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Research Article

The Diversity and Uniqueness of Avifauna in Erek-Erek Geoforest at Ijen Geopark, East Java, Indonesia

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ABSTRACT
Erek-Erek Geoforest (EEG) is one of the Biosites of Ijen Geopark located at the eastern slope of Mount Ijen. This location has unique topography of highland forests restricted by mountain ridges. This topography creates dense vegetation and humid ecosystem supporting microhabitats for endemic birds. This study aims to investigate the diversity and uniqueness of avifauna in EEG based on the existing value of birds. The method used is a point count at three potential station for the presence of birds. The data collected are the bird species, individual number of species, and species existence based on conservation status, distribution, and protection status. Data analysis includes the Shannon Wiener diversity index (H'), Evenness index (E), and existence factor (Ef) of bird community. The results show there are 57 species of birds belonging to 46 genera and 31 families. The diversity of birds in EEG Biosite has a high value (H'=3.40) and also a high evenness value (E=0.84). The Ef value of birds in this area is 51.35, which means the uniqueness value is a medium category. There are three bird species that have the highest Ef value, i.e *Arborophila orientalis* (Ef=80.00), *Pycnonotus bimaculatus* (Ef=73.33) and *Locustella montis* (Ef=73.33). The three species are endemic to Indonesia, especially *A. orientalis* whose distribution is limited to the highlands of East Java. Based on the composition, diversity, and uniqueness of avifauna in the EEG, it becomes valuable information for the government, Ijen Geopark Manager, and local communities to manage EEG Biosite conservatively by maintaining the existence of avifauna and their habitats.

INTRODUCTION
Mount Ijen is a complex highland area that stretches from the Bali Strait to the Bondowoso region (Caudron et al. 2015; Wirakusumah et al. 2019). In 2018, this area was designated as the Ijen National Geopark along with parts of the Meru Betiri National Park and Alas Purwo National Park. Then in 2020-2021, the East Java provincial government proposed the Ijen National Geopark to be a UNESCO Global Geopark (UGG) candidate (Geopark Ijen 2022). Geopark is a single or combined geographic area, which has a Geological Heritage Site (Geosite), Cultural Heritage Site (Culture-Site), and Biological Heritage Site (Biosite). One

of biosite covered in Ijen Geopark is Erek-Erek Geoforest (EEG). This area is a highland tropical rainforest ecosystem that has reached climax succession (Mulyana 2005). Geographically, EEG is located on the eastern slope of Mount Ijen and is the confluence of the valleys of Mount Merapi Ungup-ungup and Mount Rante (Siddiq 2015; Geopark Ijen 2022). This highland (1000-1800mdpl) has a high complexity stratification of plants. This condition provides important microhabitats and ecological niches specifically for bird communities (avifauna).

The basic information of birds community in the EEG is very important for ecotourism development supporting Ijen Geopark UGG. It is well known that a distinctive attraction for visitors in biosite is avitourism (Kuuder et al. 2015; Liu et al. 2021). According to Sitanggang et al. (2020), avitourism or bird-watching-based tours is one of the potential attractions by watching various kinds of birds with attractive colours and behaviours in their natural habitat. Furthermore, the characteristics of colours, sounds, shapes, or behaviours of the birds are attractive to bird-watchers (Moss 2004; Aditya et al. 2020). All the birds found in this area, specifically the endemic one, have potential value because of their unique characteristics and existences.

Birds can become an ecosystem, area, or even country icons because of their uniqueness, for example beautiful and endemic *Oreornis* (Papua), *Macrocephalon* (Sulawesi), and *Buettikoferella* (Nusa Tenggara) (Prawiradilaga 2019). Therefore, increasing knowledge and databases regarding the diversity of birds in EEG can be an additional reference for the development strategy in the Ijen Geopark UGG candidates' tourism site so that it becomes a distinctive attraction for visitors. One method for its development is to determine the diversity and unique value of the avifauna community. The uniqueness of flora and fauna can be determined by comparing the frequency of encounters, conservation status, and endemicity (Sulistiyowati & Buot 2015). In its development, the unique value approach, especially endemicity, can also be implemented for the bird community (Prawiradilaga 2019).

The existence of avifauna in the Ijen Mountains has not been clearly revealed. The East Java Natural Resources Conservation Center reported about 107 bird species were found in the Ijen Crater Nature Park, but the report is still in the form of field notes. Mittermeier et al. (2014) in their expedition on Mount Ijen, reported about 82 bird species occupying habitats at an altitude of 920-3000 masl. Mount Ijen is a habitat for bird species with limited distribution and endemic to highlands (Mackinnon et al. 2010). As stated by Pujolar et al. (2022), the unique topography of highland forests that are restricted by hills, valleys, or mountains will provide specific habitats for birds. So that these conditions affect the level of uniqueness of the bird community. Meanwhile, there is no scientific report on the existence of birds in the eastern part of Ijen, especially EEG. So this study aims to determine the diversity and uniqueness of avifauna in the EEG Ijen Geopark, East Java, Indonesia.

MATERIALS AND METHODS

Study Area

The research project was conducted in August–September 2021 at the Erek-erek Geoforest (EEG) of the Ijen Mountains, East Java (Figure 1). Observations were carried out in August, then data collection was carried out in September. The research area consists of forest area (1378 masl), forest edge area (1404 masl), and river bank forest area (1367 masl).

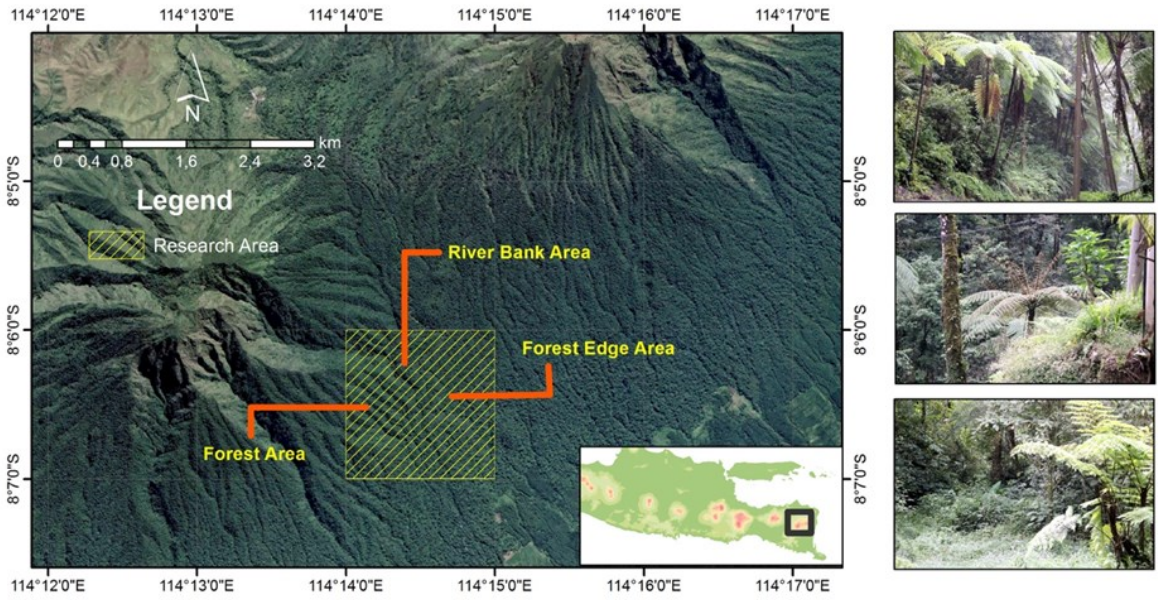

Figure 1. Study area in Erek-erek Geoforest, Ijen Geopark.

Data Collection

The point count method was used to collect data on avifauna and detect the presence of birds through physical sightings carried out in a fixed position for a predetermined duration (Bibby et al. 2000). There are three observation points set up based on vegetation characteristics. The range used in the observation (r) is 20 meters around the observation point. Observation time was ± 20 minutes at each point. Physicals or sounds of the birds were used to identify the presence of bird species (Sumaila et al. 2020). Data were collected on three consecutive days every week, then divided into two sessions in one day, morning (diurnal) (Sutherland et al. 2004) at 05.00-09.00 WIB and night (nocturnal) (Bartolommei et al. 2013) at 19.00-23.00 WIB. The visual morphology characteristics of birds were observed using the Binoculars (Bushnell Powerview 10x50), DSLR Camera (EOS 60D Cannon), Telephoto Lens (75-300mm), and field stationery. The sound of the birds was recorded using a Sony ICD-PX240. The process of identification and verification of physical avifauna species uses morphological characteristics referred to MacKinnon et al. (2010) and Taufiqurrahman et al. (2022), while that of sound-recorded confirmation using https://xeno-canto.org//. Furthermore, the number of individual birds for each species and type of habitat occupied is also counted.

Data Analysis

Data analysis through three approaches, i.e determining species composition, species diversity, and species qualification. The species composition is analysed based on bird taxonomy, conservation status, and protection status. The conservation status and endemicity of avifauna were referred to the International Union for Conservation of Nature (IUCN) Redlist (https://www.iucnredlist.org/). Meanwhile, the protection status was referred to the Regulation of the Minister of Environment and Forestry No. P.106 of 2018 and international trade regulation (https://cites.org/eng/app/index.php. Bird species diversity was determined by the Shannon-Wiener index (H') and species evenness (E) (Magurran 1988). Furthermore, the determination of the species qualification value (Ef) of birds

in the EEG refers to Sulistiyowati and Buot (2015) by considering three variables, i.e frequency of encounters, endemicity, and conservation status. Finally, the Ef value is converted into the weight and status of uniqueness which is the result of the revised formula by Tim Studi Keunikan Flora dan Fauna Universitas Indonesia (1995) and Sulistiyowati (2008).

RESULTS AND DISCUSSION

The composition of avifauna in EEG Biosite, Ijen Geopark

We identified 57 bird species belonging to 46 genera and 31 families from EEG Biosites of Ijen Geopark (Table 1). Ten species are protected by the Indonesia Government, including Crested Serpent-eagle (*Spilornis sheela*), Black eagle (*Ictinaetus malaiensis*), Javan kingfisher (*Halcyon cyanoventris*), Wreathed hornbill (*Rhyticeros undulatus*), Flame-fronted barbet (*Psilopogon armillaris*), Javan banded pitta (*Hydrornis guajanus*), White-bellied fantail (*Rhipidura euryura*), Streaky-breasted spiderhunter (*Arachnothera affinis*), White-flanked sunbird (*Aethopyga eximia*), and Javan Grey-throated White-eye (*Heleia javanica*). Based on the data above, there are two species that are endemic to Java (*R. euryura*; *Ae. eximia*) and four endemic to Java-Bali (*H. cyanoventris*; *P. armillaris*; *H. guajanus*; *H. javanica*) (Table 1). The species *R. euryura* and *Ae. eximia* is commonly found in mountainous areas. Furthermore, *H. javanica* also has a distribution in the highlands, which is above 1500 masl, as well as *P. armillaris* which has a higher elevation range of up to 2500 masl (MacKinnon et al. 2010; Mittermeier et al. 2014). Meanwhile, *H. cyanoventris* and *H. guajanus* are distributed in lowland to highland forests at 1000-1500 masl, especially *H. guajanus* prefer near rivers (MacKinnon et al. 2010; Iskandar et al. 2021).

The family with the highest species richness was Muscicapidae (8 species). This family is a very large and diverse in the old world. In the great Sunda, there are about 43 species and some of which are wintering migrants (MacKinnon et al. 2010). This study also confirmed–records from previous expeditions in the Ijen mountains (Mittermeier et al. 2014), such as Black eagle (*I. malaiensis*), Red Junglefowl (*Gallus gallus*), Grey-cheeked green pigeon (*Treron griseicauda*), Oriental cuckoo (*Cuculus saturates*), Barred Eagle-owl (*Bubo sumatranus*), Common flameback (*Dinopium javanense*), Javan banded pitta (*H. guajanus*), Velvet-fronted nuthatch (*Sitta frontalis*), Siberian Thrush (*Zoothera aurea*), White's thrush (*Geokichla citrina*), Arctic warbler (*Phylloscopus borealis*), Blue whistling thrush (*Cyanoptila cyanomelana*), and Javan Grey-throated White-eye (*H. javanica*).

According to the IUCN Red List, birds in the EEG have four conservation statuses (LC: 54 species (95%); NT: one species (2%); VU: two species (3%)) (Figure 2). It shows that EEG is one of the important habitats for near-threatened and vulnerable birds in East Java. One of which is *Rhyticeros undulatus* which has a limited distribution in the primary forest of the Greater Sunda region (Sukmantoro et al. 2007; MacKinnon et al. 2010). It is due to the very specific selection of feed and nests (Poonswad 1993; Rahayuningsih et al. 2017). The EEG area is also suspected to be one of the nesting or foraging areas of this species in Ijen. Meanwhile, based on the Convention on International Trade in Endangered Species (CITES), 53 species (93%) were non-appendix and four species (7%) were Appendix II (Figure 2). Appendix II is not included in the endangered category but has the possibility to be threatened with extinction if the trade is not regulated, so a licensing mechanism is needed through the management authority. Another important piece of infor-

Table 1. Species composition of avifauna in the EEG. Abbreviation as follows: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Not Appendix (NA), Protected (P), Not Protected (NP).

Family: Species		Common Name	Status		
			IUCN	CITES	National Status
Accipitridae					
	Spilornis cheela	Crested Serpent-eagle	LC	II	P
	Ictinaetus malaiensis	Black eagle	LC	II	P
Alcedinidae					
	*Halcyon cyanoventris**	Javan kingfisher	LC	NA	P
Bucerotidae					
	Rhyticeros undulatus	Wreathed hornbill	VU	II	P
Campephagidae					
	Coracina larvata	Sunda cuckooshrike	LC	NA	NP
	Pericrocotus miniatus	Sunda minivet	LC	NA	NP
Caprimulgidae					
	Caprimulgus macrurus	Large-tailed nightjar	LC	NA	NP
Cisticolidae					
	*Orthotomus sepium**	Olive-backed tailorbird	LC	NA	NP
	Phyllergates cucullatus	Mountain tailorbird	LC	NA	NP
Columbidae					
	Treron griseicauda	Grey-cheeked green pigeon	LC	NA	NP
	Ptilinopus porphyreus	Pink-headed fruit dove	LC	NA	NP
	Macropygia ruficeps	Little Cuckoo-dove	LC	NA	NP
	Macropygia emiliana	Ruddy Cuckoo-dove	LC	NA	NP
	Ducula lacernulata	Dark-backed imperial pigeon	LC	NA	NP
Cuculidae					
	Phaenicophaeus curvirostris	Chestnut-breasted malkoha	LC	NA	NP
	Cuculus saturates	Oriental cuckoo	LC	NA	NP
Dicruridae					
	Dicrurus leucophaeus	Ashy drongo	LC	NA	NP
	Dicrurus remifer	Lesser racket-tailed drongo	LC	NA	NP
	Dicrurus paradiseus	Greater racquet-tailed drongo	LC	NA	NP
Locustellidae					
	*Locustella montis**	Sunda Grasshopper-warbler	LC	NA	NP
Megalamidae					
	*Psilopogon armillaris**	Flame-fronted barbet	LC	NA	P
Muscicapidae					
	Brachypteryx leucophrys	Lesser shortwing	LC	NA	NP
	Cyanoptila cyanomelana	Blue-and-white flycatcher	LC	NA	NP
	Enicurus velatus	Sunda forktail	LC	NA	NP
	Eumyias indigo	Indigo flycatcher	LC	NA	NP
	Ficedula westermanni	Little pied flycatcher	LC	NA	NP
	Ficedula hyperythra	Snowy-browed flycatcher	LC	NA	NP
	*Myophonus glaucinus**	Javan whistling-thrush	LC	NA	NP
	Myophonus caeruleus	Bluewhistling-thrush	LC	NA	NP
Nectariniidae					
	Arachnothera affinis	Streaky-breasted spiderhunter	LC	NA	P
	*Aethopyga eximia***	White-flanked sunbird	LC	NA	P
Paridae					
	Parus major	Great Tit	LC	NA	NP
Pellornidae					
	Malacocincla sepiaria	Horsfield's babbler	LC	NA	NP
	Trichastoma pyrrogenys	Temminck's babbler	LC	NA	NP

Table 1. Contd.

Family: Species		Common Name	Status		
			IUCN	CITES	National Status
Phasianidae					
	*Arborophila orientalis****	Grey-breasted partridge	VU	NA	NP
	Gallus gallus	Red Junglefowl	LC	NA	NP
Phylloscopidae					
	*Phylloscopus grammiceps**	Javan warbler	LC	NA	NP
	Phylloscopus trivirgatus	Mountain warbler	LC	NA	NP
	Phylloscopus borealis	Arctic warbler	LC	NA	NP
Picidae					
	Dinopium javanense	Common flameback	LC	NA	NP
Pittidae					
	*Hydrornis guajanus**	Javan banded pitta	LC	NA	P
Pnoepygidae					
	Pnoepyga pusilla	Pygmy Wren-babbler	LC	NA	NP
Podargidae					
	Batrachostomus javensis	Javan frogmouth	LC	NA	NP
Pycnonotidae					
	Pycnonotus bimaculatus	Orange-spotted bulbul	NT	NA	NP
	Ixos virescens	Sunda bulbul	LC	NA	NP
Rhipiduridae					
	*Rhipidura euryura***	White-bellied fantail	LC	NA	P
Sittidae					
	Sitta azurea	Blue nuthatch	LC	NA	NP
	Sitta frontalis	Velvet-fronted nuthatch	LC	NA	NP
Strigidae					
	Bubo sumatranus	Barred Eagle-owl	LC	II	NP
Timaliidae					
	*Cyanoderma melanothorax**	Crescent-chested babbler	LC	NA	NP
Turdidae					
	Geokichla citrina	White's thrush	LC	NA	NP
	Zoothera aurea	Siberian Thrush	LC	NA	NP
	Zoothera sibirica	Orange-headed thrush	LC	NA	NP
Vangidae					
	Hemipus hirundinaceus	Black-winged flycatcher-shrike	LC	NA	NP
Vireonidae					
	Pteruthius aenobarbus	Triling shrike-babbler	LC	NA	NP
	Pteruthius flaviscapis	Pied Shrike-babbler	LC	NA	NP
Zosteropidae					
	*Heleia javanica**	Javan Grey-throated White-eye	LC	NA	P

Notes: *endemic to Java and Bali; ** endemic to Java; *** endemic to East Java highland.

mation, there are also 18% protected birds in the EEG. Expectedly, this protected status will certainly limit hunting and trade in Indonesia. However, awareness is also needed to maintain the birds that have not been protected and their natural habitats.

The EEG that are not conservation areas must be of particular concern in the monitoring of birds, especially those that are endemic and threatened. The potential for habitat degradation and illegal poaching in Indonesia is still high. As reported by Nijman et al. (2022), the threat of poaching and illegal trade, especially raptors on Java, Bali, and Lombok still exists. So that proposing this EEG area to be Ijen Geopark Biosites is a very appropriate step for in-situ conservation efforts.

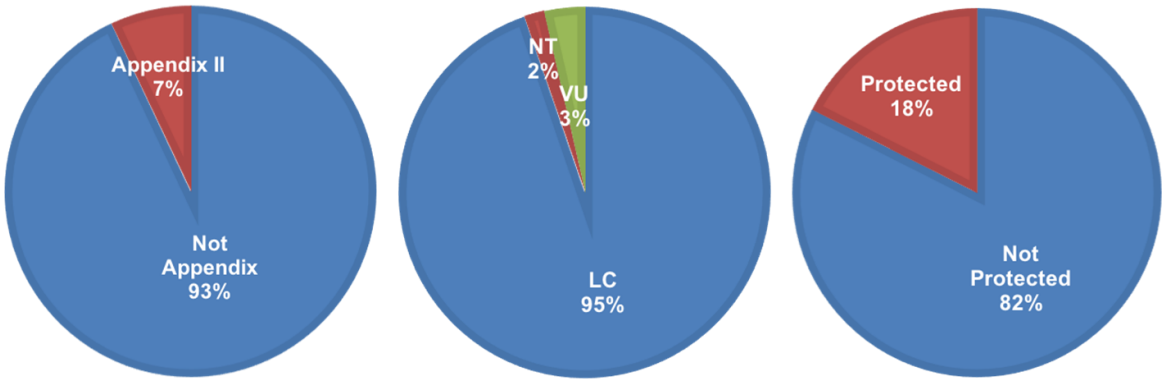

Figure 2. The CITES Appendices (left); Conservation status (middle); and National status (right) of Avifauna in EEG.

Furthermore, the discovery of Javan banded pitta (*H. guajanus*) in this study is valuable information for government and conservationists because this species is endemic and has a decreasing population (Birdlife International 2016). The *H. guajanus* species is endemic to Java and Bali which prefers closed primary and secondary forests at 1500 masl (Rheindt & Eaton 2010; Haryono & Pramono 2019). This species is found in the Ciletuh-Pelabuhan Ratu Geopark, West Java (Iskandar et al. 2021) and the natural forest of Mount Salak (Husodo et al. 2020). In this study, *H. guajanus* is found in forest area and occupied in the forest floor with dense tree canopy cover. This species was observed to be active during the day and more often observed sound than physically visible. The EEG is also a habitat for nocturnal birds, one of which is the Javan frogmouth (*B. javensis*). This species is a nocturnal species that was distributed in Southeast Asia, Palawan, and the Greater Sunda (MacKinnon et al. 2010; Puan et al. 2015). In the EEG area, this species occupies more of the riverbank forest area.

The diversity of avifauna in EEG Biosite, Ijen Geopark

According to the Shannon Wiener index, the diversity value of birds in the EEG Biosite was included in the high category (H'=3.40). This value is higher than other Java highlands, such as Telaga Warna Bogor (Ekowati et al. 2016), the land around mount Argopuro (Aryanti et al. 2018), and Promasan hiking trail Mount Ungaran (Purnamaningrum et al. 2021). This shows that EEG is one of the preferred habitats for birds in the highlands of Java. Based on this, further research is also needed on the characteristics and suitability of the avifauna habitat in the EEG. The high diversity value is also influenced by the abundance of each species. This species diversity consists of two primary components, i.e species richness and evenness (Ludwig & Reynolds 1998). In this study, it was

Figure 3. From left: *Arborophila orientalis*, *Hydrornis guajanus*, *Batrachostomus javensis* (Captured by Samsuri).

found that the average value was quite high (E=0.84). This value indicates that the avifauna in the EEG Biosite tends to be evenly distributed and no species dominates. In addition, this condition indicates the complexity of the interactions that occur in various species (Soegianto 1994). It means that the EEG is suitable habitat for 57 species because of foods and nesting availability supported evenly. Geopark Ijen (2022) states that the EEG area has a complete vegetation structure, i.e. herbs, shrubs, and trees such as *Cyathea contaminans*, *Mallotus* sp, *Annona* sp, *Toona sureni*, *Casuarina junghuhniana*, *Pterospermum diversifolium*, and *Ficus* sp. Further research is also needed on the presence of nests, availability of food, and preferences of vegetation as habitat. The availability of food resources and nests is an important factor that affects the abundance of bird species in a habitat (Martin 1995; Jara et al. 2020).

The qualification value (Ef) of the bird community at the Ijen Geopark EEG Biosite is 51.35, so it means the uniqueness of the bird community in this area is a medium category. The determination of this category is based on Tim Studi Keunikan Flora dan Fauna UI (1995) and Sulistiyowati (2008). This category is mainly influenced by each bird in this area having variations in frequency, endemicity, and conservation status values. There are three species of birds that have the highest Ef values, i.e *A. orientalis* (80.00), *P. bimaculatus* (73.33) and *L. montis* (73.33) (Figure 4). These three species are limited distribution in highland forests. Species *A. orientalis* is limited to the mountains Iyang and Ijen at an altitude of 500-2000 masl (MacKinnon et al. 2010). Meanwhile, *P. bimaculatus* has a more extreme altitude distribution (800-3000 masl). This species was found in the mountains of Sumatra, Java, and Bali. (MacKinnon et al. 2010; Mittermeier et al. 2014). Species *L. montis* prefer in open areas with dense bushes and shrubs at the edge of the forest or crater slopes above 1500-2100 masl (Madge 2016). This species also has a very limited distribution, i.e Mount of Central Java, East Java, and Bali (Taufiqurrahman et al. 2022).

The bird species composition, diversity and existence found in EEG is valuable information for the government and Ijen Geopark Managers for further conservation action specifically as an avitourism destination. This area has a unique species composition and high avifauna diversity. The information is also can be used as a conservation-based educational area for all elements of society, whether local communities, students, or researchers in developing their research. The development of avitourism in collaboration with local communities is an indispensable conservation strategy. Hereinafter, further research on avifauna ecology in EEG is also very needed, such as population or habitats of endemic birds. One of which is to estimate the population of the Grey-breasted partridge (*A. orientalis*) and assess their habitat characteristics. In addition, it can also determine the threat level of avifauna in the EEG. Accordingly, the data of avifauna, both ecological and threats in the EEG are more complete.

CONCLUSION

In this study, 57 bird species were found in the EEG Ijen Geopark Biosite as their habitat. There are 10 birds that are protected under government regulations, then 54 birds categorized as LC, one NT species, and two VU species. The Ijen Geopark EEG Biosite area has a high diversity of bird species that indicates the avifauna in the EEG Biosite tends to be evenly distributed and no species dominates. The unique value of the bird community in this area is in the medium category. There are three bird species that have the highest Ef values, i.e *A. orientalis*, *P. bimaculatus*, and *L. montis*.

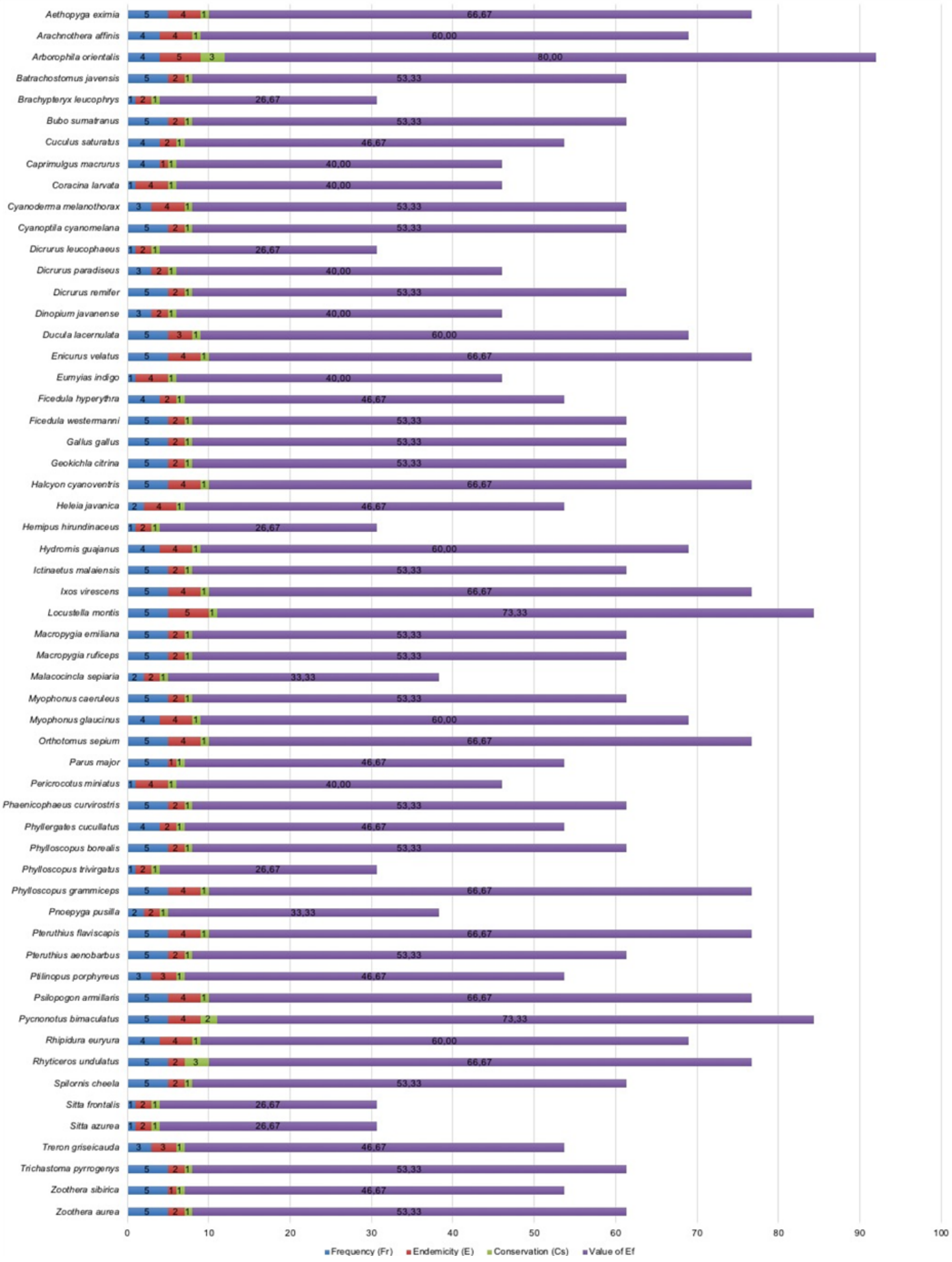

Figure 4. The Ef Value of Birds Community in EEG Ijen Geopark.

AUTHORS CONTRIBUTION

A.M.S designed the research, collected the data, species documentation, analysed the data, and wrote the initial manuscript. A.S.K., A.A., and S.

contributed to collecting the data, species documentation, and verification of birds species. H.S. and A.S.K. reviewed, revised, and proofread the final manuscript.

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CONFLICT OF INTEREST

The authors confirm that there are no known conflicts of interest associated with this publication.

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