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RESEARCH ARTICLE

IMPACT OF TOLL ROAD CONSTRUCTION ON BIODIVERSITY: AN ANALYSIS OF FLORA AND FAUNA IN INDONESIA

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ABSTRACT

The construction of toll roads in Indonesia significantly changes land use, highlighting the need for effective environmental management. A major concern is the loss of endemic habitats, which can lead to biodiversity extinction. This research analyzes the diversity and conservation status of flora and fauna in the affected area, using vegetation analysis for flora and the point count method for fauna. The results of the vegetation analysis indicate that the species composition includes 12 species from the Fabaceae family, 7 species from Asteraceae, and 5 species from Moraceae. The highest Importance Value Index in the tree stratum is attributed to *Swietenia macrophylla*. The highest flora diversity index is found in the herbaceous stratum (H' = 3.25), while the diversity indices for other groups are as follows: dragonflies (H' = 1.24), Lepidoptera (H' = 3.26), avifauna (H' = 2.25), and herpetofauna (H' = 2.07). Regarding the conservation status of flora taxa, *Dalbergia latifolia* and *Swietenia macrophylla* are classified as vulnerable, while Tectona grandis is considered endangered. In the Lepidoptera group, *Spalgis epius* and *Mycalesis horsfieldii* are categorized as endangered, while *Euploea mulciber* and *Orsotriaena medus* are vulnerable. *Rubigula dispar* and *Acridotheres javanicus* are classified as vulnerable species within the avifauna group. Although the construction of the toll road will involve clearing part of the forest that includes *Tectona grandis* and its associated fauna, this impact is deemed manageable because no species require specialized habitats. For reforestation efforts, it is recommended to plant *Ficus spp., Swietenia macrophylla, Dalbergia latifolia, and Tectona grandis.*

KEYWORDS

Biodiversity, Endemic Habitats, Flora and Fauna, Conservation Status, Reforestation

1. INTRODUCTION

The construction of toll roads represents a strategic transportation investment in Indonesia aimed at fostering economic growth and promoting equity. One such initiative is the development of the Solo-New Yogyakarta International Airport Toll Road, which is part of the national strategic programs currently being implemented by the government, as outlined in Presidential Regulation Number 109 of 2020 regarding the acceleration of national strategic projects (Temenggung et al. 2021). The Solo- New Yogyakarta International Airport Toll Road is being constructed in three segments. Section 2 is the construction of the Solo - New Yogyakarta International Airport Toll Road with a road length of 22.40 kilometers and a road area of 6,808,048 square meters (Hasiholan, Ismanti, and Rifa'i 2023). According to Government Regulation Number 4 of 2021, the construction of a 22.40 km long toll road and land acquisition of 177.44 ha (≥ 20 ha) require environmental impact analysis documents.

The Indonesian Ministry of Environment and Forestry will grant environmental permission for these activities. (Isworo 2023). Toll road building is predicted to modify land use and is the primary driver of biodiversity changes, hence interfering with the composition and variety of flora and animals at development sites. (Assidiq, Al Mukarramah, and Bachril 2021). Environmental Impact Analysis is a scientific study to achieve the goal of making decisions in accordance with sustainable environmental principles. This research only focuses on biological elements, namely the influence on biological components that are likely to experience fundamental changes as a result of the action in question, as follows: (Bond et al. 2020). The biological element of the environmental components impacted is an essential part in environmental impact analysis studies, which are the primary focus of impact analysis.

Vegetation analysis is an element of biology that examines the organization of a variety of species and forms, the structure of vegetation, or plant communities. Vegetation structure consists of growth form, stratification, and canopy closure. Vegetation analysis provides quantitative information regarding the structure and composition of plant communities. Vegetation analysis requires data on type, diameter and height to estimate the importance index of forest community components (Puletti et al. 2021). Avifauna is an important element in the unity of biological aspects that must be studied. Avifauna are species that live in a particular ecosystem and depend on vegetation for their life. Avifauna diversity is the abundance or number of avifauna found in a particular area. The diversity of avifauna species in a location reflects the integrity and richness of the ecosystem as a whole. Avifauna species serve as environmental markers that are rich in biodiversity, therefore, efforts to protect and conserve them are very important to prevent avifauna population decline. (Gibru and Mengesha 2019).

Dragonflies play a crucial part in ecological balance. Aside from that, dragonflies may be used to assess the quality of the aquatic environment because they reside in water throughout the nymph phase. Changes in water quality have a significant impact on the number of dragonfly nymphs, making them a useful indication of whether the water is clean or dirty. Polluted water disrupts the life cycle of dragonflies, causing population numbers to fall (Perron and Pick 2020). Butterflies (Lepidoptera) provide ecological significance as part of the food chain, prey for predators, and pollinators, ensuring the sustainability of plant

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regeneration and the balance of the environment. Butterflies' global nature leads to their widespread distribution in a variety of habitats. To overcome the loss in environmental quality, one strategy is to assess the link between variables that produce environmental disturbances and bioindicators. Butterflies have promise as bioindicators since they are sensitive to changes in their surroundings (Frahtia, Attar, and Diabi 2022).

Herpetofauna is an essential component of the food chain and a useful bioindicator for describing ongoing environmental changes. The variety and composition of herpetofauna species are influenced by the structure of their environment. Many changes in habitat structure induced by human activities have a detrimental influence on natural herpetofauna species diversity. Small environmental changes can affect the lives of herpetofauna, and many herpetofauna species are herpetofauna-specific. Certain herpetofauna can only thrive in extremely particular settings and are highly sensitive to habitat changes (Howell 2023). Mammals contribute significantly to ecological equilibrium. Mammals are in charge of soil fertility, flower pollination, seed dissemination, and ecological pest management. Mammals can preserve ecological equilibrium and contribute significantly to forest dynamics. If these animal species disappear, the forest vegetation pattern will shift, resulting in a loss of plant species variety. Environmental diversity and quality influence the quantity and species of animals in a given area (Lacher Jr et al. 2019).

The decrease in biodiversity is a key problem in all development efforts that harm biological and natural resources. The conservation state of flora and fauna is critical in terms of biodiversity extinction in particular areas. The conservation condition of flora and wildlife, biodiversity, and environmental impact analysis must all be fully integrated.(Bond et al. 2021). The International Union for Conservation of Nature and Natural Resources' Red List is a common international standard for assessing wildlife. The red list is a list of species that are on the verge of extinction, along with their critical status, population condition, and natural range, as well as the factors that jeopardize their long-term viability and efforts to conserve them (IUCN 2021).

Protection status based on PP No. 7 of 1999, CITES status, and IUCN Redlist status are the primary statuses used in biodiversity assessments (Lee et al. 2019). The aim of this research is to analyze biodiversity and the conservation status of flora and fauna, and make recommendations based on the biological conditions found regarding the environmental impacts resulting from the construction of the Solo-New Yogyakarta International Airport toll road.

2. Research Methodology

2.1 Tools and Materials

The instruments and materials utilized in the biodiversity study are as follows: (Table 1)

Table 1: List of instruments used to observe each taxon investigated.

Name of tool/material	The taxa investigated					
	Flora	**Avifauna**	**Dragonfly**	**Butterfly**	**Mammals.**	**Herpetofauna**
Observation plot	V	-	-	-	-	-
Phi-band/meter	V	-	-	-	-	-
Specimen plastic	V	-	-	-	-	-
Cut the branches	V	-	-	-	-	-
Digital camera	V	V	V	V	V	V
Road sign	V	V	V	V	V	V
Rangefinder	V	-	-	-	-	-
Binoculars	-	V	-	-	V	-
Telephoto lens (300mm)	V	V	V	V	V	V
Insect net	-	-	V	V	-	-
Stick handler	-	-	-	-	-	V
Papilot paper	-	-	V	V	-	-
Headlamp	-	-	-	-	-	V
Caliper (Vernier calipers)	-	-	-	-	-	V
Ruler	V	-	V	V	-	V
Camera Trap	-	-	-	-	V	-
Spacious meter	V	-	-	-	-	-
Hand counters	-	V	V	V	-	-
Fledgling tape	V	V	V	V	V	V
GPS	V	V	V	V	V	V
Label	V	-	V	V	-	V
MMC Camera	V	V	V	V	V	V
2 meter steel sling	-	-	-	-	V	-
Wire Clips	-	-	-	-	V	-
Machete	V	V	-	-	V	V
Observation Form	V	V	V	V	V	V
Stationery	V	V	V	V	V	V
Harvester marker	V	V	V	V	V	V
Identification manual	V	V	V	V	V	V
Lux meters	V	V	V	V	V	V
Soil tester	V	V	V	V	V	V
Thermohygrometer	V	V	V	V	V	V

2.2 Sampling Location

The flora and fauna survey was based at Kaligondang village, district Temon, Kulon Progo regency is the most complete site and activity plan, with an area of ±131,000 m^2, equivalent to 327 grids of 20x20. The survey took place on July 25–29, 2023, and comprised an investigation of flora or plants, avifauna (birds), odonata (dragonflies), lepidoptera (butterflies), mammals, and herpetofauna (amphibians and reptiles). Figure 1 depicts sampling of biological component locations based on a 20x20 m grid, while Figure 2 describes the dominant land cover at the survey site.

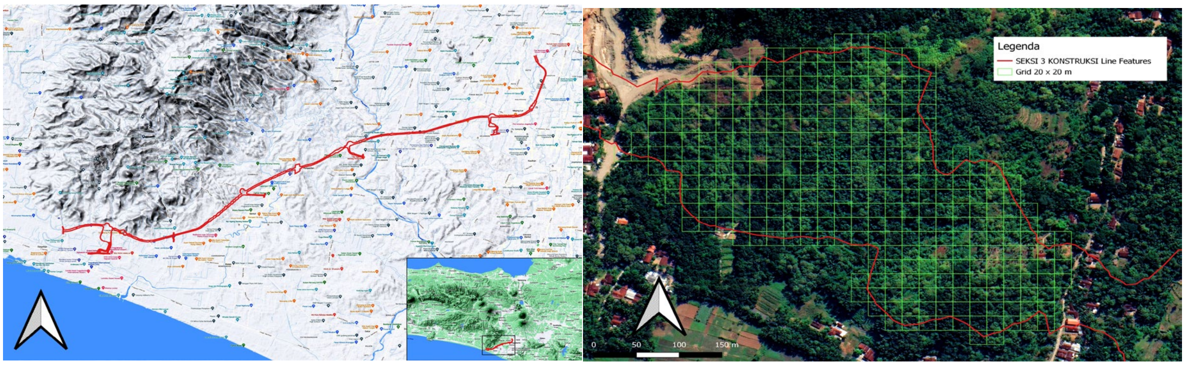

Figure 1: Sampling of biological components based on a 20x20 m grid.

Figure 2: Description of the dominant land cover at the survey location

According to a preliminary study, the site area's habitat is homogenous vegetation, with *Tectona grandis*), *Swietenia macrophylla*, and *Acacia auriculiformis* being generally dominant. This place has a lowland vegetation region with an altitude range of 33–104 m above sea level, a somewhat dry climate with an air temperature of 27.2–30.1 °C, an air humidity of 51–75%, and soil wetness ranging from 8% to 60%. The table 1 below presents more detailed information on environmental conditions:

Table 1: Environmental parameter values in the observation area			
Indicator	**Path 1**	**Path 2**	**Path 3**
Light Intensity (Lux)	951-5185	583-2347	1488-4872
Air Temperature ((°C)	27.2-28.8	29-30.1	28-28.1
Soil pH	6.5-7	6.5-6.9	6,8-6.9
Air Humidity (%)	51-75	55-60	52-56
Soil Moisture (%)	20-50	20-60	20-30

Source: primary data 2023

2.3 The Taxa Examined in the Research

2.3.1 Flora

An exploratory qualitative methodology is used in the investigation with purposive sampling techniques. Flora data were collected using a quadratic technique, with nine observation plots assigned to three observation lines. On each route, three 20x20 observation plots were planted sequentially using the belt transect approach (Figure 3). Each kind in each layer of the observation plot is identified directly. Each individual's dominance in the tree, pole, and sapling layers of each quadrat was determined by measuring the trunk diameter at breast height. Meanwhile, for the chick layers, simply the number of individuals of each kind is recorded. For undergrowth, 2x2 m subplot was established, and the percentage canopy cover was calculated.

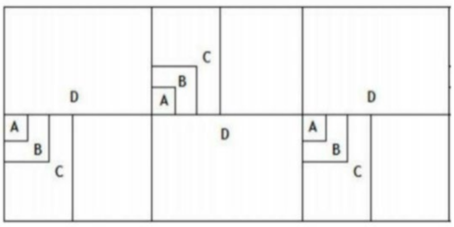

Figure 3: Plot placement model using the belt transect principle

Figure 1 Plot placement model using the belt transect principle: A. 2x2 m plot for undergrowth and sapling strata; B. 5x5 m plot for sapling strata; C. 10x10 m plot for pole strata; and D. 20x20 plot for tree strata. Table 2. shows the distribution of plot size and borders for each strata analyzed.

Table 2: Plot size and boundaries in ech stratum for plant taxa		
Strata	**Limitation**	**Plot size (m)**
Tree	Diameter >20cm	20x20
Pole	Diameter =/ >10-20 cm	10x10
Stake	Diameter <10 cm, height >1.5 m	5x5
Saplings	Diameter <10 cm, height <1.5 cm	2x2

The exploration of plant types not found in the plot was carried out using the connecting paths between observation points and exploration is carried out to complete the list of plant types identified inside the survey site.

2.3.2 Avifauna

Avifauna data was collected in the field using the Indices Ponctuels d'Abondance (IPA) or Point Count technique. The observer stops at a spot in the studied area and counts all birds identified (both visually and audibly) throughout a 20-minute period. The distance between two points is 100 metres, and the observer's seeing radius is 25 metres.(Akçay et al. 2020).

Data was collected over three days, with daily observations at three places and repetition at each (for a total of six sets of data per point. Observations were conducted in the morning from 06.00 to 09.00 West Indonesia Time, with repeats taking place in the afternoon from 15.00 to 18.00 West Indonesia Time. Each bird sighted throughout the survey period was identified by kind, number of birds, and time of contact. Each kind is documented to help with identification both in the field and at basecamp. Sound identification allows for the recording of bird calls, which are subsequently recognized in basecamp using bird sound guide (Purnamaningrum, Bihi, and Harits 2021)

2.3.3 Odonata dan Lepidoptera

Dragonfly and butterfly species were observed using the Visual Encountering Survey (VES) approach along three specified transect lines. Data was collected twice, with one repetition per observation line (for a total of three sets of line data. Observations were performed by walking along a transect path and noting all varieties of dragonflies and butterflies, the number of individuals of each type, and their activity throughout the observation period (08.00 to 13.00 West Indonesia Time). Observed behaviors include feeding, oviposition (laying eggs), perching and/or sunbathing, flying, and mating. Species whose scientific names are unknown are collected using an insect net, placed in papilot paper, and given a temporary labeled for subsequent identification at the basecamp in accordance with the criteria used.

2.3.4 Mamalia

The animals observed in this study included arboreal and terrestrial mammals, as well as a variety of other wild species. Observations of mammals are carried out through 3 variations of methods: (1) visual encounters using the point count method, (2) observation of various markers of presence (footprints, droppings, claw marks, sounds, voices, and so on) on the path, and (3) installation of a of a camera trap. Each point is observed for 20 minutes with three repetitions, whereas camera traps can be installed in the desired location, taking into account factors such as animal paths, the discovery of traces/feces, food and drink sources, and so on. Camera traps can automatically record animal activities. Camera traps can overcome limitations in direct monitoring of mammals, such as at night. There was 1 camera trap installed in this survey over a period of 4 days. Mammal taxa were identified using point counts and camera traps by comparing numerous sources, such as a Book Titled Conservation Status and Role of Mammals on the Island of Java (Amori, Gippoliti, and Helgen 2008). Meanwhile, numerous indications indicating the presence of mammals on the route were discovered by assessing footprint form, number of toes, presence of hoof impressions, and claw depth. Identification is accomplished by comparing the paperwork and samples collected to the criteria followed

2.3.5 Herpetofauna

The Visual Encounter Survey (VES), like that of Lepidoptera and Odonata, is the primary method for gathering data on herpetofauna. Data collection is based on individual contacts in each category on the observation path, which is separated into three routes. Each route combines the VES and transect/lane methods. What distinguishes data collection from dragonflies and butterflies is that there are two observation times: 07:00–11:30 West Indonesia Time for diurnal herpetofauna and 18:30–21:00 West Indonesia Time for nocturnal herpetofauna.

3. Identification and Naming of Species

Plant taxa are recognized by comparing the physical characteristics of the flora, both generative (flowers and fruit) and vegetative (stature, stem, leaves, leaf arrangement), contained in identification books. Avifauna taxa are recognized by comparing the results of documentation or observations in the form of general characteristics and the color of each type's feather patterns with identification guides (MacKinnon 2021) Odonata taxa were recognized by matching morphological features such as the shape, pattern, and color of the abdomen (stomach), eyes, thorax (chest), and wing venation to Semarang Raya's Odonata standards. (Grimaldi 2023) Lepidoptera taxa are recognized by examining the body size, color, venation, and patterns on the wings, as well as the overall form of the wings, and then comparing them to the identification guide.

Mammal taxa recorded using point counts and camera traps were recognized by comparing numerous sources, such as a book entitled Conservation Status and Role of Mammals on the Island of Java. (Maharadatunkamsi et al., (2020). Meanwhile, the existence of different markers (footprints, dirt, claw marks, sounds, noises, and so on) on the path is determined by measuring the kind of footprint, number of toes, presence of nail prints, and depth of scratches. Measure the length and breadth of the feces, as well as the type of feed that remains in the feces. Identification results can be compared with other references to prior discoveries, such as a book entitled "A Guide to Tracks of Mammals in Western Indonesia.". (Francis 2019).

The names are based on scientific and English identities. Scientific nomenclature is standardized by utilizing the Global Biodiversity Information Facility (GBIF) online database. (https://www.gbif.org/). Scientific nomenclature for flora taxa is based on online data from the World Checklist of Selected Plant Families/WCSP (https://wcsp.science.kew.org), while GBIF data is still used internationally. Additional Indonesian names for bird species may be found in the Indonesian Bird List 2. While the English name and scientific name according to the Handbook of the birds of the world and BirdLife International digital checklist of the birds of the world (Westrip 2022)

4. Diversity Index, and Community Stability

Community stability may be measured by computing the diversity value of each species based on the Shannon-Wiener (H') calculation using the Diversity tool facility from the Past4 Project application, as follows:. (She et al. 2023)

$$H' = -\Sigma Pi.\ln Pi$$

$$Pi = \frac{ni}{N}$$

H' is the Shannon-Wiener diversity index, and Pi is the proportion of importance of type i (ni) to all species in each taxa (N).

Importance values for flora taxa are determined by computing the Important Value Index (INP) for each type seen within plot coverage. The INP value of the tree, sapling, and pole strata is calculated by summing the relative values of three vegetative factors, dominance, density, and frequency. Meanwhile, for tiller layers, the INP value is solely determined by density and frequency. Understory plants' INP is governed by two vegetative parameters: dominance and frequencyv(Ahmed et al. 2020). In general, INP calculations may be expressed using the following formula:

$$NPi = DoRi + DeRi + FRi$$

Note: H' is the Shannon-Wiener diversity index, and Pi is the proportion of importance value of type i (ni) to all species in each taxa (N).

In contrast to the importance value of flora taxa, the importance value of fauna taxa (avifauna, odonata, lepidoptera, mammals, and herpetofauna taxa) is determined by the number of individuals of each type, whereas the Pi value is calculated by dividing the number of individuals of type i by the total number of individuals found.

5. Result and Discussion

5.1 Overview of the Research Location

Based on the data from environmental parameter measurements (Table 1) in the observation area, the light intensity ranges from 583 Lux to 4872 LuxPath 1 has the highest light intensity range, from 951 to 5185 Lux. Path 2 has a range of 583 to 2347 Lux, while Path 3 has a light intensity range of 1488 to 4872 Lux. This varying light intensity can affect the photosynthetic activity of plants in the observation area, which plays an important role in providing energy for chlorophyll-containing plants. The ideal light intensity for photosynthesis in forests typically ranges from 1000 to 2500 Lux; however, for plants growing under a denser forest canopy, the light intensity may be lower, ranging from 100 to 1000 Lux. Each type of plant has different light requirements, so this range can vary depending on the species. In tropical forests, productive light intensity during the day can reach up to 10,000 Lux at the forest canopy level, while in the understory, it ranges from 100 to 2000 Lux. (Schuh and Immich 2022). In general, the range of light intensity measured in the data can support the growth of various types of plants, indicating the potential for ecosystem diversity in the observation area.

The air temperature (°C) throughout the paths is relatively consistent, ranging from 27.2°C to 30.1°C. This range is suitable for tropical plants, which typically thrive in these temperatures (Dantas et al. 2020). The soil pH in all areas measured close to neutral, ranging from 6.5 to 7.0. This pH range is generally favorable for plant growth, as many tropical plants thrive in slightly acidic to neutral conditions. (INUWA and BILYAMINU 2020). Air humidity ranges from 51% to 75%, which generally supports the growth of tropical plants in the research area. Although Path 2 exhibits a lower humidity range of 55% to 60%, this condition remains within the acceptable tolerance levels for plant growth. (Priya and Senthil 2021).

Soil moisture percentages vary across the paths: Path 1 shows a relatively high variation, ranging from 20% to 50%, while path 2 and path 3 have lower moisture ranges of 20% to 60% and 20% to 30%, respectively. overall, a soil moisture range of 20% to 60% is considered favorable for plant health. (Krisnawati and Adie 2017). The observation areas displayed generally favorable conditions for tropical plant growth, with suitable temperature and pH levels. However, variations in light intensity and soil moisture among the different paths indicate that some locations may be more optimal than others, potentially affecting plant productivity. Further monitoring of these parameters is essential to understand their overall impact on plant growth.

5.2 Species richness/species composition

There were 165 species from 67 families recognized throughout the five groups investigated. Plants (66 species), avifauna and butterflies (36 each), herpetofauna (15 types), dragonflies (7 types), and mammals (4 types) are listed in order of number of types.

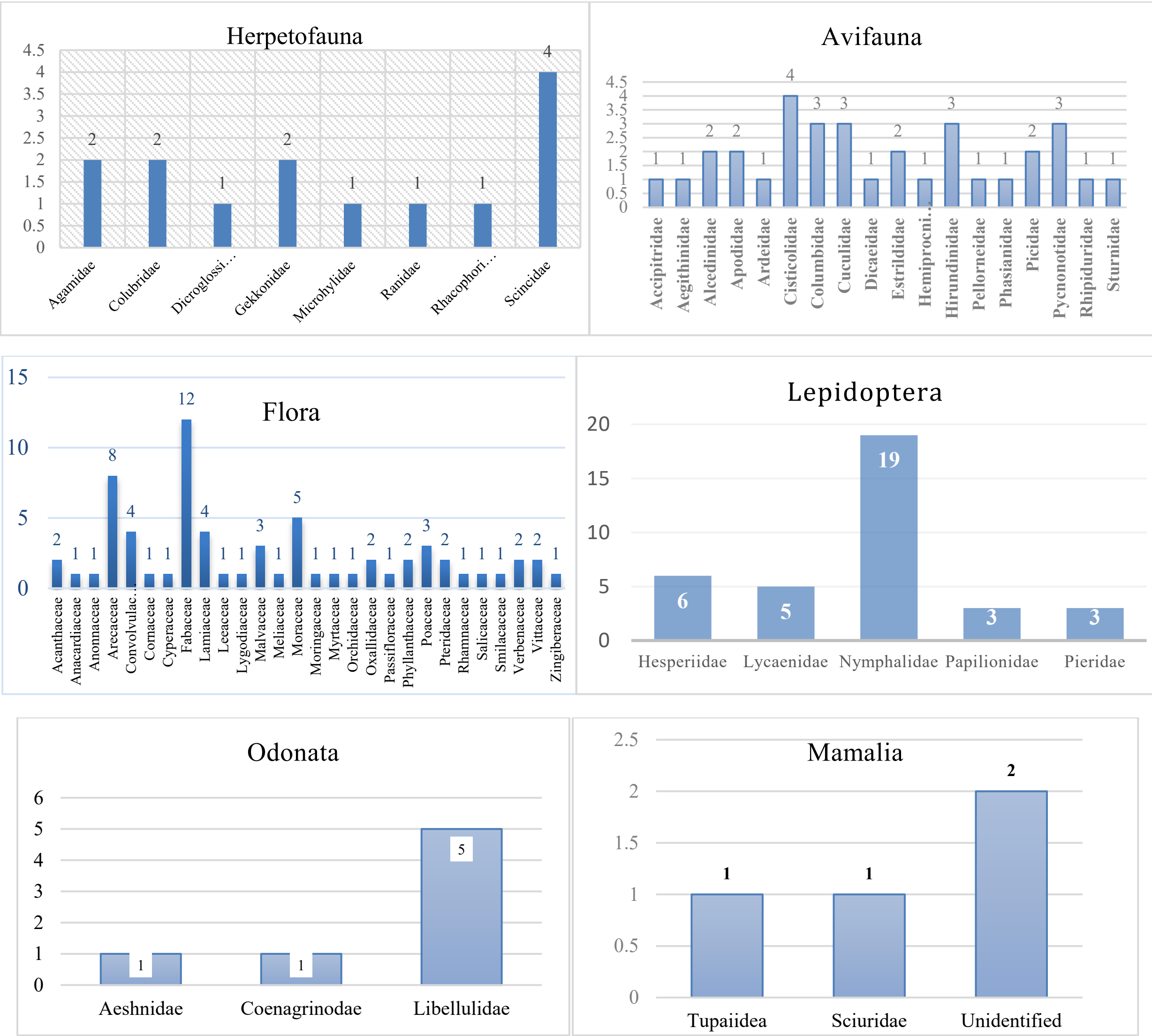

Figure 4: Species composition is based on the taxonomy studied

5.3 Flora

The flora survey covers 3,600 square meters. Based on early survey data, the types of vegetation encountered tended to be uniform, with the primary stands being teak (*Tectona grandis*) and mahogany (*Swietenia macrophylla*), and the opportunities in all observation areas were not significantly different. Because the surveyed area is adjacent to community settlements, the plants found there are mostly production plants, as evidenced by the dominance of Teak (*Tectona grandis*) and Mahogany (*Swietenia macrophylla*) at the tree and pole levels, as well as the Gamal (Gliricidiasepium) at the sapling level. (Mayasari et al., 2012).

Table 3: Flora types identified at the study location

No	Family	Scientific name	Local name	IUCN	CITES	UU
1	Acanthaceae	*Andrographis paniculata*	Sambiloto	LC	Not listed	No
2	Acanthaceae	*Ruellia repens*	Kecubung Tanah	LC	Not listed	No
3	Anacardiaceae	*Mangifera indica*	Mangga	LC	Not listed	No
4	Anonnaceae	*Anonna squamosa*	Sirsak	LC	Not listed	No
5	Arecaceae	*Cocos nucifera*	Kelapa	LC	Not listed	No
6	Asteraceae	*Ageratum conyzoides*	Bandotan	LC	Not listed	No
7	Asteraceae	*Chromolaena odorata*	Krinyuh	LC	Not listed	No
8	Asteraceae	*Elephantopus scaber*	Tapak Liman	LC	Not listed	No
9	Asteraceae	*Emilia sonchifolia*	Kukut Jawa	LC	Not listed	No
10	Asteraceae	*Porophyllum ruderale*	Ketumbar Bolivia	LC	Not listed	No
11	Asteraceae	*Synedrella nudiflora*	Enceng Gondok Hutan	LC	Not listed	No
12	Asteraceae	*Tridax procumbens*	Rumput Semalu	LC	Not listed	No
13	Convolvulaceae	*Ipomoea obscura*	Kangkung Hutan	LC	Not listed	No
14	Convolvulaceae	*Merremia caespitosa*	Bunga Beruk	LC	Not listed	No
15	Convolvulaceae	*Merremia emarginata*	Bunga Kunci	LC	Not listed	No
16	Convolvulaceae	*Merremia hederacea*	Bayam Hutan	LC	*NA*	No

Table 3 (Cont.): Flora types identified at the study location						
17	Cornaceae	*Alangium chinense*	Cepokak	LC	Not listed	No
18	Cyperaceae	*Carex sp*	Rumput teki	LC	Not listed	No
19	Fabaceae	*Acacia auriculiformis*	Akasia	LC	Not listed	No
20	Fabaceae	*Albizia chinensis*	Sengon	LC	Not listed	No
21	Fabaceae	*Caliandra sp*	Kaliandra	LC	Not listed	No
22	Fabaceae	*Calopogonium mucunoides*	Daun Bambangan	LC	Not listed	No
23	Fabaceae	*Centrosema pubescens*	Senduro	LC	Not listed	No
24	Fabaceae	*Dalbergia latifolia*	Sono keling	VU	Listed II	Yes
25	Fabaceae	*Flemingia macrophylla*	Klepu	LC	Not listed	No
26	Fabaceae	*Flemingia strobilifera*	Kletingan	LC	Not listed	No
27	Fabaceae	*Gliricidia sepium*	Kaliandra	LC	Not listed	No
28	Fabaceae	*Leucaena leucocephala*	Kemanding/Lamtoro	LC	Not listed	No
29	Fabaceae	*Mimosa pudica*	Putri malu	LC	Not listed	No
30	Fabaceae	*Samanea saman*	Trembesi	LC	Not listed	No
31	Lamiaceae	*Hyptis capitata*	Jinten Hitam	LC	Not listed	No
32	Lamiaceae	*Leucas lavandulifoia*	Meniran	LC	Not listed	No
33	Lamiaceae	*Salvia occidentalis*	Kecibeling	LC	Not listed	No
34	Lamiaceae	*Tectona grandis*	Jati	EN	Listed II	Yes
35	Leeaceae	*Leea indica*	Mindi Jawa	LC	Not listed	No
36	Lygodiaceae	*Lygodium microphyllum*	Pakis Gajah	LC	Not listed	No
37	Malvaceae	*Corchorus aestuans*	Daun Ketumbar	LC	Not listed	No
38	Malvaceae	*Sida rhombifolia*	Sida guri	LC	Not listed	No
39	Malvaceae	*Urena lobata*	Pulutan	LC	Not listed	No
40	Meliaceae	*Swietenia macrophylla*	Mahoni	VU	Listed II	No
41	Moraceae	*Ficus callosa*	Ilat-ilatan	LC	Not listed	No
42	Moraceae	*Ficus hispida*	Keluwih	LC	Not listed	No
43	Moraceae	*Ficus montana*	Uyah-uyahan	LC	Not listed	No
44	Moraceae	*Ficus septica*	Awar-awar	LC	Not listed	No
45	Moraceae	*Ficus tinctoria*	Kelor Laut	LC	Not listed	No
46	Moringaceae	*Moringa oleifera*	Kelor	LC	Not listed	No
47	Myrtaceae	*Syzigium cumini*	Jamblang/Juwet	LC	Not listed	No
48	Orchidaceae	*Didymoplexis pallens*	Bunga Lidah Bab	LC	Not listed	No
49	Oxallidaceae	*Oxalis barrelieri*	Calincing	LC	Not listed	No
50	Oxallidaceae	*Paederia foetida*	Daun kentut	LC	Not listed	No
51	Passifloraceae	*Passiflora foetida*	Passiflora liar	LC	Not listed	No
52	Phyllanthaceae	*Phyllanthus urinaria*	Meniran	LC	Not listed	No
53	Phyllanthaceae	*Pyhllanthus niruri*	Meniran	LC	Not listed	No
54	Poaceae	*Axonopus compressus*	Rumput gajah mini	LC	Not listed	No
55	Poaceae	*Brachiaria reptans*	Waderan	LC	Not listed	No
56	Poaceae	*Imperata cyllindrica*	Alang-alang	LC	Not listed	No
57	Pteridaceae	*Pteris ensifolia*	Pakis	LC	Not listed	No
58	Pteridaceae	*Pteris vittata*	Paku Gajah	LC	Not listed	No
59	Rhamnaceae	*Ziziphus mauritiana*	Bidara	LC	Not listed	No
60	Salicaceae	*Flacourtia indica*	Rambeh Jawa	LC	Not listed	No
61	Smilacaceae	*Smilax sp*	Akar Saga	LC	Not listed	No
62	Verbenaceae	*Lantana camara*	Tembelekan	LC	Not listed	No
63	Verbenaceae	*Stachytarpetha jamaicensis*	Pecut Kuda	LC	Not listed	No
64	Vittaceae	*Causonis trifolia*	Arbei	LC	Not listed	No
65	Vittaceae	*Vitex pinnata*	Suruh	LC	Not listed	No
66	Zingiberaceae	*Curcuma zanthorrhiza*	Temulawak	DD	Not listed	No

Information:

Note:

a) IUCN b) CITES c) Indonesia regulation

Status of protection, IUCN Based on the conservation status of the page International Union for Conservation of Nature and Natural Resources/IUCN (https://www.iucnredlist.org) with status, Global Population: The status of global population development is displayed in the status IUCN: DD = Data Deficient, LC: Least Concern (less attention or low risk), CR: Critically Endangered (critical or threatened with extinction in the near future), VU: Vulnerable (vulnerable or at risk of extinction in the wild). Indonesia Regulation Indonesia Regulation P.106/MENLHK/SETJEN/KUM.1/12/2018 of the Minister of Environment and Forestry of the Republic of Indonesia, The IUCN red list categories are low risk (least concern, LC), vulnerable (vulnerable, VU) and danger (endangered, EN) and lack of data (data deficient, DD);

Based on the species composition, the plant families commonly found in this study are Fabaceae (12 types), Asteraceae (7 types) and Moraceae (5 types). It is very natural that these two plant families are common, especially in the teak forest ecosystem type. This is because systematically, the three families have quite a large number of members, Asteraceae with 32,913 species, Fabaceae with 24,505 species, and Moraceae with 1,217 species. (Aumeeruddy and Mahomoodally 2022) (Soerjani 1987), these three plant families have a very wide range of habitats and very good adaptability; and deliberately planted by the community, especially for the Fabaceae (Table 4).

Table 4: Importance value index and species diversity at the study location

Species name	Local name	Importance Value Index		
		Stake	**Pole**	**Tree**
Acacia auriculiformis	Akasia	38,22%	44,57%	47,92%
Albizia chinensis	Sengon	0,00%	0,00%	5,78%
Caliandra sp.	Kaliandra	5,99%	2,22%	16,48%
Cocos nucifera	Kelapa	0,00%	0,00%	12,33%
Dalbergia latifolia	Sono keling	10,95%	13,45%	5,94%
Ficus callosa	Ilat-ilatan	6,32%	2,22%	0,00%
Ficus hispida	Waluh Hutan	16,59%	9,68%	0,00%
Ficus tinctoria	Nyamplung	0,00%	0,00%	6,29%
Gliricidia sepium	Kaliandra	41,21%	38,45%	5,89%
Leucaena glauca	Kemanding/Lamtoro	5,82%	2,22%	0,00%
Moringa oleifera	Kelor	0,00%	0,00%	6,05%
Swietenia macrophylla	Mahoni	101,02%	101,91%	122,62%
Syzigium cumini	Jamblang/Juwet	0,00%	0,00%	6,46%
Tectona grandis	Jati	73,89%	85,27%	64,23%
Diversity Index (H')		**1,763613**	**1,629886**	**1,752625**

Source: Primary Data 2023

The diversity index of annual plants (perennials) has a low value in all strata (H'<2). This shows that the annual plant community in the study area is very sensitive to the extinction of a particular species. As the name suggests, teak wood is dominated by teak trees; however, mahogany and acacia are also widespread in this type of habitat. Because these species are dominant, and there are only 18 different t ree species in the plot, the diversity value is naturally low Compared to perennial plants, understory plants have a high diversity value of H'=3.25 and good stability. The understory plant community will continue to operate well because other plant kinds may fill the ecological gaps left by other species. In general, the types of undergrowth discovered during sampling are weeds capable of adapting to varied environmental circumstances (McAlpine, Lamoureaux, and Timmins 2021). Krinyuh plants (Chromolaena odorata), tembelekan (Lantana camara), and other Asteraceae species has a wide range of light intensity also creates an environment that supports plants with different preferences, resulting in a considerably more diversified understory plant community than perennial plants.

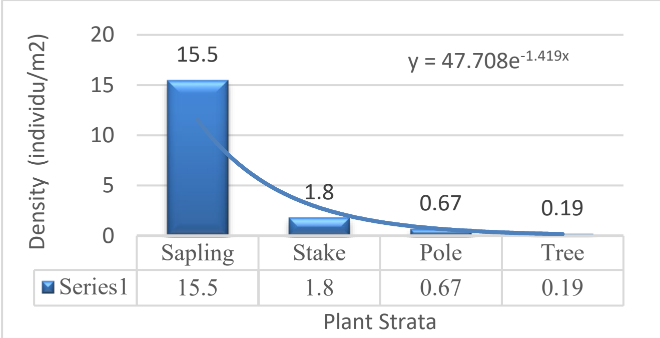

Figure 5: Density of Hardwood Plants at Each Stratum in the Sampling Area

The sustainability of the plant community in the region analyzed is good, as represented in the graph by the trend of the J curve (exponential), which suggests there is plant regeneration, especially perennial plants in the area studied (Mazuze et al. 2024). Considering plants in the food chain as producers, the sustainability of these plants suggests that communities of other taxa will continue to exist in the future, as long as there is no disruption or human interference. The region explored demonstrates how plants are used by diverse creatures. Aside from serving as a home, the study's homogenous teak forest environment has a variety of flora that attract wildlife such as butterflies and birds. The presence of diverse undergrowth as food for butterflies such as Tembelekan *(Lantana camara*), horsewhip (*Stachytarpetha jamaicensis*), and numerous varieties of the Asteraceae. Homogeneous forest types, despite their low plant diversity, must be considered as animal habitats and providers of environmental services. As shown in plot 2.3 line 2, there is a former water source under the Ficus tinctoria tree, which has since dried up; however, a similar source that is still active was discovered outside the observation route, a type of Ficus with dense roots capable of binding water. (Berg and Corner 2005).

Based on Figure 5 (Exponential model Y = 47,708 e -1.419x) there is strong potential for regeneration through the sapling strata, there is a decline in the other strata, creating challenges that must be addressed. Actions are needed to support the growth of young plants so they can develop into mature trees and maintain the sustainability of the ecosystem. Actions are needed to support the growth of young plants and ensure they develop into mature trees, some of the actions that need to be taken are periodic monitoring and consistent monitoring of the growth of young trees, weed and invasive plant removal, use of organic fertilizers and pest and disease protection: take preventive measures to protect young trees from pests and diseases, and ensure their health and resilience(Fuentes-Montemayor et al. 2022).

5.4 Odonata (Dragonfly)

The dragonfly survey revealed seven different types of dragonflies from three families (Familia): Libellulidae, Coenagrionidae, and Aeshnidae. The Libellulidae family is the most numerous, having five different varieties, while the Coenagrionidae and Aeshnidae families each have 1 type. The Anisoptera suborder has the highest species abundance, namely 47 individuals from the 6 species observed. This is because dragonflies from the suborder Anisoptera themselves have the characteristics of a wide home range. (Fitriana 2016)

Table 5: List of odonata types identified at the study location

No	Family	Scientific name	Local name	IUCN	CITES	UU
1	Aeshnidae	*Gynacantha subinterrupta*	Capung edar umbai temu	LC	Not listed	No
2	Coenagrinodae	*Agriocnemis femina*	Capung jarum centil	LC	Not listed	No
3	Libellulidae	*Neurothemis ramburii*	Capung tengget jala	LC	Not listed	No
4	Libellulidae	*Orthetrum chrysis*	Capung sambar perut kait	LC	Not listed	No
5	Libellulidae	*Orthetrum sabina*	Capung sambar hijau	LC	Not listed	No
6	Libellulidae	*Potamarcha congener*	Capung sambar perut pipih	LC	Not listed	No
7	Libellulidae	*Tholymis tillarga*	Capung sambar senja	LC	Not listed	No
	Diversity Index (H') : 1,24					

Information: The IUCN red list category is low risk (least concern, LC)

The Libellulidae family has a large number of members, is cosmopolitan, making it possible to find it in various types of habitat. *Neurothemis ramburii* is the most prevalent kind in the three observation lines, accounting for 30 individuals. This variety of dragonfly is considered to be particularly tolerant of drastic changes in the environment. It is an aggressive predator, thus it has excellent adaptability (Teristiandi and Riyanto 2021). Neurothemis ramburii nymphs can also endure environmental changes and water salinity. (Hasanah, Rohman, and Susanto 2021). Dragonflies are a very good indication of environmental health, especially in terms of water quality in a region.(Semiun et al. 2023).

It is even known that certain species have sensitivity to environmental changes, or otherwise only live in polluted areas (Rachmawati et al. 2023). Dragonflies also have another natural role as predators of small insects that disrupt agriculture. The dragonflies seen in the observation area suggest that the region is relatively dry and beginning to undergo disruptions. Dragonflies of the suborder Zygoptera are frequently observed in the streams near observation locations and in the grass of rice fields. The study results revealed that the Agriocnemis femina dragonfly was only found along Route 1, one of the grassy areas. In the low category, dragonfly species had a Shannon-Winner diversity index of 1.24. A community has low diversity if the community is composed of few species (Pongen 2024)

5.5 Lepidoptera (Butterflies)

Butterflies provide several ecological services in an ecosystem, including pollination and environmental bioindicators. Butterflies have a deep relationship to plants and serve as bioindicators of environmental quality.(Chowdhury et al. 2023). Butterflies are also indicators of air pollution, as a result, butterflies are frequently found in cool regions with low pollution (Parikh, Rawtani, and Khatri 2021)

Table 6: List of lepidoptera identified at the study location

No	Familia	Scientific name	Local name	IUCN	CITES	UU
1	Hesperiidae	*Borbo cinnara*	Kupu-kupu padi.	*NA*	Not listed	No
2	Hesperiidae	*Iambrix salsala*	Kupu-kupu lembu	*NA*	Not listed	No
3	Hesperiidae	*Matapa aria*	Kupu-kupu ular	*NA*	Not listed	No
4	Hesperiidae	*Notocrypta paralysos*	Kupu-kupu langit	*NA*	Not listed	No
5	Hesperiidae	*Parnara sp*	Kupu-kupu rumput	*LC*	Not listed	No
6	Hesperiidae	*Potanthus ganda*	Kupu-kupu pelipisan	*NA*	Not listed	No
7	Lycaenidae	*Catochrysops strabo*	Kupu-kupu biru kecil	*LC*	Not listed	No
8	Lycaenidae	*Chilades pandava*	Kupu-kupu biru pandan	*LC*	Not listed	No
9	Lycaenidae	*Jamides celeno*	Kupu-kupu biru gelap	*NA*	Not listed	No
10	Lycaenidae	*Miletus boisduvali*	Kupu-kupu kunir	*NA*	Not listed	No
11	Lycaenidae	*Spalgis epius*	Kupu-kupu tengkek	*NA*	Not listed	No
12	Nymphalidae	*Cupha erymanthis*	Kupu-kupu perang	*NA*	Not listed	No
13	Nymphalidae	*Discophora sondaica*	Kupu-kupu sonda	*NA*	Not listed	No
14	Nymphalidae	*Doleschalia bisaltide*	Kupu-kupu nyonya	*NA*	Not listed	No
15	Nymphalidae	*Euploea mulciber*	Kupu-kupu raja	*NA*	Not listed	No
16	Nymphalidae	*Euploea sp.*	Kupu-kupu raja	*LC*	Not listed	No
17	Nymphalidae	*Ideopsis juventa*	Kupu-kupu biru	*NA*	Not listed	No
18	Nymphalidae	*Junonia erigone*	Kupu-kupu mata satu	*NA*	Not listed	No
19	Nymphalidae	*Junonia hedonia*	Kupu-kupu bintik	*NA*	Not listed	No
20	Nymphalidae	*Junonia iphita*	Kupu-kupu labeo	*NA*	Not listed	No
21	Nymphalidae	*Melanitis leda*	Kupu-kupu hitam	*LC*	Not listed	No
22	Nymphalidae	*Melanitis zithenius*	Kupu-kupu petang	*NA*	Not listed	No
23	Nymphalidae	*Mycalesis horsfieldii*	Kupu-kupu bulat	*NA*	Not listed	No
24	Nymphalidae	*Neptis hylas*	Kupu-kupu padu	*LC*	Not listed	No
25	Nymphalidae	*Orsotriaena medus*	Kupu-kupu raja	*NA*	Not listed	No
26	Nymphalidae	*Phalantha phalantha*	Kupu-kupu pelipisan	*NA*	Not listed	No
27	Nymphalidae	*Polyura hebe*	Kupu-kupu kapak	*NA*	Not listed	No
28	Nymphalidae	*Tanaecia palguna*	Kupu-kupu rempah	*NA*	Not listed	No
29	Nymphalidae	*Ypthima horsfieldii*	Kupu-kupu cacing	*NA*	Not listed	No
30	Nymphalidae	*Ypthima pandocus*	Kupu-kupu cacing	*LC*	Not listed	No
31	Papilionidae	*Graphium agamemnon*	Kupu-kupu raja	*LC*	Not listed	No
32	Papilionidae	*Papilio memnon*	Kupu-kupu raja hitam	*LC*	Not listed	No
33	Papilionidae	*Papilio polytes*	Kupu-kupu raja hijau	*LC*	Not listed	No
34	Pieridae	*Catopsilia pomona*	Kupu-kupu kunir	*LC*	Not listed	No
35	Pieridae	*Eurema blanda*	Kupu-kupu kuning	*NA*	Not listed	No
36	Pieridae	*Eurema hecabe*	Kupu-kupu kuning kecil	*LC*	Not listed	No
	Indeks Keaekaragaman (H') : 3,26					

Information:

The IUCN red list category is low risk (least concern, LC)

The survey findings showed 122 butterflies from 36 different families: Nymphalidae (19 kinds), Hesperiidae (6 types), Lycaenidae (5 types), Papilionidae (3 types), and Pieridae (3 types). Papilionidae has the fewest individuals, followed by Pieridae, Hesperiidae, and Lycaenidae. Meanwhile, the Nymphalidae is the butterfly family with the most members and species. The Nymphalidae family is a member of the Rhopalocera suborder with the biggest number of species in comparison to other families. (Kirton 2021). Butterflies from members of the Nymphalidae family are polyphagous so they are easier to adapt and are found in various types of habitat (Mallick 2023).

The type of Nymphalidae butterfly with the most abundant number of individuals is Cupha erymanthis (14 individuals) followed by Ypthima horsfieldii (11 individuals). This is related to the discovery of *Flacourtia* which is the host plant or food for the larvae of the *Cupha erymanthis* (Nitin et al. 2018). Based on data collection, the *Flacourtia indica* plant species is quite easy to find throughout the survey area. Likewise, Ypthima horsfieldii is quite easy to find due to the dominance of Poaceae throughout the survey area.

The analysis of diversity factors in the survey region yielded a species diversity index value of H'=3.26. This number falls into the high diversity category, suggesting that the butterfly community in the survey region is stable or does not have a dominant species. The study region has a high butterfly diversity value due to the variety of ecological conditions. The presence of varying light exposure and a variety of flowering plants that provide food for butterflies is likely to contribute to the high diversity value attained.. The types of plants used to feed butterflies include *Lantana camara, Stachytarpheta jamaicensis*, and various types from the Asteraceae family. Like the shaded area on route 2, it is favored by several types of butterflies in the Nymphalidae family such as *Melanitis leda*, *Mycalesis horsfieldii* and *Discophora sondaica*. Meanwhile, another route with abundant light exposure supports butterflies - with their nature as poikilothermic animals - carrying out sunbathing or basking activities to increase their body temperature. (Hasanah, Rohman, and Susanto 2021)(Rohman et al., 2019).

5.6 Avifauna (Birds)

The avifauna study identified 391 individuals from 29 bird species. These birds belong to 17 different families. Cuculidae, Nectariniidae, and Pycnonotidae are the families with the most species, each having three. Apodidae has the most members, with 118, followed by Estrildidae (110), and Cisticolidae (35). The type and coverage of horizontal vegetation are critical for the avifauna. Vegetation destruction causes various species of avifauna to become endangered as the components that can sustain them as a place to live and a source of food for various types of avifauna diminish. The existence of insect-eating bird species in the research region, as well as the ecology of teak woods that are ideal for insect habitat, tend to attract insects, which in turn draw the attention of birds that devour them. As a result, it is not unexpected that the researched plant species host a large number of insectivorous members of the Cuculidae and Apodidae families.

Table 7: Types of avifauna identified in the study area

No	Familia	Scientific name	Local name	IUCN	CITES	UU
1	Accipitridae	*Spilornis cheela*	Elang-ular Bido	LC	II	Yes
2	Aegithinidae	*Aegithina tiphia*	Cipoh Kacat	LC	Not listed	No
3	Alcedinidae	*Halcyon cyanoventris*	Cekakak Jawa	LC	Not listed	No
4	Alcedinidae	*Todiramphus chloris*	Cekakak sungai	LC	Not listed	No
5	Apodidae	*Apus nipalensis*	Kapinis Rumah	LC	Not listed	No
6	Apodidae	*Collocalia linchi*	Walet Linci	LC	Not listed	No
7	Ardeidae	*Bubulcus ibis*	Kuntul kerbau	LC	Not listed	No
8	Cisticolidae	*Cisticola juncidis*	Cici padi	LC	Not listed	No
9	Cisticolidae	*Orthotomus ruficeps*	Cinenen Kelabu	LC	Not listed	No
10	Cisticolidae	*Orthotomus sutorius*	Cinenen Pisang	LC	Not listed	No
11	Cisticolidae	*Prinia inornata*	Perenjak padi	LC	Not listed	No
12	Columbidae	*Geopelia striata*	Perkukut jawa	LC	Not listed	No
13	Columbidae	*Spilopelia chinensis*	Tekukur Biasa	LC	Not listed	No
14	Columbidae	*Treron vernans*	Punai Gading	LC	Not listed	No
15	Cuculidae	*Cacomantis merulinus*	Wiwik Kelabu	LC	Not listed	No
16	Cuculidae	*Cacomantis variolosus-sepulcralis*	Wiwik Uncuing	LC	Not listed	No
17	Cuculidae	*Phaenicophaeus curvirostris*	Kadalan Birah	LC	Not listed	No
18	Dicaeidae	*Dicaeum trochileum*	Cabai Jawa	LC	Not listed	No
19	Estrildidae	*Lonchura leucogastroides*	Bondol Jawa	LC	Not listed	No
20	Estrildidae	*Lonchura maja*	Bondol Haji	LC	Not listed	No
21	Hemiprocnidae	*Hemiprocne longipennis*	Tepekong Jambul	LC	Not listed	No
22	Hirundinidae	*Cecropis daurica*	Layang-layang Loreng	LC	Not listed	No
23	Hirundinidae	*Hirundo javanica*	Layang-layang Batu	LC	Not listed	No
24	Hirundinidae	*Hirundo rustica*	Layang-layang Asia	LC	Not listed	No
25	Nectariniidae	*Anthreptes malacensis*	Burung-madu Kelapa	LC	Not listed	No
26	Nectariniidae	*Arachnothera robusta*	Pijantung Besar	LC	Not listed	No
27	Nectariniidae	*Cinnyris jugularis*	Burung-madu Sriganti	LC	Not listed	No
28	Pellorneidae	*Malacocincla sepiaria*	Pelanduk Semak	LC	Not listed	No
29	Phasianidae	*Gallus varius*	Ayam-hutan Hijau	LC	Not listed	No
30	Picidae	*Dendrocopos analis*	Caladi Ulam	LC	Not listed	No
31	Picidae	*Dinopium javanense*	Pelatuk Besi	LC	Not listed	No
32	Pycnonotidae	*Pycnonotus aurigaster*	Cucak Kutilang	LC	Not listed	No
33	Pycnonotidae	*Pycnonotus goiavier*	Merbah Cerukcuk	LC	Not listed	No
34	Pycnonotidae	*Rubigula dispar*	Cucak Kuning	VU	Listed II	No
35	Rhipiduridae	*Rhipidura javanica*	Kipasan Belang	LC	Not listed	Yes
36	Sturnidae	*Acridotheres javanicus*	Kerak kerbau	VU	Listed II	No
	Diversity index (H')= 2,52					

Source: Primary Data, 2023

The Javanese Bondol *(Lonchura leucogastroides*) has the largest population among the studied bird species, with 109 individuals, while the Linci Swallow (*Collocalia linchi*) follows with 72. The Javanese Bondol is a resilient bird that thrives in disturbed, created, or artificial ecosystems, as well as in residential areas, both urban and rural, living alongside humans. In contrast, the Linci Swallow inhabits a variety of environments across Java and Bali, ranging from open coastal regions to dense mountainous forests (Kurnia et al. 2021).

These two species of birds typically migrate in small to big flocks, both varieties are prevalent, having large populations and widespread distribution. The bird species diversity index in this study falls within the middle group (H'=2.52). This suggests that the avian community in the study region is rather stable. This is due to the area's relatively high species richness, which includes 29 bird species, yet particular species, such as the Javan Bondol and the Linci Swallow, continue to dominate.

5.7 Mamalia

Mammals perform important functions in ecology as carnivores (predators), herbivores, or omnivores, thereby contributing to the food chain and maintaining environmental balance, predators help manage prey animal populations, and herbivores change plant patterns, thereby impacting forests and flora (Lacher Jr et al. 2019). Based on visual monitoring findings using the Site Count method, only one family was found, namely Tupaiidea, while outside the observation location Sciuridea and members of the suborder Megachiroptera were found but they were not classified at family level. Two members of the Tupaiidea family were discovered at the observation location, the Kekes Squirrel (*Tupaia javanica*), and three members of the Sciuridae family, the Coconut Squirrel (*Callosciurus notatus*). *Tupaia javanica* and *Callosciurus notatus* consume fruit and seeds, which aid in the proliferation of plants. Both may be found in a variety of environments, including lowland woods, mountain forests, gardens, and urban areas, and they are quite adaptable to the human environment.(Kwatrina et al. 2023).

5.8 Herpetofauna

Herpetofauna is a category of vertebrate creatures that includes amphibians and reptiles. . The habitats and lifestyles of amphibians and reptiles are said to be comparable. Herpetofauna are crawling creatures whose body temperature is determined by the temperature of their surroundings, often known as poikilotherms. In addition, these animals have an exothermic metabolism. (Muia 2023). Herpetofauna is relatively significant in the ecosystem, serving as a component of the food chain and contributing to ecological stability. Herpetofauna play a vital role in the food chain and serve as environmental bioindicators (Velasco et al. 2024).

According to observations, the garden lizard (*Eutropis multifasciata*) was the most prevalent herpetofauna (32 individuals). This lizard is commonly found in warm-weather plantation areas. This lizard's characteristic activity is sunbathing or basking. Sunbathing is essential for the survival of ectothermic species, particularly lizards, because their body temperature is heavily impacted by the ambient temperature (Gaudenti et al. 2021) The availability of insects also impacts the number of actions detected in these lizards, because insects are their food source. Table 8 is the herpetofauna types identified in the study area, is follow :

Table 8: The herpetofauna types identified in the study area

No	Familia	Scientific name	Local name	IUCN	CITES	UU
1	Agamidae	*Bronchocela cristatella*	Bunglon Jambul Hijau	LC	Not listed	No
2	Agamidae	*Draco volans*	Cicak Terbang	LC	Not listed	No
3	Colubridae	*Dendrelaphis pictus*	Ular Tampar	LC	Not listed	No
4	Colubridae	*Gonyosoma oxycephalum*	Ular Bajing	LC	Not listed	No
5	Dicroglossidae	*Occidozyga sumatrana*	Bencet Rawa	LC	Not listed	No
6	Gekkonidae	*Gecko gecko*	Tokek	LC	Listed II	No
7	Gekkonidae	*Hemidactylus frenatus*	Cicak Kayu	LC	Not listed	No
8	Gekkonidae	*Hemidactylus garnotii*	Cicak Rubah	LC	Not listed	No
9	Microhylidae	*Microhyla palmipes*	Percil Berselaput	LC	Not listed	No
10	Ranidae	*Chalcorana chalconota*	Kongkang Kolam	LC	Not listed	No
11	Rhacophoridae	*Polypedates leucomystax*	Katak Pohon Bergaris	LC	Not listed	No
12	Scincidae	*Eutropis multifasciata*	Kadal Kebun	LC	Not listed	No
13	Scincidae	*Eutropis rugifera*	Kadal Serasah Bergaris	LC	Not listed	No
14	Scincidae	*Lygosoma quadrupes*	Kadal-ular Kecil	LC	Not listed	No
15	Scincidae	*Subdoluseps bowringii*	Kadal-pasir Bowring	LC	Not listed	No
	Diversity index (H')= 2,07					

Source: Primary Data, 2023

Another variety that is frequently observed at observation sites is Eutropis jasafera, which may be found along all observation routes. During observations, E.rugifera was frequently detected in leaf litter. *E.rugifera*, also known as the striped litter lizard, lives in litter habitats where it preys on tiny arthropods. It also climbs approximately 1-2 meters in the bushes and is active throughout the day (Amarasinghe et al. 2021).

The existence of amphibians in an environment is closely related to the presence of water. Amphibians need water to complete the metamorphosis cycle and become adults (Liedtke, Wiens, and Gomez-Mestre 2022). This research found four types of amphibians in very low numbers due to the arid environment of the observation area and the lack of water sources nearby. This also has an impact on the Shannon-Wienner diversity index in herpetofauna taxa which is classified as moderate (H'=2.07). The absence of water bodies and dry substrate conditions indicate minimal presence of amphibians..

5.9 Important species have been identified.

In the research location, two protected species of eagles were found: the Kipasan Eagle (*Rhipidura albiscapa*) and the Bido Snake Eagle (*Spilornis cheela*). The Kipasan Eagle is protected due to hunting pressure that has led to a decline in its population, while the Bido Snake Eagle is protected because of its important role as a top predator in maintaining the balance of the food chain. Although both are raptors, they are not endemic species and can be found in various habitats across Java. Like other birds, the Bido Snake Eagle and Kipasan Eagle can adapt to different environments as long as there is sufficient food and nesting sites.

The Kipasan Eagle (*Rhipidura albiscapa*) is a small bird (11.5-21 cm long) with a tail that is longer than its wings. When the tail is folded, the tip is rounded; however, when it is spread out or when foraging in the air, the tail takes on a distinctive fan shape, which gives rise to the family name (Sotnychuk 2021). The Bido Snake Eagle (*Spilornis cheela*) is a large eagle found in the research location, with a range extending from India in the west to Nepal and Sri Lanka, then east to China, south through Southeast Asia, the Malay Peninsula, the Greater Sunda Islands, and finally Palawan in the Philippines. This eagle belongs to the Accipitridae family. The primary prey of the Bido Snake Eagle includes small snakes, birds, and mammals such as mice (Damayanti, Marhaento, and Poedjirahajoe 2022). Additionally, two avifauna taxa are classified as vulnerable (VU): the yellow cucak (*Rubigula dispar*) and the buffalo lizard (*Acridotheres javanicus*). Both are vulnerable and need conservation due to overharvesting for use as songbirds. While the yellow cucak is relatively common in the research location, the buffalo lizard is harder to find. The presence of these two species is quite natural, considering that teak forests provide an ideal habitat for insect-eating birds like them (Lubis 2017).

Based on flora indicators, Mahogany (*Swietenia macrophylla*), Teak (*Tectona grandis*), and Sono Keling (*Dalbergia latifolia*) are popular production plants that have experienced overharvesting, resulting in a decline in their populations, according to IUCN statistics. Teak is classified as at risk, indicating that it is more likely to become endangered compared to other species. Nevertheless, its use as a production wood allows Teak and other timber species to continue thriving, making them a common feature in the lowland forests of Java.(Pavitt et al. 2021)

6. Conclusions

Plants are the most diverse taxon (66 species), followed by avifauna and lepidoptera (36 species each), herpetofauna (15 species), odonata (7 species), and mammals (4 species). Important plant taxa discovered during this inquiry include *Tectona grandis, Swietenia macrophylla, Dalbergia latifolia, and Didymoplexis pallen. Spilornis cheela, Riphidura javanica, Pycnonotus melanicterus, Acridotheres javanicus, Tupaia javanica, and Gecko gecko* are among the most common species encountered. The diversity index, especially for mammals, cannot be calculated because the number of species observed does not meet the requirements of the Shannon-Wienner diversity calculation.

The main recommendation is to manage and monitor the impact of the toll road development plan on biodiversity based on the analysis of flora and fauna. Some portions of the studied teak forest (tectona grandis) will need to be cleared; however, the fauna in the area is considered safe, as no species rely on a specific environment. To mitigate the impact of land clearing, replanting efforts should be implemented. Recommended species for replanting include: *Ficus spp*. Mahogany (*Swietenia macrophylla*) sono keling (*Dalbergia latifolia*) teak (*Tectona grandis*). These species were chosen based on their dominance in the area and their suitability for the natural habitats of local wildlife. This approach not only aids in ecosystem recovery but also ensures that biodiversity in the region is preserved during and after development. Additionally, ongoing monitoring should be conducted to assess the success of the replanting efforts and the health of the fauna following construction. Engaging local communities in these efforts can also enhance conservation outcomes and promote sustainable practices.

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