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Research Article

Butterfly Diversity from Isolated Lowland Area: An Assessment in Langsa Urban Forest, Langsa, Aceh, Indonesia

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ABSTRACT
Langsa Urban Forest (LUF) is a 10-ha of the isolated urban forest in Langsa, Aceh, which is maintained to preserve urban biodiversity such as the butterfly. No recent study has been done in this area on butterfly biodiversity including the diversity and plant's potential for host and food plant sources. A one-month survey in July 2021 using the standard walk method on four transects was conducted. There are 36 species recorded during this study including 5 families, with Nymphalidae as the most abundant family and *Leptosia nina* as the most abundant species. Shannon-Wiener diversity index was used for this recent research with the value of H' 1.78–2.78 and the Evenness index with scale 0.66–0.94. Most of the species have broad geographical ranges, with 3 of them restricted to the Indomalayan realm. There are 117 plants were recorded which 33 species supposed as host and food plants divided into 26 as host plants, 11 as food plants, and 4 for both. No specific plants threatened the collected butterflies, but it's important since providing diversity data.

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INTRODUCTION
Butterflies (Papilionoidea) comprise *c.* 17,000 species worldwide, with *c.* 2,000 of them found in Indonesia (Peggie & Amir 2006), with all known 7 families occurring i.e Papilionidae, Hedylidae, Hesperidae, Lycaenidae, Nymphalidae, Pieridae and Riodinidae (Kawahara & Breinholt 2014; EOL 2022), and is the most studied group among insects (Panjaitan et al. 2020). Butterflies are very important in ecosystems because of their role in plants' pollination (Peggie & Amir 2006), and as a component of food webs. Meanwhile, the larvae are often categorized as pests (Nair et al. 2014; Panjaitan et al. 2020). Oftentimes, butterflies are appreciated for their beauty, and therefore, often used as a subject to optimize ecotourism (Subahar & Yuliana 2010; Kurnianto et al. 2016).

The presence of butterflies usually depends on the availability of plants (Curtis et al. 2015), either as host plants for larva to eat or as food plants for the adult butterfly to forage on (Subahar & Yuliana 2010), and

their interaction sometimes can be specific (New 1997; Peggie & Amir 2006). The more specific interaction, the more butterflies become susceptible to disturbances in the environment, so they can act as environment bioindicators (Swaay et al. 2012). Several studies have shown that butterfly diversity will increase with the high diversity of plants, whereas areas with low diversity of plants have low butterfly diversity (Vu et al. 2015; Widhiono 2015).

Langsa Urban Forest (LUF) is an isolated urban forest that is mainly used for ecotourism in Langsa, Aceh, the northernmost province in Sumatra. In general, biological explorations in this province are limited. Several studies on butterflies in Aceh have been carried out, for example, Banda Aceh (Alfida et al. 2016), Aceh Jaya (Yusuf et al. 2018), Aceh Besar (Akla et al. 2018), and Subulussalam (Suwarno et al. 2019), but no study dealing with butterflies has been done in Langsa Urban Forest (LUF). In this study, we investigate the diversity, host and food plants, distribution, also conservation of butterflies in LUF, an isolated urban forest on the eastern side of Aceh Province. The data from LUF is important to complete information about butterfly diversity in one of the poorly explored areas in Indonesia, and the conservation and development plan of LUF as ecotourism.

MATERIALS AND METHODS

Study Area

LUF is located in Paya Bujok Seulemak Village, Langsa Baro District, Langsa City (4°29'25" N 97°56'44" E), and at an elevation of around 7 m asl (Figure 1 and 2). It is a ±10 hectare green area mainly used for ecotourism, with a remnant natural forest fragment at some parts. Air temperature range from 30–32°C and humidity at 50–60%. In this forest, there are some natural stands of trees mostly dipterocarps, including the Endangered *Shorea pauciflora* King, and understorey to forest floor vegetation. LUF was recently converted to a tourism resort, which is based on the Qanun of Langsa City No. 16 in the Year 2015, it is aimed to preserve, harmonize and balance the urban ecosystem of Langsa, covering environmental, social, and cultural elements.

Field survey and data collection

Four transects were laid in four selected sites in LUF, each representing a different type of habitat: forested areas (1, 2) and open areas (3, 4) (Figure 2). Location 1 consists of trees and is dominated by herbs such as *Asystasia gangetica*. Location 2 is dominated by trees and covered by leaf litter. Location 3 as an open area is dominated by understorey vegetation i.e *Axonopus compressus*, *Ageratum conyzoides*, etc. Location 4 is an open area and filled with flowering plants, including *Melastoma malabathricum* and *Bougainvillea glabra*.

Butterflies were recorded once a week in July 2021 from 09.00 to 15.00 GMT+7, preferably during good weather. Data collection was done using a modification of the standard walk method (Pollard & Yates 1993; Swaay et al. 2012), with each station placed 150 m distant. The observations were made along the transects of 10 m width. When needed, specimens were collected to facilitate identification. Identification was done using morphological and photographs comparison to relevant literature including Braby (2004), Peggie and Amir (2006), Baskoro et al. (2018), and Iqbal et al. (2021).

Plant species data are also recorded and used to analyse the potential source of the host or foodplant. The plants' uses were compiled according to data from our field surveys and literature (Subahar & Yuliana 2010; Rusman et al. 2016; Kunte et al. 2021a; Kunte et al. 2021b). Geo-

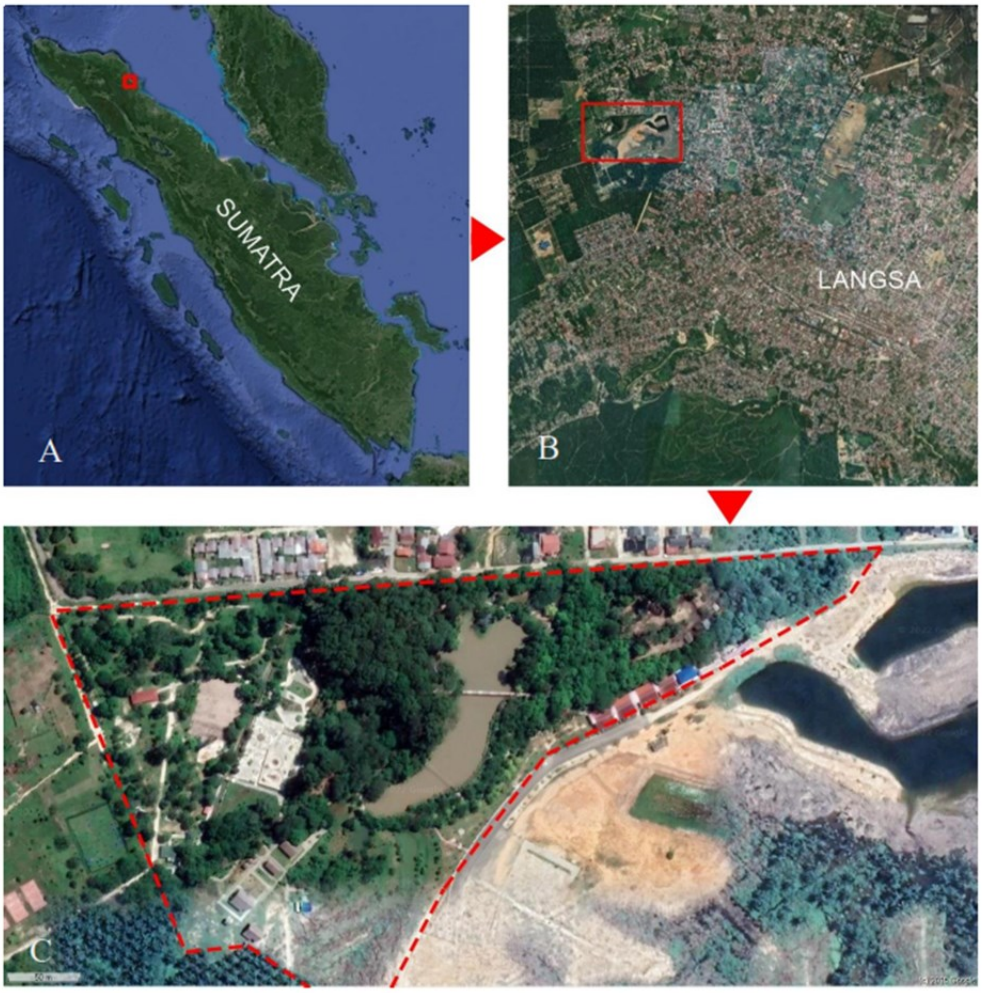

Figure 1. Map of Langsa Urban Forest: Sumatra (A), Langsa (B), and LUF (C) (Terra Incognita software 2022).

Figure 2. Map of butterfly inventory in LUF (Google Earth software 2021) and photographs of four stations: forested areas (1, 2) and open areas (3, 4).

graphical distribution analysis was done according to six zoogeographical regions (24 subregions) from Wallace (1876), and species distribution data were obtained from the literature (Braby 2004; Larsen et al. 2007; Morgun & Martin 2012; Hitchings & Campbell 2016; Hardy & Lawrence 2017; Rosmidi 2017; Yong et al. 2018; Domine & de la Cruz 2020; Echude et al. 2020; Nayak 2020; Rahman & Maryati 2020; Manzoor et al. 2020; Iqbal et al. 2021; Kunte et al. 2021a; Kunte et al. 2021b; GBIF 2022) (see Appendix). The conservation status of butterflies and plants were adapted from IUCN Red List (2022).

Data analysis

The recorded butterflies are listed and discussed. To categorise the diversity of butterflies in LUF, we calculate the diversity index (H') according to Krebs (1999) as the following formula:

$$H' = \sum_{i=1}^{s}(pi)(log2pi)$$

To analyse the spatial distribution, we calculate the evenness index following Magurran (2004) as the following formula:

$$J' = H'/\ln S$$

The diversity index results can be classified into low (<1), medium (1-3), and high (>3). The evenness index ranges between 0 and 1, with 1 being the maximum value (Krebs 1999). Photographs were taken using a digital camera. The plate of representative species was prepared using photo editing software, each species with both ventral and dorsal sides. A scale is also included for each photograph.

RESULTS AND DISCUSSION

Results

There are 36 species belonging to 5 families of butterflies recorded from LUF, with Nymphalidae being the largest family with 17 species (47.2%), followed by Lycaenidae with 6 species (16.67%), Pieridae with 5 species (13,89%), and the lowest from Papilionidae and Hesperidae, each with 4 species (11.11%) (Figure 3).

A total of 143 butterfly species were collected, most of them from Nymphalidae and the fewest individuals from Hesperidae. At the species level, *Leptosia nina* has the highest number of individuals (36), followed by *Mycalesis mineus* (14) and *Hypolimnas bolina* (10). Ten species (27.8%) were only recorded from a single individual (Table 1).

Quantitative approaches indicate good results in the presence of butterflies in LUF. Using the diversity index, it is shown that all four sites support medium diversity, as shown by H's value of 1.78–2.78. This finding is also supported by the Evenness Index which shows a range of 0.66–0.94, which means that out of four sites, three of them show a very even distribution (Table 2).

A plant inventory in four selected sites yielded 117 species (24 families) with 33 species (20 families) of them being the potential host or food plants (Table 3). Based on observations, found 33 species (20 families) could be used as hosts and food plants for butterflies. There are 26 species of plants that can be used as host plants, 11 species as food plants, and 4 species as both. The recorded plants' habitus range from herbs, shrubs, trees, liana, and palms, with some species, being aliens.

Discussion

Species diversity

The number of species found comprised *c.* 4% of the total butterflies known in Sumatra (890 species) (Widjaja et al. 2014). With 36 species,

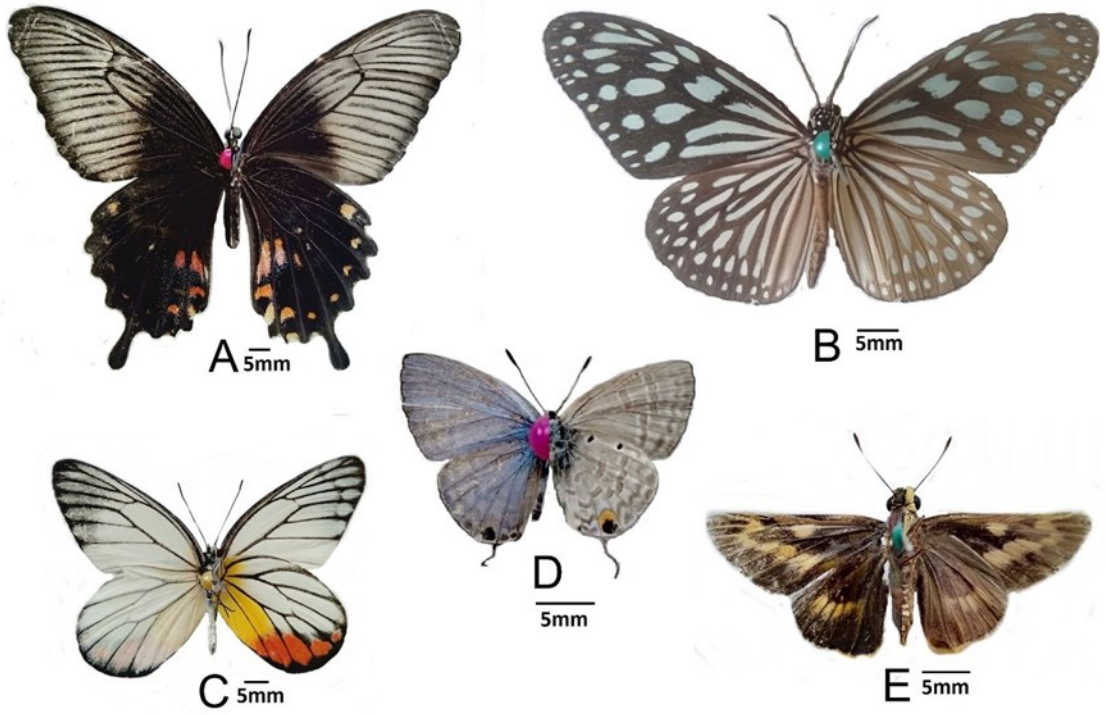

Figure 3. Representatives of each butterfly family in Langsa Urban Forest, Aceh, Indonesia: (A) Papilionidae (*Papilio polytes*), (B) Nymphalidae (*Ideopsis vulgaris*), (C) Pieridae (*Delias hyparete*), (D) Lycaenidae (*Catochrysops panormus*), and (E) Hesperidae (*Cephrenes acalle*).

which likely increased if further studies were conducted, LUF has either a higher or lower number of species compared to other areas in Aceh, e.g. 31 species in Pulau Raya Aceh Jaya (Yusuf et al. 2018), 30 species in City Garden Banda Aceh (Suwarno et al. 2018), 25 species in Soraya Research Station, Subulussalam (Suwarno 2019), and 18 species in BNI Banda Aceh Urban Forest (Alfida et al. 2016), but lower than in Brayeun River, Aceh Besar with 51 species (Akla et al. 2018). It is interesting, however, because Pulau Raya and Soraya Research Station are both natural ecosystems. The difference maybe is caused by other factors but is worthy of further investigation.

Compared to other urban parks outside Aceh, the position of LUF is also quite remarkable as it has more than twice the number of species in a 99-ha Angke Kapuk Nature Tourism Park, North Jakarta (13 species) (Ruslan et al. 2019) with the dominant plant only from Acanthaceae family and is close, although lower, to a 50ha urban ecosystem of Universitas Negeri Medan (43 species) (Siregar & Simatupang 2017), where found 6 families of plants similar to those in LUF, i.e Rutaceae, Rubiaceae, Melastomataceae, Acanthaceae, Euphorbiaceae and Moraceae, but 7 other plants families not found in LUF.

The diversity indexes from all sites are categorized as medium, with the highest index being Station 4. This condition is due to the support of flowering plants which can act as food plants (54.54%) for butterflies. Butterflies are very active visiting many different nectar plants as food plants. Butterfly diversity increase when the habitat is suitable for nectar plant as food plant as well as host plants (Nacua 2016; Rusman et al. 2016; Thakur & Chaudhuri 2017).

The taxonomic grouping of species shows a similar pattern to any previous local-scale research in Indonesia, in which the Nymphalidae usually become the dominant family (Leo et al. 2016; Panjaitan et al. 2020). This situation is not surprising as Nymphalidae is the largest fam-

Table 1. List of butterfly species in Langsa Urban Forest, Aceh, Indonesia.

Family/Subfamily/Species	Number of individu per site				Total	IUCN Conservation Status
	1	2	3	4		
PAPILIONIDAE						
Papilioninae						
Graphium agamemnon (Linnaeus, 1758)	-	-	1	-	1	NE
Papilio polytes Linnaeus, 1758	1	2	-	-	3	NE
Papilio demoleus Linnaeus, 1758	-	-	-	2	2	NE
Papilio memnon Linnaeus, 1758	-	2	-	1	3	NE
NYMPHALIDAE						
Danainae						
Euploea midamus (Linnaeus, 1758)	-	1	-	-	1	NE
Ideopsis vulgaris (Butler, 1874)	-	1	-	2	3	LC
Limenitidinae						
Athyma perius (Linnaeus, 1758)	1	-	2	-	3	NE
Lexias pardalis (Moore, 1878)	2	1	-	-	3	NE
Neptis hylas (Linnaeus, 1758)	1	-	-	-	1	NE
Neptis clinia Moore, 1872	1	1	1	-	3	NE
Nymphalinae						
Junonia orithya (Linnaeus, 1758)	-	-	1	1	2	LC
Junonia hedonia (Linnaeus, 1764)	1	1	-	1	3	NE
Junonia atlites (Linnaeus, 1763)	-	1	-	-	1	NE
Junonia almana (Linnaeus, 1758)	-	-	2	-	2	LC
Hypolimnas bolina (Linnaeus, 1758)	-	3	3	4	10	NE
Satyrinae						
Elymnias hypermnestra (Linnaeus, 1763)	1	-	-	-	1	NE
Melanitis phedima (Cramer, [1780])	1	-	1	1	3	NE
Mycalesis mineus (Linnaeus, 1758)	1	4	8	1	14	NE
Mycalesis janardana Moore, 1857	1	4	-	-	5	LC
Mycalesis perseus (Fabricius, 1775)	2	-	4	-	6	NE
Ypthima horsfieldi Moore, 1884	-	1	-	1	2	NE
PIERIDAE						
Coliadinae						
Eurema hecabe (Linnaeus, 1758)	-	-	2	1	3	NE
Eurema sp. Hübner, 1818	1	1	1	1	4	NE
Pierinae						
Delias hyparete (Linnaeus, 1758)	-	-	-	1	1	NE
Appias olferna Swinhoe, 1890	-	-	4	-	4	NE
Leptosia nina (Fabricius, 1793)	22	9	1	4	36	NE
LYCAENIDAE						
Theclinae						
Arhopala kinabala Druce, 1895	-	1	-	-	1	NE
Flos apidanus Cramer, [1777]	1	2	1	-	4	NE
Rapala manea (Hewitson, 1863)	-	-	-	1	1	NE
Polyommatinae						
Catochrysops panormus (C. Felder, 1860)	-	-	1	1	2	NE
Zizina otis (Fabricius, 1787)	-	-	4	2	6	LC
Zizula hylax (Fabricius, 1775)	-	-	1	1	2	LC

Table 1. Contd.

Family/Subfamily/Species	Number of individu per site				Total	IUCN Conservation Status
	1	2	3	4		
HESPERIDAE						
Hesperinae						
Caltoris bromus (Leech, 1844)	1	-	-	-	1	NE
Cephrenes acalle (Höpffer, 1874)	-	-	-	3	3	NE
Pelopidas conjuncta (Herrich-Schäffer, 1869)	-	-	1	1	2	NE
Potanthus sp. Scudder, 1872	-	1	-	-	1	NE
Total number of individu	**38**	**36**	**39**	**30**	**143**	
Total number of species	**15**	**17**	**17**	**19**		

Table 2. Diversity and Evenness index of butterflies in Langsa Urban Forest, Aceh, Indonesia.

Station	Number of species	Number of individuals	Number of host plants	Number of food plants	H'		Evennes Index
					Value	Category	Value
1	15	38	16	4	1.78	medium	0.66
2	17	36	4	1	2.52	medium	0.89
3	17	39	8	5	2.39	medium	0.84
4	19	30	12	6	2.78	medium	0.94

Table 3. List of plant diversity that used by butterfly as host plant and food plant.

Family/Species	Station				Occurrence / conservation status of native	Butterfly species association*
	1	2	3	4		
ACANTHACEAE						
Asystasia gangetica (L.) T.Anderson	√	-	√	√	Alien	HP: *H. bolina*, *J. hedonia*, *J. orythya** FP: *J. hedonia*, *E. hecabe*
Rostellularia sp.	-	-	-	√	-	FP: *E. hecabe*, *Eurema* sp., *Z. Otis*
APOCYNACEAE						
Alstonia scholaris (L.) R.Br.	√	-	-	-	Native/LC	FP*: P. polytes*, *J. atlites*, *D. hyparete*, *Rapala* sp., *Euploea* sp.
ARECACEAE						
Arenga pinnata (Wurmb.) Merr.	-	-	√	-	Native/NE	HP: *E. hypermnestra*
Cyrtoctachys renda Blume	√	-	-	√	Native/NE	HP: - FP: -
Hyophorbe lagenicaulis (L.H.Bailey) H.E.Moore	√	-	-	√	Alien	HP*: E.hypermnestra**
ARISTOLOCHIACEAE						
Thottea sp.	-	√	-	√	-	HP: -
ASTERACEAE						
Ageratum conyzoides L.	-	-	√	√	Alien	FP: -
Emilia sonchifolia (L.) DC.	-	-	√	√	Native/NE	FP: -
Synedrella nodiflora (L.) Gaertn	-	-	√	-	Alien	FP: -
COMBRETACEAE						
Terminalia catappa L.	√	-	-	-	Native/LC	HP: *Arhopala* sp., *F. apidanus*, *Rapala* sp.

Table 3. Contd.

Family/Species	Station				Occurrence / conservation status of native	Butterfly species association*
	1	2	3	4		
DIPTEROCARPACEAE						
Hopea sp.	-	√	-	-	-	HP*: Arhopala* sp.
EUPHORBIACEAE						
Macaranga tanarius (L.) Müll.Arg.	√	-	-	√	Native/LC	HP: - FP: -
FABACEAE						
Alysicarpus vaginalis (L.) DC.	√	-	-	-	Native/NE	HP: *Z. otis*
Bauhinia purpurea L.	-	-	√	-	Alien	HP: *Eurema* sp.
Mimosa pudica L.	√	-	√	-	Alien	HP: *J. orithya, E. hecabe, Zizina Otis, Zizula hylax* FP: *J. lmanac, Eurema* sp.
LAURACEAE						
Litsea sp.	√	-	√	-	-	HP: -
MAGNOLIACEAE						
Magnolia × *alba* (DC.) Figlar	√	-	-	-	Native/NE	HP: *G. agamemnon*
MELASTOMACEAE						
Melastoma malabathricum L.	-	√	-	√	Native/NE	HP: *J. atlites, E. hypermnestra*
MORACEAE						
Ficus benghalensis L.	√	-	-	√	Alien	HP: *Euploea* sp.
Streblus asper Lour.	-	√	-	-	Native/LC	HP: *Euploea* sp.
MUSACEAE						
Musa × *paradisiaca* L.	-	-	-	√	Native/NE	HP: -
MYRTACEAE						
Syzygium cumini (L.) Skeels	√	-	-	-	Native/LC	HP: *F. apidanus, Arhopala* sp.
NYCTAGINACEAE						
Bougainvillea glabra Choisy	-	-	-	√	Alien	FP: *P. polytes, J. almana, D. hyparete*
PHYLLANTHACEAE						
Phyllanthus niruri L.	-	-	√	-	Native/NE	HP: *A. perius*
POACEAE						
Axonopus compressus (Sw.) P.Beauv.	√	-	√	√	Alien	HP: *Melanitis sp., Mycalesis mineus*, Mycalesis perseus*, Mycalesis* sp.
Bambusa vulgaris Schrad. ex J.C.Wendl.	√	-	-	-	Native/NE	HP: *Melanitis* sp., *Caltoris* sp., Potanthus sp.
Paspalum conjugatum P.J.Bergius	√	-	-	-	Native/LC	HP: -
Imperata cylindrica (L.) P.Beauv.	-	-	√	√	Native/NE	HP: -
Saccharum officinarum L.	√	-	-	√	Alien	HP: *Melanitis* sp., *P. conjuncta*
RUBIACEAE						
Ixora javanica (Blume) DC.	-	√	-	-	Native/LC	FP: *P. demoleus, P. memnon, P. polytes, P. conjuncta, G. agamemnon*
Neolamarckia cadamba (Roxb.) Bosser	√	-	-	-	Alien	HP: -
RUTACEAE						
Citrus × *limon* (L.) Osbeck	-	-	-	√	Alien	HP: *P. polytes*, P. demoleus, G.agamemnon*
Total species per station	**17**	**5**	**11**	**16**		

Note: HP: host plant; FP: food plant; -: no data; *: direct observation

ily with perhaps 650 species or 34.21% of all known butterflies (Widjaja 2014). On the other hand, the lowest number of species was recorded from the inconspicuous family of Hesperidae and is also similar to other areas in Indonesia, such as Baluran National Park (6.35%), Sangihe Island (0.64%), Talaud Island (3.12%) and Landsfill Balai Gadang (4.54%) (Leo et al. 2016; Koneri & Nangoy 2019; Muhelni & Anwar 2020).

Technical issues may also contribute to the low number of certain families. In LUF, the number of swallowtail butterflies from Papilionoideae is only four species, similar to those of Hesperidae. Our result may be underestimated as species from this family usually fly fast and are hard to observe or even captured, for instance, *Graphium* (Betts & Wootton 1988). Other studies, even in the vegetation-rich ecosystems also yielded a low number of this family, e.g. Baluran National Parks comprised c. 1.58% (Leo et al. 2016).

Species distribution

Most of the species in LUF have broad geographical distributions with 19 subregions from five zoogeographical regions, i.e. Palearctic, Ethiopian, Oriental Region, Australian, and Neotropical (Appendix). Most of the species are distributed in Oriental and Australian regions. Only three species are distributed in five regions, four species in four regions, seven species in three regions, fifteen species in two regions, and seven species in one region (Oriental Region). These numbers show that the geographic distributions of the species are considerably broad.

Three species occupy five regions, *Papilio demoleus* (Morgun & Martin 2012; Yong et al. 2018), *Hypolimnas bolina* and *Eurema* sp., while the species with four regions is *Junonia orithya* (Biricik 2011), *Eurema hecabe*, *Zizina otis* and *Zizula hylax*. A large proportion of species also can be found in the Australian region (80,55%), followed by Palearctic (36,11%), Ethiopian (19,44%), and Neotropical (8,33%). In the Oriental region, three species restricted to the Indomalayan realm, LUF butterflies are also found in India (83,33%), followed by Ceylon (77,78%), and Indo-China (69,44%).

Host and food plants

The population dynamics of butterflies in certain areas are influenced by the vegetation, in part, related to the presence of host and food plant species (Curtis et al. 2015; Suwarno et al. 2018; Panjaitan et al. 2020). Butterfly abundance is influenced by plant species found in the ecosystem. The abundance and richness of butterflies depend on abundance and richness of plants species (Yamamoto et al. 2007; Subahar & Yuliana 2010, Hantson & Baz 2011; Panjaitan et al. 2020) with generalist butterfly has a higher number than a specialist butterfly in the ecosystem (Hantson & Baz 2011).

In LUF, around 28.20% of the recorded plants are either hosts or food plants, or partly both. The most common plant species found as hosts and food plants belong to Poaceae (15.15%), followed by the Arecaceae, Asteraceae, and Fabaceae families (all 9.09%), and other 14 families represented by 1 species (3.03%). Many plant families in LUF have been previously reported as important groups for butterflies.

Poaceae, used by 4 butterfly genera from Hesperidae and Nymphalidae as host plants in LUF, there are *Melanitis*, *Mycalesis*, *Caltoris* dan *Potanthus*. This was also reported by Leo et al. (2016) and Peggie and Amir (2006), Poaceae are widely used as host plants by Hesperidae and Nymphalidae, while Asteraceae and Fabaceae for the Nymphalidae (Peggie & Amir 2006). Therefore, it is not surprising that many Nym-

phalidae species were recorded in LUF. Besides that, Fabaceae is also an important source of nectars for adult butterflies, especially for Lycaenidae (Rusman et al. 2016), yielding the diverse species of Lycaenidae found in station 3 where the family is also diverse.

Conservation

According to the IUCN Red List (2022), the conservation status of the five evaluated species is all of Least Concern (LC), while the others are Not Evaluated (NE). Least Concern species have a lower risk of extinction, but some of them are slow declines, so it is important to monitor these species to prevent them from becoming threatened in the future (IUCN 2022). Despite the medium diversity we found, the LUF did not support the conservation of threatened species. Furthermore, according to the regulation from the Indonesian Ministry of Environment and Forestry No. 106 in the year 2018, there are also no protected butterflies. This implies that the conservation effort in the future should be an ecosystem-level approach since the use of flagship species (see Verissimo et al. 2011) is considered inapplicable.

On a local scale, however, some species are only found once during the study. Those types of species need further attention, especially in efforts to avoid local extinction. To make sure that the species will sustain, some strategies can be implemented by the local stakeholders, for example by making sure that the presence of food or host plants is also maintained. A focus should be made on the native plant species to maintain the original ecosystem interaction.

The presence of alien plants, especially those that are used as a source of food or host plants, a yet-unknown role in the diversity of butterflies in LUF. This group of plants has been known to negatively impact the butterfly species richness (Gallien et al. 2017) but has positive impacts on the butterfly species in another research (Mukherjee et al. 2015). Out of 33 food and or host plants, 11 of them are alien species, which is considered a large proportion. Those alien plants such as *Asystasia gangetica* and *Mimosa pudica* can be used as host or food plants, i.e *J. orithya*, *J. almana*, *J. hedonia*, *H. bolina*, *E. hecabe*, *Z. otis*, and *Z. hylax*. As no data on the food and or host plant partition between the native vs alien species are available, further studies are encouraged to ensure the alien plant's role in the LUF ecosystem. The conservation status of the plant is also important as described before that some of the least concern species are slow declines. This information is necessary to make sure that the plants used as food and or host plants are available to maintain the existence of butterflies. This type of effort would be useful to create a conservation action plan in LUF.

CONCLUSION

The current study revealed 36 species of butterflies in an isolated lowland urban forest of Langsa, Aceh, Indonesia. The pattern of species composition more or less follows a common pattern in other areas of Indonesia with Nymphalidae being the most species-rich family. The vegetation in LUF also supports the butterfly diversity by providing sources of food, host, or both, from 33 species or 28.20 percent of all known species. Further studies are needed to support the idea of making LUF a conservation site for urban butterflies, e.g. year-long monitoring of butterflies and food and or host plant species traits. These types of studies will gain a better understanding of the biology of butterflies in this area and also could serve as important references for future conservation.

AUTHORS CONTRIBUTION

H.P.E.S. designed the research and supervised all the processes, A.Y.P collected and analysed butterfly diversity data and wrote the manuscript, W.A.M collected and analysed plant data and wrote the manuscript, K.A.P collected butterflies, I.Y.W. analysed butterfly species and wrote the manuscript. All authors agreed on the final version of the manuscript.

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CONFLICT OF INTEREST

The authors declare that they hold no competing interests and no funding applied.

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APPENDIX

Family / Subfamily / Species	Distribution	Data Source
PAPILIONIDAE		
Papilioninae		
Graphium agamemnon (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesia, Australian	GBIF (2022) Iqbal et al. (2021) Nayak (2020)
Papilio polytes Linnaeus, 1758	Oriental: Indian, Ceylon, Indo-China, Indo-Malaya Australian: Austro-Malayan Paleartic: Manchurian	Domine and dela Cruz (2020) GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Manzoor et al. (2020) Nayak (2020) Rosmidi (2017)
Papilio demoleus Linnaeus, 1758	Neotropical: Antilean Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Australian Ethiopian: West Africa Paleartic: Europe, Mediteranian	Echude et al. (2020) GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Manzoor et al. (2020) Morgun and Martin (2012) Nayak (2020) Yong et al. 2018
Papilio memnon Linnaeus, 1758	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Australian Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020) Rahman and Maryati (2020) Rosmidi (2017)
NYMPHALIDAE		
Danainae		
Euploea midamus (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Kunte et al. (2021)
Ideopsis vulgaris (Butler, 1874)	Oriental: Indo-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Limenitidinae		
Athyma perius (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Lexias pardalis Moore, 1878	Oriental: Indian, Indo-China, Indo-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Kunte et sl. (2021) Rahman and Maryati (2020)
Neptis hylas (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan Paleartic: Manchurian	GBIF (2022) Iqbal et al. (2021) Hardy and Lawrence (2017) Manzoor et al. (2020) Nayak (2020) Rahman and Maryati (2020)
Neptis clinia Moore, (1872)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)

APPENDIX Contd.

Family / Subfamily / Species	Distribution	Data Source
Nymphalinae		
Junonia orithya (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, New Zealand, Australia Ethiopian: East Africa, West Africa, South Africa, Malagasy Paleartic: Europe, Mediteranian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Larsen et al. (2007) Manzoor et al. (2020) Nayak (2020)
Junonia hedonia (Linnaeus, 1764)	Oriental: Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian	Domine and dela Cruz (2020) GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Rahman and Maryati (2020)
Junonia atlites (Linnaeus, 1763)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Australian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020)
Junonia almana (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020) Rahman and Maryati (2020)
Hypolimnas bolina (Linnaeus, 1758)	Neotropical: Mexican, Antillean Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesian, New Zealand, Australian Ethiopian: West Africa, East Africa, Malagasy Paleartic: Mediteranian	GBIF (2022) Domine and dela Cruz (2020) Hardy and Lawrence (2017) Hitchings and Campbell (2016) Iqbal et al. (2021) Nayak (2020) Rosmidi (2017)
Satyrinae		
Elymnias hypermnestra (Linnaeus, 1763)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Iqbal et al. (2021) Nayak (2020) Rosmidi (2017)
Melanitis phedima (Cramer, 1780)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020)
Mycalesis mineus (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Domine and dela Cruz (2020) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020) Rahman and Maryati (2020)
Mycalesis janardana Moore, 1857	Oriental: Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Mycalesis perseus (Fabricius, 1775)	Oriental: Indian, Ceylon, Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Rahman and Maryati (2020)
Ypthima horsfieldi Hübner, 1819	Oriental: Indo-Malayan	GBIF (2022) Iqbal et al. (2021) Rahman and Maryati (2020)

APPENDIX Contd.

Family / Subfamily / Species	Distribution	Data Source
PIERIDAE		
Coliadinae		
Eurema hecabe (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian Ethiopian: West Africa, East Africa, South Africa Paleartic: Europe, Manchurian	Domine and dela Cruz (2020) GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Larsen et al. (2007) Manzoor et al. (2020) Nayak (2020) Rahman and Maryati (2020)
Eurema sp. Hübner, 1818	Neotropical: Chilean, Brazilian, Mexican, Antillean Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian Ethiopian: West Africa, East Africa, South Africa, Malagasy Paleartic: Europe, Manchurian	GBIF (2022)
Pierinae		
Delias hyparete (Linnaeus, 1758)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Appias olferna Swinhoe, 1890	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Australian	Braby (2004) GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Leptosia nina (Fabricius, 1793)	Oriental: Indian, Ceylon, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Domine and dela Cruz (2020) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020) Rahman and Maryati (2020)
LYCAENIDAE		
Theclinae		
Arhopala kinabala (H.H. Druce, 1895)	Oriental: Indo-Malayan	Iqbal et al. (2021)
Flos apidanus (Cramer, [1777])	Oriental: Indian, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Kunte et al. (2021)
Rapala manea (Hewitson, [1863])	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Nayak (2020)
Polyommatinae		
Catochrysops panormus (C. Felder, 1860)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Australian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Zizina otis (Fabricius, 1787)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian Ethiopian: West Africa, South Africa Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Kunte et al. (2021)

APPENDIX Contd.

Family / Subfamily / Species	Distribution	Data Source
Zizula hylax (Fabricius, 1775)	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan, Polynesian, Australian Ethiopian: West Africa, East Africa, South Africa, Malagasy	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021) Larsen et al. (2007)
HESPERIDAE		
Hesperinae		
Caltoris bromus Leech, 1894	Oriental: Indo-China, Indo-Malayan Australian: Austro-Malayan Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Cephrenes acalle Höpffer, 1874	Oriental: Indian, Ceylon, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Pelopidas conjuncta (Herrich-Schäffer, 1869)	Oriental: Indian, Ceylon, Indo-Malayan Australian: Austro-Malayan	GBIF (2022) Hardy and Lawrence (2017) Iqbal et al. (2021)
Potanthus sp. Scudder, 1872	Oriental: Indian, Ceylon, Indo-China, Indo-Malayan Australian: Austro-Malayan Paleartic: Manchurian	GBIF (2022) Hardy and Lawrence (2017)