BIODIVERSITAS
Volume 24, Number 12, December 2023
Pages: 6836-6843

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d241244

Amphibian community structure in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia

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Manuscript received: 25 August 2023. Revision accepted: 28 December 2023.

Abstract. *Tanjung RD, Kusrini MD, Mardiastuti A, Yustian I, Setiawan A, Iqbal M. 2023. Amphibian community structure in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia. Biodiversitas 24: 6836-6843.* Amphibian community structures in Isau-Isau Wildlife Reserve, South Sumatra, were investigated from Mei until July 2023. The data were obtained by Visual Encounter Survey combination with line transect. The data analyzed were Species Richness (Margalef Index), Diversity Index (H', Shannon-Wiener), Dominance (D, Simpson Index), and Evenness Index (J', Pielou) calculated using PAST 4.0 software. In addition, we also analyzed abiotic factors such as air temperature, humidity, water temperature, pH, total dissolved solids (TDS), and dissolved oxygen (DO). The abiotic data were included as explanatory variables in Canonical Correspondence Analysis (CCA). A total of 12 amphibian species consisting of 11 genera and 4 families were recorded. Of them, 11 species are classified as least concern, while one species, *Theloderma licin*, is classified as data deficient by the IUCN Red List of Threatened Species.

Keywords: Abiotic factors, amphibians, community structure, Isau-Isau Wildlife Reserve, several land-use

INTRODUCTION

Amphibians are highly sensitive to environmental degradation, with approximately 41% of known species threatened with extinction globally (IUCN 2021). Amphibians are known to play a role in the food chain as consumers, predators, prey, and bioindicators of environmental conditions (Hocking and Babbit 2014; Kanagavel et al. 2017; Carlsson and Tydén 2018; Priambodo et al. 2019). Therefore, their presence in nature cannot be ignored, and the conservation of species and their habitats should be prioritized. Gillespie et al. (2015) revealed that different habitat conditions have implications for differences in amphibian community composition because each amphibian species responds differently to changes in existing environmental conditions. In amphibian habitats, heterogeneity affects amphibian species richness (Luja et al. 2017). Habitat heterogeneity can provide amphibian species with quantitative information on different vegetation types related to food resources, space, and microhabitat types (Badillo-Saldaña et al. 2016). However, habitat heterogeneity can be disrupted by human activities through pollution, degradation, and land use change (e.g., deforestation), leading to cascading effects on amphibian communities such as taxonomic homogenization and decreased species richness (Berriozabal-Islas et al. 2018).

Many studies have shown that even in disturbed areas, such as rice fields, the potential to discover new species is still very high (e.g., Veith et al. 2001; Riyanto and Kurniati 2014). In addition, several studies have demonstrated the impact of forest conversion on amphibian communities (Wanger et al. 2010), where the results clearly show that forest conversion has a direct impact on amphibian populations due to their sensitivity to land use change. For amphibians, forest cover is essential for their survival. Increased land use change also correlates with changes in environmental conditions, such as temperature and humidity, and makes many species, including amphibians, more vulnerable to population declines (Muslim 2017).

Land use changes into several types of land use have occurred in Sumatra, one of which is in South Sumatra Province. South Sumatra is a province in Indonesia located on the island of Sumatra with a population of around 8 million. Its total area is about 9.2 million hectares, of which 3.4 million hectares are forest areas and 1.3 million hectares are peatlands. According to Pagiola (2000), more than 19 million hectares of forest have been lost from the region in that time, including 6.7 million hectares in Sumatra. Land use change into several types of land use has occurred in many areas, one of which is around the Isau-Isau Wildlife Reserve (SM) in South Sumatra Province. Isau-Isau Wildlife Reserve has an area of 16,742.92 ha, which is administratively located between Lahat Regency and Muara Enim Regency, South Sumatra Province (BKSDA Sumsel 2020). The area is threatened by illegal logging and illegal agricultural plantations within the protected area. As the human population around the area increases and the local environment changes, the pressure on the landscape increases (Prasetyo et al. 2014). Various forms of land use in the Isau-Isau Wildlife Reserve Area, which can be assumed to represent several conditions of vegetation succession, can be an interesting research location to study the response of amphibians to habitat changes, and in the Isau-Isau Wildlife Reserve Area and its surroundings, most of them have been converted into plantation areas, and anthropogenic activities which will directly or indirectly affect the structure and composition of the animals contained therein including one of them amphibians.

The only publication on amphibians in Isau-Isau Wildlife Reserve was published by Yustian et al. (2023). They only reported the occurrence of *Theloderma licin* at Isau-Isau as the fourth record in Sumatra. Therefore, it is important to conduct this study in the area, as it is crucial for conservation areas to have faunal data. Appropriate conservation strategies can only be carried out if the basic data used as a reference (e.g. biology, habitat, ecology, population, and distribution) for the species are complete (IUCN 2019). This research is expected to provide information on amphibian community structure in the area. The information obtained can also be used as supporting data for designing amphibian habitat conservation strategies in Isau-Isau Wildlife Reserve. This study was conducted to determine the composition and structure of amphibian communities in various types of land use in the Isau-Isau Wildlife Reserve, South Sumatra.

MATERIALS AND METHODS

Study area

The survey was conducted from May to July 2023 in Isau-Isau Wildlife Reserve, South Sumatra (Figure 1). We collected data on amphibians in several land use types around Isau-Isau Wildlife Reserve, namely primary Dryland Forest (PF), Secondary dryland Forest (SF), Mixed Farmland (MF), Rice Fields (RF), and Settlements (SM) (Figure 2). Our focus in this study was on riparian habitats found in each land use type in the location.

Vegetation in Isau-Isau Wildlife Reserve

We recorded some vegetation found in the primary dryland forest, including giant lotus (*Raflessia arnoldii* R.Br.), rattan, caladium (*Caladium* sp.), meranti (*Shorea* sp.), kayu pasang (*Lithocarpus* sp.), beringin (*Ficus* sp.), bamboo, medang (*Litsea* sp.). In secondary dryland forests, the vegetation were durian (*Durio* sp.), coffee (*Coffea* sp.), kecombrang (*Etlingera elatior* (Jack) R.M.Sm.), cinnamon (*Cinnamomum burmannii* (Nees & T.Nees) Blume), orange (*Citrus* sp.), babandotan (*Ageratum conyzoides* L.), ketapang (*Terminalia catappa* L.) and petai (*Parkia speciosa* Hassk.). For mixed farmland, there are coffee plants (*Coffea* sp.), durian (*Durio* sp.), sahang (*Piper nigrum* L.). While in settlement locations, the vegetation is coffee plants (*Durio* sp.), oil palm plants (*Elaeis guineensis* Jacq.), and vegetables. The rice fields chosen for our research were in the villages of Tanah Abang, Pagar Agung, and Lawang Agung because of the less difficult access and advice from the staff of Resort IX Isau-Isau.

Procedures

Data collection

In this study, we used the Visual Encounter Survey (VES) method combined with line transects in each riparian area in the land use types (primary dryland forest, secondary dryland forest, mixed farmland, rice fields, and settlements) in Isau Wildlife Reserve. Referring to Kusrini (2019), the Visual Encounter Survey (VES) method can estimate relative richness, abundance, and compile a list of species in an area.

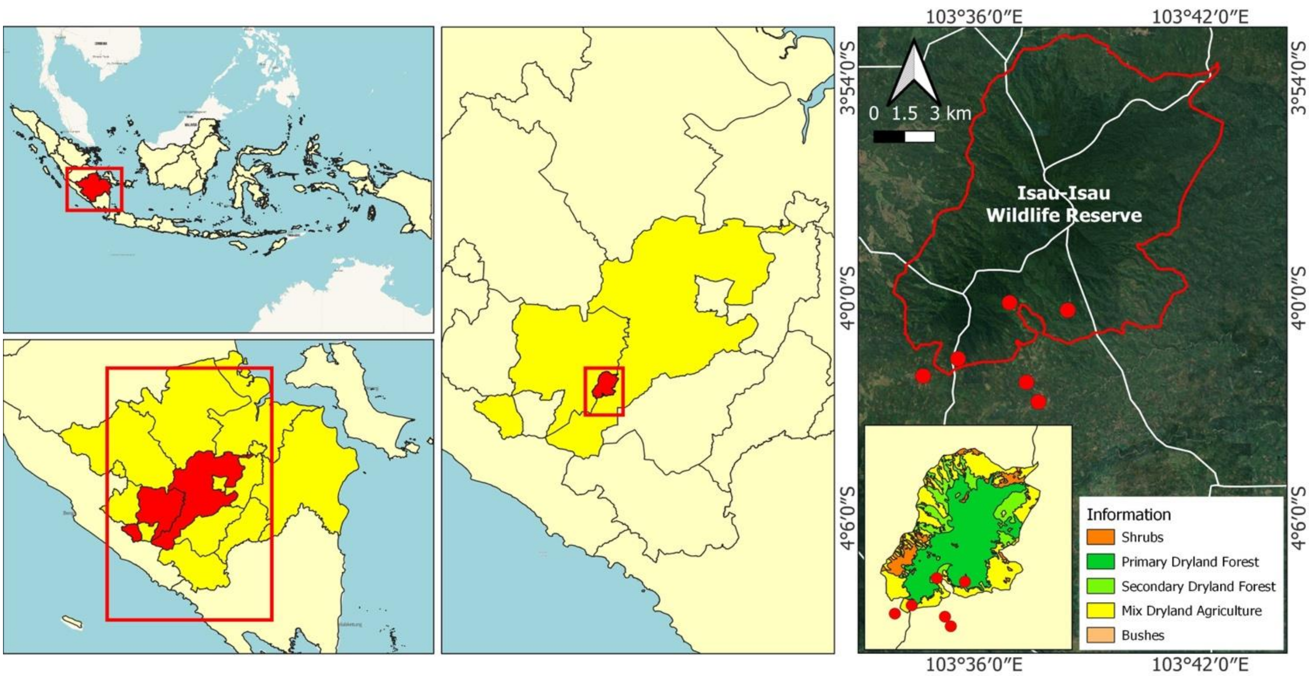

Figure 1. Location of Isau-Isau Wildlife Reserve, South Sumatra, Indonesia

Figure 2. Sample land-use type in Isau-Isau Wildlife Reserve and the surrounding, South Sumatra, Indonesia. Note: A. Primary dryland forest; B. Secondary dryland forest; C. Mixed farmland; D. Settlement, E. Rice fields

We focused our observation transect lines on riparian areas found in the land use types of primary dryland forest, secondary dryland forest, mixed farmland, rice fields, and settlements. We made 2 transect lines that were 400 m long, with each left and right edge of the line 3 m apart for each land use type. Each line was marked using GPS and marking tape. Each line will be repeated twice. Here, we emphasize that the focus of data collection was on riparian habitats because these habitats are important for many amphibian species as they provide suitable conditions (e.g., high ambient humidity) for reproduction and maintenance of their populations. In addition, riparian habitats provide food and shelter for amphibians (Boissinot et al. 2015).

Sampling was carried out by visiting the observation path at night with two repetitions for each path in each land use type. Observations were carried out at 19.00-23.00 WIB. Observations started from the zero point of the track and focused on places suspected of being nests or hiding places for amphibians, such as tree branches, under rotten logs, between tree roots, in rock crevices, in soil holes, under piles of garbage, or on riverbanks. Everything caught on the observation track was bagged and recorded. Data recorded included species name, weight, SVL (Snout Vent Length), coordinates, time of discovery, activity, and abiotic factors data (dissolved oxygen (DO), humidity, total dissolved solids (TDS), water temperature, and water pH). For abiotic factors, we measure dissolved oxygen with DO meter (Lutron DO-5510), humidity and water temperature with thermohygrometer (Hanna Instrument HI 9564), total dissolved solids with TDS meter (Hanna Instrument), and water pH with pH meter (Lutron PH-207HA). In addition, photo documentation was also conducted using a camera (Canon EOS 1500D).

Species identification

Data obtained was entered into a tally sheet, and unidentified species were sampled for further identification. Specimens encountered were captured by hand, their location recorded and then documented for individual identification. Unidentified species were preserved for further identification using 70% alcohol. After measurement and documentation, non-preserved amphibians were released back to their original location. Field identification of amphibians was carried out using the Field Guide to Amphibians and Reptiles in the Batang Toru Forest Area by Kamsi et al. (2017). The naming of amphibian species refers to the Amphibian Species of the World (Frost 2023).

Data analysis

We categorized amphibian species by family and reported their conservation status based on the IUCN Red List of Threatened Species. The data analyzed were species richness (Margalef Index), the Diversity Index (H', Shannon-Wiener), Dominance (D, Simpson Index), and Evenness Index (J', Pielou) calculated using PAST 4.0

software. In addition, we also analyzed abiotic factors such as air temperature, humidity, water temperature, pH, total dissolved solids (TDS), and dissolved oxygen (DO) were included as explanatory variables in Canonical Correspondence Analysis (CCA).

RESULTS AND DISCUSSION

Species diversity of Amphibians in Isau-Isau Wildlife Reserve

This study found a total of 60 individuals, including 12 species, 11 genera, and 4 families (Figure 3; Table 1). The number of amphibian species found in this study is similar to the previous study conducted in the South Sumatra Province, which found 11 amphibian species in Gunung Raya Wildlife Reserve, South Sumatra (Yulistio et al. 2022). The highest number of individuals was the Family Dicroglossidae (27 individuals; 45%), with the species composition were *Fejervarya limnocharis* (10%), *Fejervarya cancrivora* (23.3%), *Occidozyga sumatrana* (6.7%) and *Limnonectes blythii*. (5%). The Rhacophoridae family had a total of 9 individuals (15%), with species composition of *Polypedates leucomystax* (6.7%), *Rhacophorus achantharrhena* (3.3%), and *T. licin* (5%). Meanwhile, the Bufonidae family has a total of 23 individuals (38.3%) with a species composition of *Phrynoidis aspera* (20%), *Duttaphrynus melanostictus* (10%), *Ingerophrynus bipocartus* (5%), and *Leptophryne borbonica* (3.3%). The lowest number of individuals is the Ranidae family, consisting of 1 individual (1.7%) and one species, *Chalcorona chalconota*.

A total of 11 species are classified as least concern by the IUCN Red List of Threatened Species, while one species, *T. licin* (Figure 3.C), is classified as data deficient. By microhabitat type, the majority of terrestrial amphibians are Bufonidae (except *Phrynoidis asper*, which occurs in both aquatic and semi-aquatic habitats), the majority of aquatic amphibians are Ranidae and Dicroglossidae (e.g., *Limnonectes blythii*., *O. sumatrana*). Most amphibian species were found on rocks near streams, stream banks, sedimentation along stream banks, riparian vegetation along stream banks, and trails along stream sides. Many tadpoles of various species were found along the riverbank. Various frog species, such as *F. cancrivora* and *P. asper*, are still abundant (Table 1).

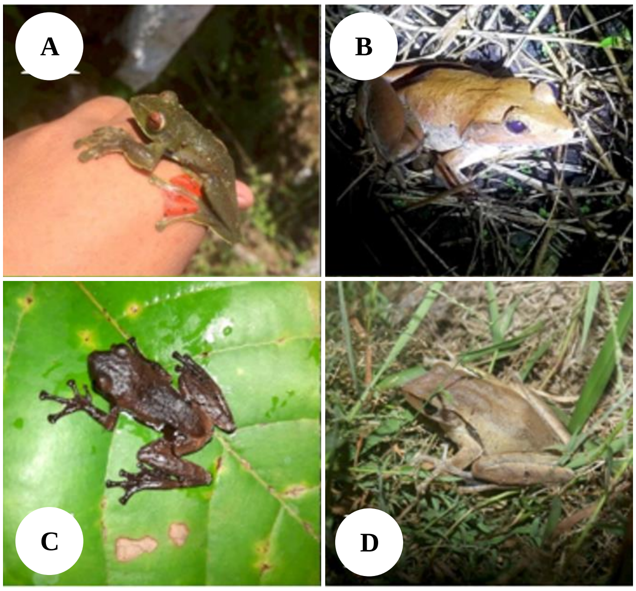

Figure 3. Amphibian species in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia. Note: A. *Rhacophorus achantharrhena*; B. *Limnonectes blythii*.; C. *Theloderma licin*; D. *Polypedates leucomystax*

Table 1. Amphibian species in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia

Species	Land-Use Type					RAI	CS	PM
	PF	SF	MF	RF	ST			
Bufonidae								
Duttaphrynus melanostictus (Schneider, 1799)	-	-	-	-	6	10	LC	T
Ingerophrynus biporcatus (Gravenhorst, 1829)	-	-	-	-	3	5	LC	T
Phrynoidis asper (Gravenhorst, 1829)	9	2	1	-	-	20	LC	AQ/S
Leptophryne borbonica (Tschudi, 1838)	2	-	-	-	-	3.3		S
Dicroglossidae								
Fejervarya cancrivora (Gravenhorst, 1829)	-	-	1	10	3	23.3	LC	H
Fejervarya limnocharis (Gravenhorst, 1829)	-	-	-	4	2	10	LC	S
Limnonectes blythii (Boulenger, 1920).	2	1	-	-	-	5.0	LC	AQ/S
Occidozyga sumatrana (Peters, 1877)	-	-	-	4	-	6.7	LC	AQ/S
Ranidae								
Chalcorana chalconota (Schlegel, 1837)	-	1	-	-	-	1.7	LC	AQ
Rhacophoridae								
Polypedates leucomystax (Gravenhorst, 1829)	-	2	2	-	-	6.7	LC	A
Rhacophorus achantharrhena (Harvey, Pemberton & Smith, 2002)	1	1	-	-	-	3.3	LC	A
Theloderma licin (McLeod & Ahmad, 2007)		2	-	-	-	5	DD	A/S

Note: RAI (Relative Abundance Index) in percentage value (%); CS: Conservation Status based on IUCN red list (LC: Least Concern, NT: Near Threatened); PM: Most Preferred Microhabitat (A: Arboreal; AQ: Aquatic; S: Semiaquatic; T: Terrestrial); PF: Primary dryland Forest; SF: Secondary dryland Forest; MF: Mix Farmland; RF: Rice Field; ST: Settlement

Community structure of Amphibian in Isau-Isau Wildlife Reserve

The highest percentage relative abundance was *F. cancrivora* (23.3%), followed by *P. asper* (20%) (Table 1). Differences in the abundance and number of amphibian species are caused by environmental conditions, including vegetation type, water quality, humidity, and temperature (Kurniawan et al. 2016). Temperature and humidity at the research site (Table 2) are still within the range suitable for amphibian life, 20-40°C and 40-100%, respectively (Karthik et al. 2018; Septiadi et al. 2018). In this study, the Secondary dryland Forest (SF) had the greatest species richness, followed by Primary dryland Forest (PF), Mixed Farmland (MF), Rice Fields (RF), and Settlements (ST) (Figure 4.A).

The highest Diversity Index (H') was found in the secondary dryland forest (1.70), while the lowest diversity was found in rice fields (1.00) (Figure 4.B). The evenness index is important because it can assess the abundance of each species in an evenly distributed community (Dutta and Mukhopadhyay 2013; Chatterjee and Mondal 2016). Based on the evenness index, the primary dryland forest land use type (had the lowest value, while the highest value was found in the mixed farmland land use type (Figure 4.C). However, the primary dryland forest land use type has the highest dominance index, followed by mixed farmland. The primary dryland forest sites are dominated by *P. asper* found along the riverbanks. Due to agricultural activities, *F. limnocharis* dominated the Rice Field (RF), as the rice field is a suitable habitat for this species and other dicroglosid frogs. As a result, the dominance index follows the opposite trend to the evenness index.

Relationship of amphibians diversity and environmental conditions

The abiotic factors in each study site can be seen in Table 2. The water temperature was 1-2°C lower than the ambient air temperature, which is normal. The pH of the water was neutral (6.59-7.62). Dissolved oxygen levels were found to be highest in the primary dryland forest and lowest in the residential area. Temperature and humidity at the research site are still within the range suitable for herpetofauna life, i.e., 20-40°C and 40-100%, respectively (Karthik et al. 2018; Septiadi et al. 2018).

The abundance of amphibians in the Isau-Isau Wildlife Reserve area is influenced by several factors. One of them is air temperature, which is a major factor for some amphibians, especially frogs (Ossen and Wassersug 2002). Temperature greatly affects metabolic processes, growth, and defense against disease. Temperature is also positively correlated with amphibian communication, which can support the success of the reproduction process. The amphibian species found are indirectly able to become bioindicators of an environment. *D. melanostictus* has a high level of resistance to several types of heavy metals. According to Shuhaimi-Othman et al. (2012), the tadpole phase of *D. melanosticus* has a high level of resistance to several heavy metals, such as Cu (Copper), Pb (lead), Zn (Zinc), Ni (Nickel), and Mn (Manganese). In this study, *D. melanostictus* was not found at all primary or secondary dryland forest land use types but was relatively abundant in residential areas. Disposing of household waste or agricultural waste that has not been properly treated makes this species cosmopolitan in these locations.

Canonical Correspondence Analysis (CCA) was applied to determine relationships among abiotic components, study sites, and amphibian species (Figure 5). The interpreted distance of specimens to sites and abiotic components illustrates the ecological distribution and preference of amphibians in choosing their habitat (Sasaki et al. 2005). Temperature, elevation, and humidity are abiotic components used to analyze the ecological distribution of amphibians in Isau-Isau Wildlife Reserve.

According to the CCA Analysis study of the inertia graph, axis 1 represents 46.01%, while axis 2 represents 29.88%. (Figure 5). Some amphibian species found in this study were associated with total dissolved solids (TDS), elevation, and humidity variables, namely *C. chalconota* in SF, *P. leucomystax, R. achantharrhena, L. barbonica, Limnonectes* sp., and *P. aspera* in PF. The changes in land cover and altitude affect herpetofauna communities because each species has a distribution range and preferred habitat (Wanger et al. 2010). Amphibian habitats are indirectly affected by changes in abiotic factors (water parameters and microclimate) (Khatiwada et al. 2019; Fulgence et al. 2022). Disturbances to riparian habitats in the study area may adversely affect amphibian communities as a result of various ecological issues identified as causing amphibian population declines, including pollution, habitat loss, habitat modification, fragmented habitats, and human exploitation of amphibians as food (Whittaker et al. 2013).

Table 2. Abiotic factors in each land use types of Isau-Isau Wildlife Reserve, South Sumatra, Indonesia

Abiotic factors		Land-use type				
		PF	SF	MF	RF	STM
Microclimate	Air temperature (°C)	21	23	23	21	24
	Relative humidity (%)	83	82	82	81	80
Water parameter	Temperature (°C)	19.6	20.5	21.5	21.0	22.1
	pH	6.78	6.59	7.62	6.78	6.78
	TDS (mg/L)	0.10	0.08	0.10	0.08	0.08
	DO (mg/L)	7.7	6.06	5.68	5.99	5.06

Note: PF: Primary dryland Forest; SF: Secondary dryland forest; MF: Mix farmland; RF: Rice field; STM: Settlement

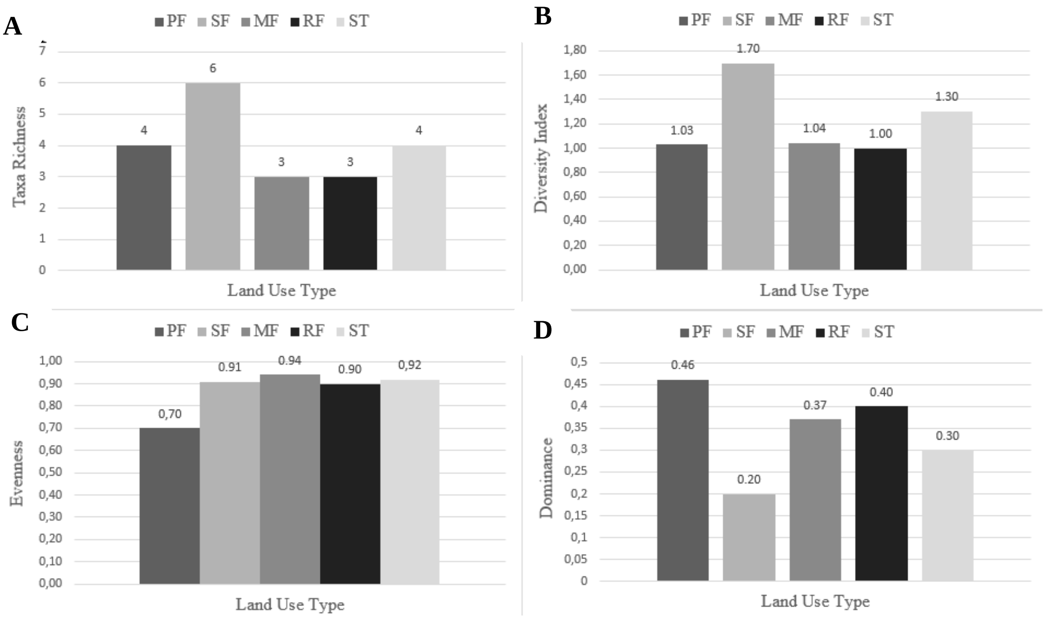

Figure 4. Diversity index and community structure of amphibian in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia: A. Taxa richness; B. Diversity Index; C. Evenness; D. Dominance

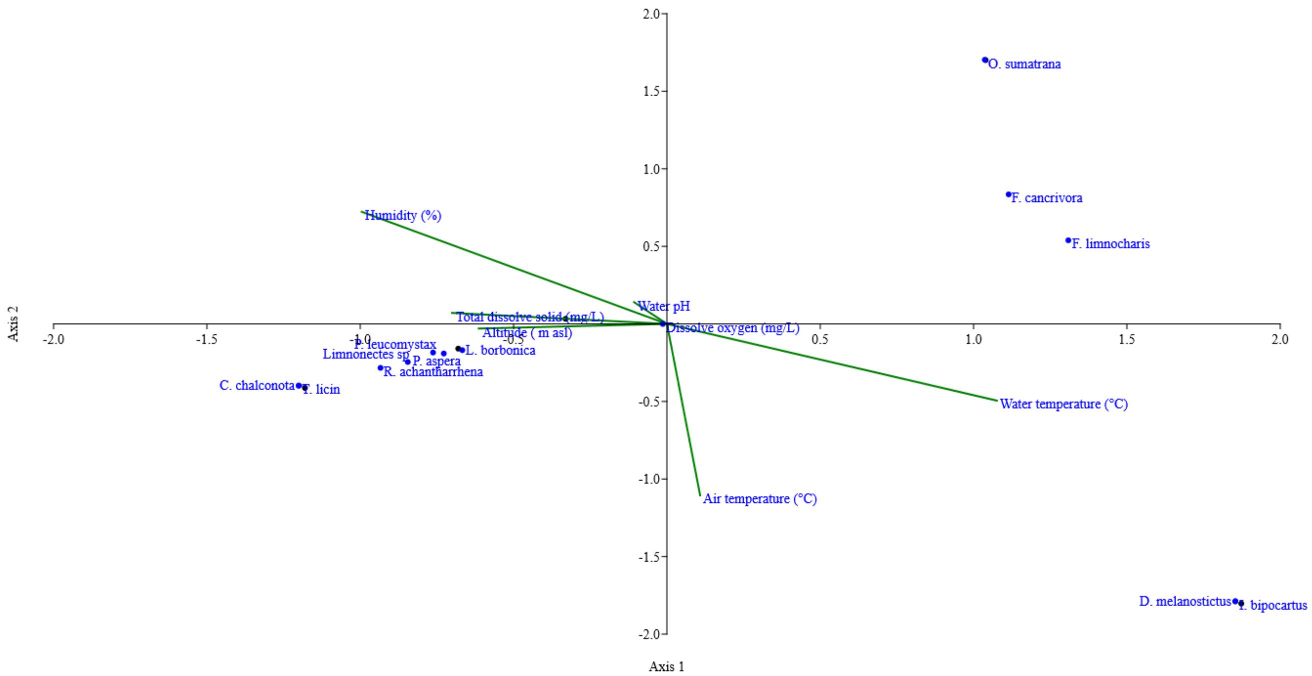

Figure 5. Canonical Correspondence Analysis (CCA) shows the relationship between the abiotic factor and amphibian species

Land cover and elevation changes can affect amphibian communities as each species has a preferred distribution and habitat (Wanger et al. 2010). Amphibian habitats are indirectly affected by changes in these abiotic factors (water and microclimate parameters) (Khatiwada et al. 2019; Fulgence et al. 2022). Disturbance to amphibian habitats can adversely affect amphibian communities due to various ecological issues identified as causes of amphibian population declines, including pollution, habitat loss, habitat modification, habitat fragmentation, road mortality, and human exploitation of amphibians for food. It should be noted that frogs are an important component of their ecosystem, serving as predators that control arthropod populations and as predators of reptiles and amphibians. If amphibian populations are reduced, it will affect food webs and ecosystems (Barnum et al. 2015).

Figure 6. Pesticides found at a coffee plantation in Isau-Isau Wildlife Reserve, South Sumatra, Indonesia

Several bottles of pesticides (Figure 6) were found in the research location. The pesticides were used by the community to spray their crop commodities, such as coffee plants. Pesticide exposure may play a key role in amphibian declines observed in agricultural landscapes (Mingo et al. 2016; Arntzen et al. 2017). In addition, amphibians are also exposed to pesticides in habitats adjacent to agricultural landscapes. For example, amphibians are exposed to pesticides during migration to and from spawning water. Pesticides can also be carried through overland flow or runoff into water bodies used by amphibians for breeding (Ockleford et al. 2018; Adams et al. 2021). In addition, amphibians are one of the wildlife species that depend directly on river conditions. Most of their life stages are associated with aquatic environments such as rivers, and any changes in river environment or quality will reflect changes in anuran diversity and community (Kopp et al. 2012).

To our knowledge, the conservation of frogs as bioindicators of environmental change has received little attention (West 2018), especially in Indonesia. In addition, amphibian research focuses on inventory and discovery of new species rather than applied ecology (Kurniawan et al. 2021; Kusrini et al. 2021). This research survey was limited by the size of the study site and the relatively short time frame, all of which pose future research challenges, including the study of frogs as non-target organisms exposed to agrochemicals and the ability of frogs to function as predators as biological control agents in agricultural habitats. Thus, community and government collaboration is essential to developing and implementing a comprehensive conservation strategy, particularly in the buffer zone of the area.

In conclusion, a total of 12 amphibian species consisting of 11 genera and 4 families were recorded in the Isau-Isau Wildlife Reserve. Of them, 11 species are classified as least concern, while one species, *Theloderma licin*, is classified as data deficient by the IUCN Red List of Threatened Species. This finding can be used as baseline data for further research, conservation activities, and management of the fauna of this wildlife reserve.

ACKNOWLEDGEMENTS

We thank the head of South Sumatera Natural Resources Conservation Center (BKSDA Sumsel) for facilitating our visit to Isau-Isau Wildlife Reserve. We thank Fikri, Ursal, Hendi, and all staff in the Regional Conservation Section (SKW III) Lahat and Resort IX Isau-Isau who have helped during the research. Thank you to Dr. Amir Hamidy for his input to the author.

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