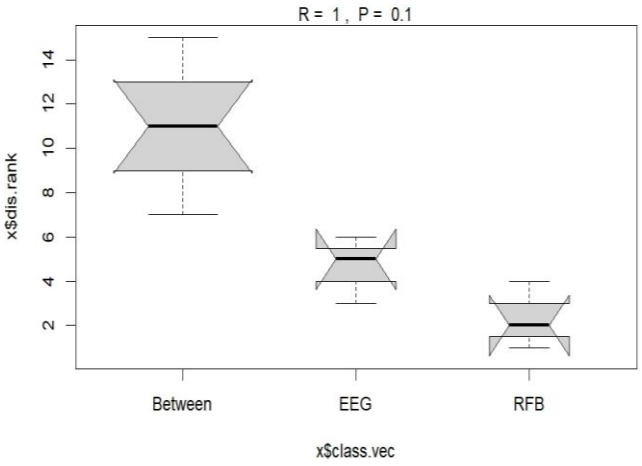

Figure 3. The analysis of similarities (ANOSIM) for birds in the RFB and EEG

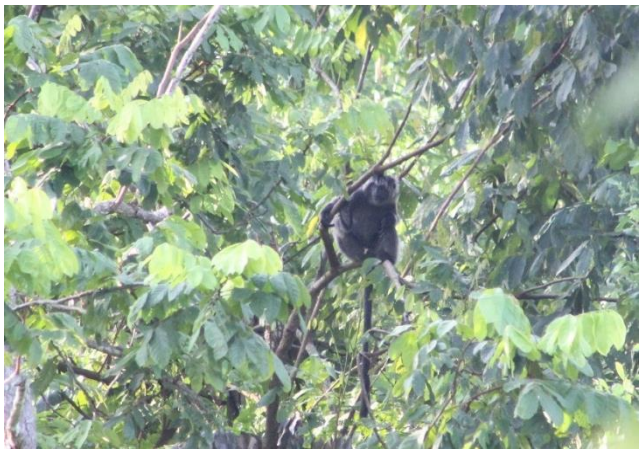

Figure 4. Javan lutung (*T. auratus*) is occupied in strata C at the RFB of Ijen Geopark, East Java, Indonesia

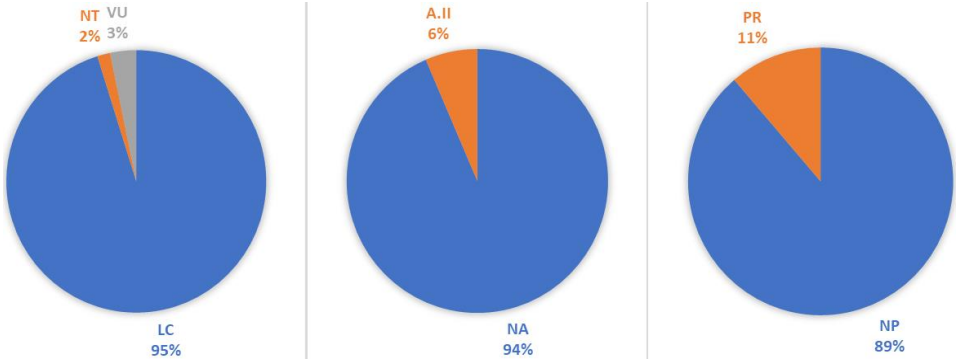

Figure 5. Percentage of wildlife species conservation statuses at Pelangi Forest of Ijen Geopark, East Java, Indonesia

Table 6. Questionnaire results based on Likert-scale analysis

Questions for respondents	Total of respondents	S likert	Index %
Have you ever been to the Pelangi Forest?			43.00
1. Never	1	1	
2. Sometimes	19	38	
3. Routine	30	90	
What do you do in the Pelangi Forest?			22.67
1. Tourism or research	35	35	
2. Tourism and hunting/logging	12	24	
3. Poaching/logging	3	9	
Have you ever picked grass or leaves in the Pelangi Forest?			27.33
1. Never	21	21	
2. Sometimes	26	52	
3. Routine	3	9	
Have you ever picked up wood or branches from the Pelangi Forest Area?			21.67
1. Never	36	36	
2. Sometimes	13	26	
3. Routine	1	3	
Have you ever hunted insects such as grasshoppers, butterflies, kroto, bees, or honey in the Pelangi Forest Area?			21.00
1. Never	38	38	
2. Sometimes	11	22	
3. Routine	1	3	
Have you ever hunted birds in the Pelangi Forest Area?			18.33
1. Never	45	45	
2. Sometimes	5	10	
3. Routine	0	0	
Have you ever hunted snakes, monitor lizards, frogs or toads in the Pelangi Forest Area?			16.67
1. Never	50	50	
2. Sometimes	0	0	
3. Routine	0	0	
Have you ever hunted large mammals such as wild boars, deer, monkeys, and lutungs in the Pelangi Forest Area?			17.67
1. Never	47	47	
2. Sometimes	3	6	
3. Routine	0	0	
Average		(Low Threats) 23.54	

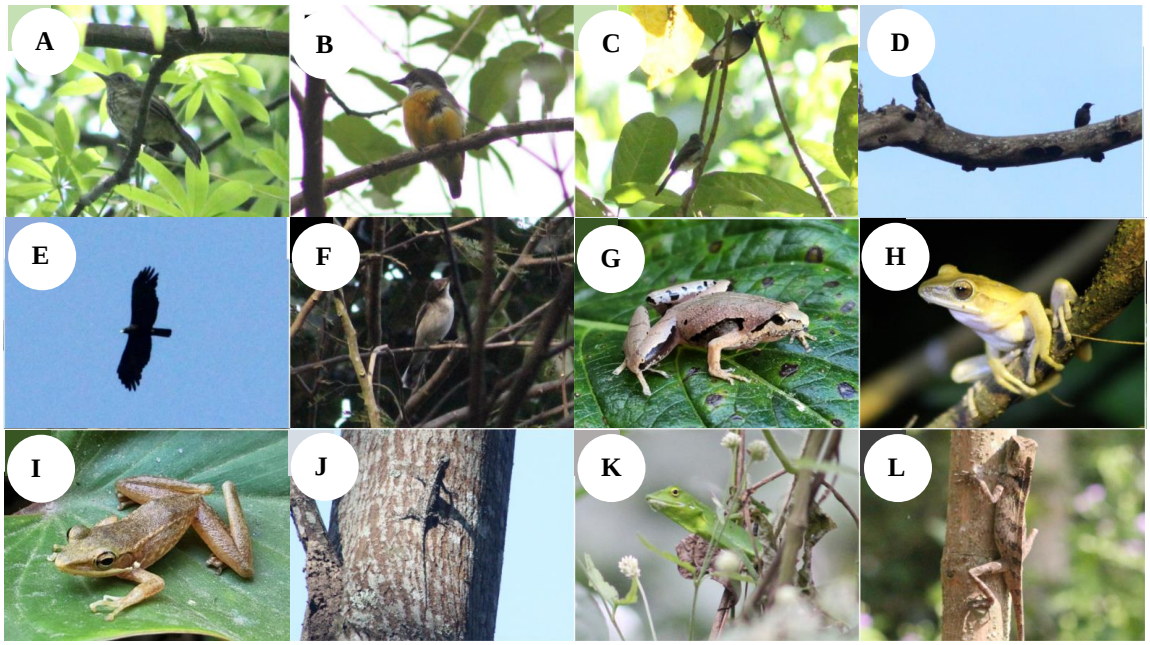

Figure 6. Representative species documentation at RFB of Ijen Geopark, East Java, Indonesia: A. *I. virescens*; B. *D. trigonostigma*; C. *H. azurea*; D. *A. minor*; E. *Ic. Malaiensis*; F. *L. sueurii*; G. *Mi. palmipes*; H. *Po. Leucomystax*; I. *Ch. Chalconota*; J. *Dr. volans*; K. *B. cristatella*; L. *G. kuhlii*

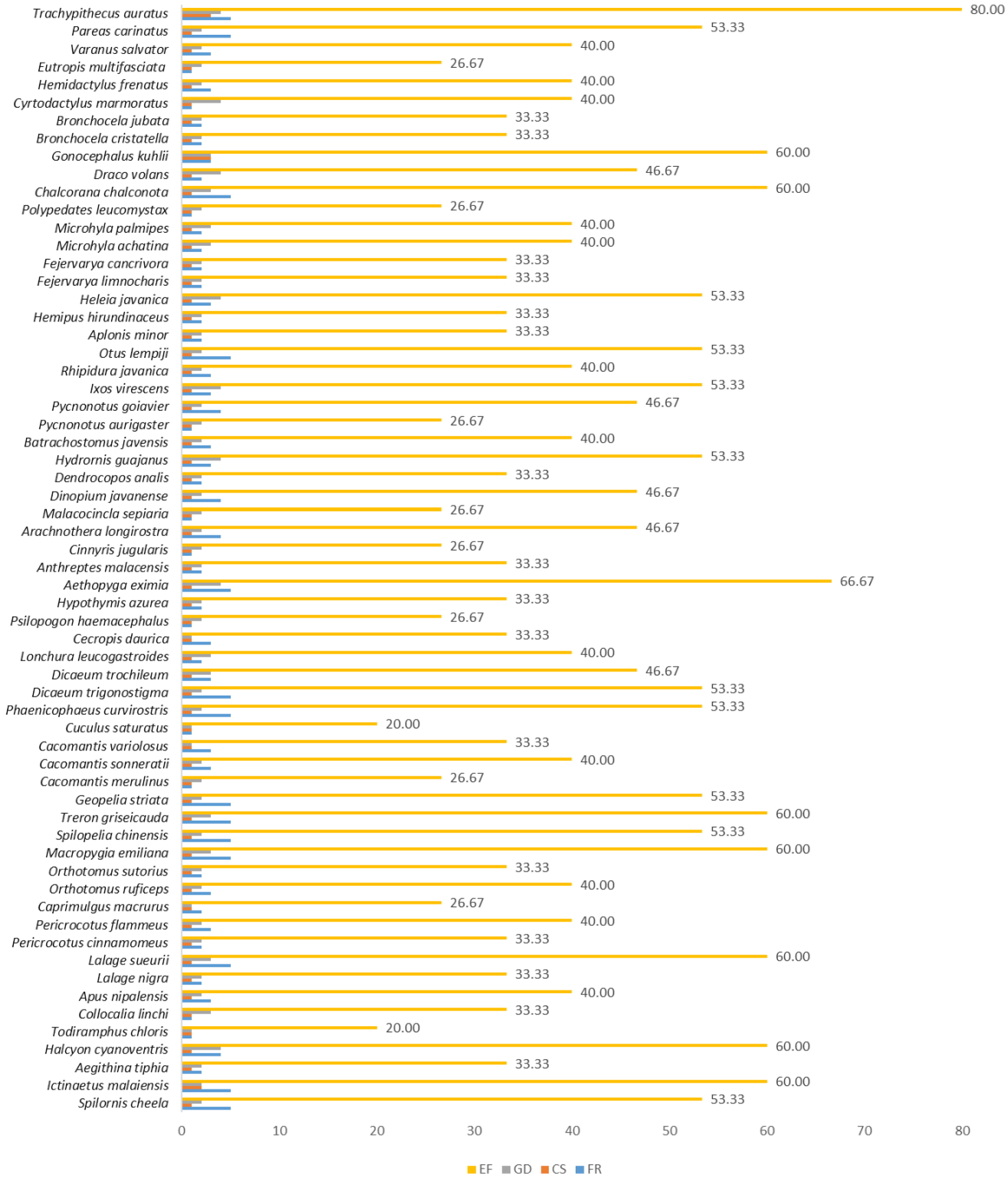

Figure 7. Existence Factor (EF) of wildlife species in the Biosite Pelangi Forest of Ijen Geopark, East Java, Indonesia

Furthermore, in the herpetofauna group, *G. kuhlii* is moderately unique. This species is endemic to Indonesia, with a restricted distribution on the Sumatra and Java islands. Recently, this species was categorized as vulnerable and crucial for conservation as of 2019 (Iskandar and Kamsi 2021). However, this species has not been restricted by international trade regulations nor protected by the Indonesian government. Species *G. kuhlii* is included in the uncommon category in RFB because it occupies mixed vegetation such as shrubs and dense trees. One form of adaptation is having a body color similar to the host plant as a form of camouflage (Figure 6.L).

Potential wildlife threats

Based on a total of 50 respondents, 34 people (68%) aged 21-40 years, 12 people (24%) aged >41 years, and four people (8%) aged <20 years filled out the questionnaire in this study. Respondents have five educational backgrounds, including 26 people (52%) senior high school graduates, 12 people (24%) with bachelor's degrees, six people (12%) elementary school graduates, and six people (12%) junior high school graduates. Furthermore, they also have varied occupational backgrounds, including 23 employees (46%), eight students (16%), seven entrepreneurs (14%), five farmers (10%), and seven others (14%) (Figure 8).

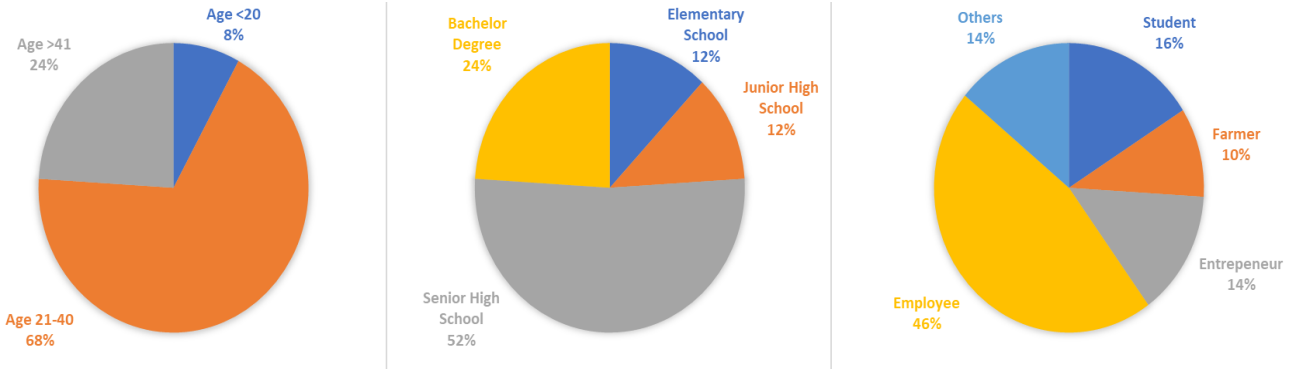

Figure 8. Respondents of a questionnaire for potential threats analysis in RFB of Ijen Geopark, East Java, Indonesia

According to Likert-scale analysis, potential threats to biodiversity in the RFB of Ijen Geopark are in the low category (23.54%). This is obtained from the average of all Likert-scale index questions in the questionnaire. Nevertheless, there are some crucial notes for the evaluation of the conservation plan, namely the illegal poaching or hunting of wildlife species, such as birds and large mammals, that still occur. Based on the results of interviews, it was also found that hunting is carried out using plant gum (*pulut* in the local name) for songbirds and air rifles for large birds and mammals. These findings underscore the urgent need for conservation efforts in RFB Geopark Ijen.

The existence of wildlife species in RFB implies the conservation efforts that KHDTK Sumberwringin and Ijen Geopark have carried out. The position of RFB, located directly adjacent to community settlements, is undoubtedly a severe threat. Settlements around forest areas can trigger conflicts between humans and wildlife (Rifaie et al. 2021). Moreover, this area is also a tourist area with many visitors. However, some staff have monitored activities or put up narration boards and prohibitions to exploit the flora and fauna in the area, which are conservation actions that have been carried out so far.

Ultimately, the potential threats at RFB are still in the low category based on the frequency and activities carried out by the local community or visitors. Nevertheless, an important note from the questionnaire is that humans were still taking grass, leaves, twigs, and wood, hunting insects, birds, and even large mammals in this area. This will impact the diversity and existence of wildlife species in RFB. According to these results, it is expected that the management of both KHDTK and Ijen Geopark can be more concerned about carrying out more massive conservation actions. In addition, organizing education-based tourism, such as birdwatching or wildlife observation, can increase awareness and knowledge about conservation for tourists and involve the surrounding society as one of the ecotourism staff. Therefore, nature conservation can be implemented by involving the community as one of its essential aspects.

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REFERENCES

Alhadi F, Kaprawi F, Hamidy A, Kirschey T. 2021. Amfibi Pulau Jawa-Panduan Bergambar dan Identifikasi. Perkumpulan Amfibi Reptil Sumatra & NABU, Medan. [Indonesian]

Anderson SH, Kelly D, Robertson AW, Ladley JJ. 2016. Pollination by birds: A functional evaluation. In: Sekercioglu ÇH, Wenny DG, Whelan CJ. Why Birds Matter: Avian Ecological Function and Ecosystem Services. University of Chicago Press, Chicago. DOI: 10.7208/9780226382777-006.

BirdLife International. 2016. *Hydrornis guajanus*. The IUCN Red List of Threatened Species 2016: E.T22736518A95136596. DOI: 10.2305/IUCN.UK.2016-3.RLTS.T22736518A95136596.en.

Boullhesen M, Vaira M, Barquez RM, Akmentins MS. 2021. Evaluating the efficacy of visual encounter and automated acoustic Jawa methods inanuran assemblages of the Yungas Andean Forests of Argentina. Ecol Indic 127: 107750. DOI: 10.1016/j.ecolind.2021.107750.

Brockerhoff EG, Barbaro L, Castagneyrol B, Forrester DI, Gardiner B, González-Olabarria JR, Lvyer PO'B, Meurisse N, Oxbrough A, Taki H, Thompson ID, van der Plas F, Jactel H. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodivers Conserv 26: 3005-3035. DOI: 10.1007/s10531-017-1453-2.

Bufalo FS, Galetti M, Culot L. 2016. Seed dispersal by primates and implications for the conservation of a biodiversity hotspot, the Atlantic Forest of South America. Intl J Primatol 37: 333-349. DOI: 10.1007/s10764-016-9903-3.

Das I. 2015. A Field Guide to the Reptiles of South-East Asia. Bloomsbury Publishing Plc, London.

Fargallo JA Navarro-López J, Palma-Granados P, Nieto RM. 2020. Foraging strategy of a carnivorous-insectivorous raptor species basedon prey size, capturability andnutritional components. Sci Rep 10 (1): 7583. DOI: 10.1038/s41598-020-64504-4.

Geopark Ijen. 2023. Ijen Geopark. Http://Geopark-Ijen.Jatimprov.Go.Id/.

Hagan JM, Whitman AA. 2006. Biodiversity Indicators for Sustainable Forestry: Simplifying Complexity. J For 104 (4): 203-210. DOI: 10.1093/jof/104.4.203.

Hills R. 2019. *Eucalyptus deglupta*. The IUCN Red List of Threatened Species 2019: E.T61911798A61911825. DOI: 10.2305/IUCN.UK.2019-3.RLTS.T61911798A61911825.en.

Iskandar D, Kamsi M. 2021. *Gonocephalus kuhlii*. The IUCN Red List of Threatened Species 2021: E.T99930252A99930320. DOI: 10.2305/IUCN.UK.2021-3.RLTS.T99930252A99930320.en.

Johnson SD. 2022. Bird Pollination. Curr Biol 32 (20): R1059-R1060. DOI: 10.1016/j.cub.2022.06.081.

Maselou DA, Anastasaki E, Milonas PG. 2019. The role of host plants, alternative food resources and herbivore induced volatiles in choice behavior of an omnivorous predator. Front Ecol Evol 6: 241. DOI: 10.3389/fevo.2018.00241.

McConkey KR. 2018. Seed dispersal by primates in Asian habitats: From species, to communities, to conservation. Intl J Primatol 39: 466-492. DOI: 10.1007/s10764-017-0013-7.

Nijman V. 2021. *Trachypithecus auratus*. The IUCN Red List of Threatened Species 2021: E.T39848A17988500. DOI: 10.2305/IUCN.UK.2021-1.RLTS.T39848A17988500.en.

Ohkawara K, Kimura K, Satoh F. 2023. How many seeds can birds disperse? Determining the pattern of seed deposition by frugivorous birds. Acta Oecol 121: 103958. DOI: 10.1016/j.actao.2023.103958.

Oksanen J, Blanchet FG, Friendly M, Kindt R, Legendre P, McGlinn D, Minchin RR, O'Hara RB, Simpson GL, Solymos P, Stevens MHH, Szoecs E, Wagner H. 2018. Vegan: Community Ecology Package. R Package Version 2.5-2.

Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S. 2009. Agroforestree Database: A Tree Reference and Selection Guide Version 4.0. Http://Www.Worldagroforestry.Org/Sites/Treedbs/Treedatabases.Asp 1-5.

Partasasmita R, Mardiastuti A, Solihin DD, Widjajakusumah R, Prijono SN. 2017. Frugivorous bird characteristic of seed disperser in shrubland tropicalforest West Java, Indonesia. Biodiversitas 18 (1): 263-268. DOI: 10.13057/biodiv/d180134.

R Core Team. 2021. R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna.

Referowska-Chodak E. 2019. Pressures and threats to nature related to human activities in European urban and suburban forests. Forests 10 (9): 765. DOI: 10.3390/f10090765.

Rifaie F, Sulistyadi E, Fitriana YS. 2021. A review of patterns and geographical distribution of human-wildlife conflicts in Indonesia. Berkala Penelitian Hayati 27 (1): 41-50. DOI: 10.23869/bphjbr.27.1.20217.

Siddiq AM, Hari S, Imaniar R, Kholiq N. 2024a. The habitat characteristics of Javan Lutung (*Trachypithecus auratus*) in Bandealit Coastal Forest at Meru Betiri National Park, East Java, Indonesia. Treubia 51 (1): 31-42. DOI: 10.14203/treubia.v51i1.4753.

Siddiq AM, Sulistiyowati H, Kurnianto AS, Aninnas A, Samsuri S. 2023. The diversity and uniqueness of avifauna in Erek-Erek Geoforest at Ijen Geopark, East Java, Indonesia. J Trop Biodivers Biotechnol 8 (1): jtbb75639. DOI: 10.22146/jtbb.75639.

Siddiq AM, Wimbaningrum R, Sulistiyowati H, Setiawan R, Setiawan A, Wahono ND. 2024b. Short Communication: A rapid survey of herpetofauna diversity in Bama coastal forest at Baluran National Park, Indonesia. Biodiversitas 25 (5): 2323-2329. DOI: 10.13057/biodiv/d250550.

Smith KT, Čerňanský A, Scanferla A, Schaal SFK. 2018. Lizards and snakes—Warmth-loving Sunbathers. In: Smith KT, Schaal SFK, Habersetzer J (eds). Messel: An Ancient Greenhouse Ecosystem. Schweizerbart, Germany.

Stratford JA, Sekercioglu CH. 2015. Birds in Forest Ecosystems. In: Corlett R, Peh K, Bergeron Y (eds). Handbook of Forest Ecology. Routeledge Press, Singapore.

Sugiyono. 2011. Metode Penelitian Kuantitatif Kualitatif Dan R&D. Alfabeta, Bandung. [Indonesian]

Sulistiyowati H, Buot Jr. IE. 2016. Ecological valuation tools to appraise biomass, necromass and soil organic matter in a natural forest ecosystem. J Wetl Divers 6: 97-108.

Sulistiyowati H, Hasanah EA, Siddiq AM, Ratnasari T, Dewi N, Kurnianto AS. 2024. Biodiversity value of tree vegetation in Pelangi Forest Biosite, Ijen Geopark, East Java, Indonesia. Biodiversitas 25 (6): 2670-2678. DOI: 10.13057/biodiv/d250637.

Sun S-G, Huang Z-H, Chen Z-B, Huang S-Q. 2017. Nectar properties and the role of sunbirds as pollinators of the golden-flowered tea (*Camellia petelotii*). Am J Bot 104 (3): 468-476. DOI: 10.3732/ajb.1600428.

Supriatna J. 2022. Field Guide to the Primates of Indonesia. Springer, Cham. DOI: 10.1007/978-3-030-83206-3.

Taufiqurrahman I, Akbar PG, Purwanto AA, Untung M, Assiddiqi Z, Wibowo WK, Iqbal M, Tirtaningtyas FN, Triana DA. 2022. Panduan Lapangan Burung-Burung di Indonesia Sunda Besar Sumatera, Kalimantan, Jawa, Bali. Vol. Edisi 1. Birdpacker Indonesia-Interlude, Batu, Jawa Timur. [Indonesian]

Thunhikorn S, Grainger MJ, McGowan PJK, Savini T. 2016. Methods used to survey avian species and their potential for surveying ground-dwelling birds in Asia. Forktail 32: 5-13.

Tsuji Y, Ningsih JIDP, Kitamura S, Widayati KA, Suryobroto B. 2017. Neglected seed dispersers: Endozoochory by Javan Lutungs (*Trachypithecus auratus*) in Indonesia. Biotropica 49 (4): 539-545. DOI: 10.1111/btp.12439.

Valencia-Aguilar A, Cortés-Gómez AM, Ruiz-Agudelo CA. 2013. Ecosystem services provided by amphibians and reptiles in neotropical ecosystems. Intl J Biodivers Sci Ecosyst Serv Manag 9 (3): 257-272. DOI: 10.1080/21513732.2013.821168.

Verduci M, Goodrich LJ, Therrien J-F, Inzunza ER. 2023. Feeding rates ofraptors during autumn migration in the Central Appalachians 1987-2022. Front Conserv Sci 4: 1250142. DOI: 10.3389/fcosc.2023.1250142.

Xu W, Yu J, Huang P, Zheng D, Lin Y, Huang Z, Zhao Y, Dong J, Zhu Z, Fu W. 2022. Relationship between vegetation habitats and bird communities in urban mountain parks. Animals 12 (18): 2470. DOI: 10.3390/ani12182470.

Yuni LPEK, Wijaya IMS, Sari IAEP. 2022. Assessing the bird and tree species diversity in the North of Badung, Bali, Indonesia. Biodiversitas 23 (9): 4482-89. DOI: 10.13057/biodiv/d230914.