# KUPUNESIA APP FOR CITIZEN SCIENCE: NEW WAY OF MAINSTREAMING INTEREST AND STUDY OF INDONESIAN BUTTERFLIES

**Djunijanti Peggie\*[#1,2,] Swiss Winasis Bagus Prabowo[#1,3], Abdul Mutholib Shahroni[#1,4], Fariq Izzudien Ash Shidiq[#1], Lutfi Irwansyah[#1], Soenarko[#1], Nabila Rahma[#1,4], and Imti Yazil Wafa[#1]**

[1]Kupunesia, Malang, East Java, Indonesia
[2]Museum Zoologicum Bogoriense, Research Center for Biosystematics and Evolution, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor 16911, Indonesia
[3]Burungnesia, Malang, East Java, Indonesia
[4]Department of Biology, Faculty of Natural and Science, Brawijaya University, Malang 65145, East Java, Indonesia
\*corresponding author: kupu2indonesia@gmail.com
#all authors have equally contributed

## ABSTRACT

Indonesia is a mega biodiversity country and is host to many endemic butterfly species. However, data about Indonesian butterflies is still very limited due to some constraints of research personnel capacity, budget, challenging access to many islands, and other factors. This paper aims to inform a new direction using the Kupunesia App as a breakthrough and to invite more citizen science participation to accelerate butterfly research in Indonesia. The involvement of butterfly enthusiasts as citizen scientists has increased the knowledge as can be seen within one month of the launching of the App in November 2022. About 500 people have downloaded the App, 182 people have contributed their data to Kupunesia App, 342 checklists were recorded and 321 species were observed from various locations in Indonesia. This momentum should be maintained so that it can effectively and sustainably support citizen scientists.

**Key words**: Android mobile App, butterfly enthusiasts, citizen science, data acquisition, Kupunesia

## INTRODUCTION

Indonesia is known as one of 17 global megadiversity countries (Mittermeier et al., 1997). Two of the 25 global biodiversity hotspots (Myers et al., 2000) are located in Indonesia, i.e., the Sundaland region (Sumatra, Kalimantan, and Java) and the Wallacea region (Sulawesi, Nusa Tenggara, and Maluku). These global biodiversity hotspots are defined as areas containing many endemic species that are at risk of becoming endangered or extinct by habitat loss (Myers et al., 2000). Indonesia's high biodiversity is under a high level of threat and loss of biodiversity, especially the many endemic species and the high threat of invasive foreign species (von Rintelen et al., 2017).

The diversity of butterflies in Indonesia is estimated to be over 2,200 species (Peggie, 2014). With the vast expanse of the Indonesian archipelago with five large islands and some groups of smaller islands that are estimated to reach 17,500 islands, the butterfly subspecies in Indonesia are numerous, totaling around 5,000 subspecies. In addition, Indonesia has

the highest number of endemic butterfly species in the world, with about 650 species (Peggie, 2014). With the inclusion of Hesperiidae into the superfamily Papilionoidea as butterflies (van Nieukerken et al., 2011; Kawahara & Breinholt, 2014), the percentage of endemicity for Indonesian butterflies may reach 30 percent.

Research on butterfly diversity in Indonesia has been carried out in some locations (see Peggie & Amir, 2006; Peggie, 2008, 2011a, 2012, 2018; Peggie & Noerdjito, 2011; Peggie & Harmonis, 2014) and also by students at universities in Indonesia. However, it is still inadequate and far from comprehensive. Funding butterfly expeditions has typically been a major obstacle. Other delimiting factors may include limited research personnel capacity, challenging access to many islands, and minimal consideration of priorities. In many developed countries, programs for recording and collecting data on the occurrence of butterflies have been conducted for a long time and are growing (McKinley et al., 2017) by involving voluntary citizen participation in data collection or analysis, known as citizen science (Dickinson et al., 2012; Haklay et al. in Vohland et al., 2021). Therefore, the involvement of citizen science (Kristensen et al., 2007; Wilson et al., 2020) is very important to accelerate data collection. With citizen science participation, data on the occurrence of butterflies in various locations previously unrecorded can be made available. This data can complement museum specimens, as long as it is reliable with valid photos and data regarding the location, time of photo taking, and the name of the photo recorder (Peggie et al., 2021).

In the last decade, citizen science has grown globally (Tulloch et al., 2013), very likely due to the advances in mobile phone technology and social media as indicated by Bonney et al. (2009) and Washitani et al. (2020) which makes public access to science more open and engaging. In the United States and Canada, the eButterfly web platform has been developed since 2012 and data has been collected from > 5,500 participants and > 28,000 locations in North America (Prudic et al., 2017). App used globally like iNaturalist allows citizen scientists to globally record data of various plants and animals (iNaturalist, 2022) and make it available to GBIF. This has supported discoveries and rediscoveries in the region as reported by Jain et al. (2018, 2019), which in fact make up a large amount of urban butterfly fauna in the region. In Malaysia, the movement to count butterflies or Butterfly Count started in 2015 (Wilson et al., 2015).

The participation of citizen science in the field of avifauna in Indonesia has contributed tremendously and resulted in the excellent Indonesian Bird Atlas through the Burungnesia App (Taufiqurrahman et al., 2016; Winasis et al., 2018). Similarly, we have seen the advancement of knowledge in the field of herpetofauna through Our Amphibian Reptile Observation Movement, Gerakan Observasi Amfibi Reptil Kita GO-ARK (Penggalang Herpetologi Indonesia, 2018).

The interest and attention of Indonesian citizen scientists toward butterflies have increased in the last 10 years. They have joined the Facebook group Butterflies of Indonesia and the Community of Friends of Indonesian Butterflies. The Butterflies of Indonesia Facebook group currently has approximately 1,500 members and 6,000 photos have been uploaded by members of the group. The community of Friends of Indonesian Butterflies consists of participants in the

Indonesian Butterfly Jamboree which has been held three times, offline in 2017 and 2019, and online in 2020 due to the COVID-19 pandemic.

The citizen science participation in Indonesian butterfly data acquisition held in conjunction with a BIFA-GBIF workshop (Peggie et al., 2021) has generated momentum to act together. The growing interest of many butterfly enthusiasts in Indonesia is an untapped potential of people power. With the same vision to map Indonesian butterflies and accelerate data acquisition, a mobile application was developed. This paper aims to inform this new way of mainstreaming interest and study of Indonesian butterflies using the Kupunesia App as a breakthrough and to invite more citizen science participation.

## MATERIALS AND METHODS

### Kupunesia App

The Kupunesia App is a mobile application downloadable for free on the Google Play Store on cellular phones since 1 November 2022. The language used is Indonesian and it is available in Android, as it will cost much to develop an iOS version. The name Kupunesia is derived from the word "kupu-kupu" which means butterflies in the Indonesian language and "-nesia" which stands for Indonesia. This naming adopted what Burungnesia App has been known, i.e., "burung" which means birds in the Indonesian language, and "-nesia" which stands for Indonesia (Burungnesia, 2016–2022). Kupunesia App adopted the same framework as Burungnesia, thanks to the generous support of the founder of Burungnesia, who became a co-founder of Kupunesia. In the same line as Burungnesia, Kupunesia is a tool for butterfly observers to collect, store, and manage field data. Furthermore, this App is to mobilize people on a voluntary basis (Kupunesia, 2022).

In Kupunesia, we have a team with long-time experience in identifying Indonesian butterflies including a professional butterfly researcher to verify the photos and data submitted. We welcome people of various backgrounds to participate as contributors. New beginners can use the Identification Field Guide page in the App to familiarize themselves with the species before they are ready to submit an observation record. This App has several page views and features that are useful in monitoring butterflies by the contributors (Fig. 1). The data sent by contributors is in the form of a description of the observation location, name of the observer (contributor), notes (weather conditions), coordinates of the observation location (latitude and longitude), habitat, observation date, time of observation, the purpose of observation, type and number of butterflies observed along with photos for validation (Fig. 2).

The data sent by participants is validated by the Kupunesia team (verifiers) for the accuracy of the coordinates of the observation location using the help of Google Earth or ArcGIS and the correct identification of the butterfly species. The Kupunesia team verifies the identification of the photo records using standard references (Morishita, 1981; Yata, 1981; Aoki et al., 1982; Tsukada and Nishiyama, 1982; Tsukada, 1985, 1991; D'Abrera, 1986, 1990; Maruyama, 1991; Seki et al., 1991).

In case of doubt, the Kupunesia team (verifiers) will contact the contributor to confirm the observation and resolve any potential discrepancies. If discrepancies cannot be resolved, then the data will be deleted and considered unusable to ensure the reliability and quality of the data. A WhatsApp group is also open to all who would like to confirm the identification so others in the group can also help.

**Data analysis**

For this paper, data submitted by the users/contributors to the Kupunesia App was made available for our analysis. We used data taken from the launch of the Beta version of Kupunesia App, which lasted for two weeks (21 August until 3 September 2022). Subsequently, data was used from the launch date of the Kupunesia App on 1 November 2022 until 3 December 2022. The data was mapped with ArcGIS pro to construct the distribution of observations throughout Indonesia.
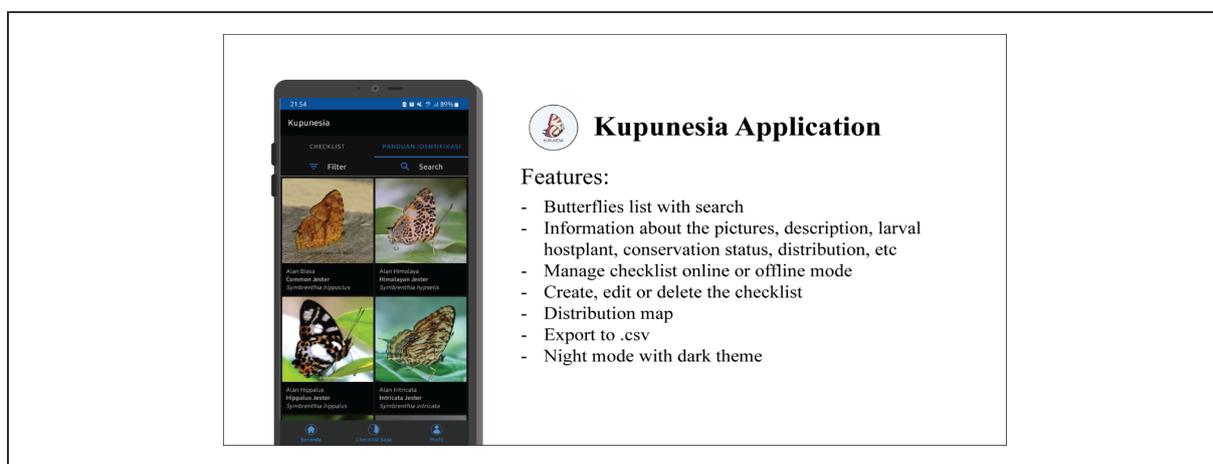


**Figure 1.** Display of the Kupunesia App on the Identification Field Guide page ("Panduan Identifikasi") and some of the features it has.
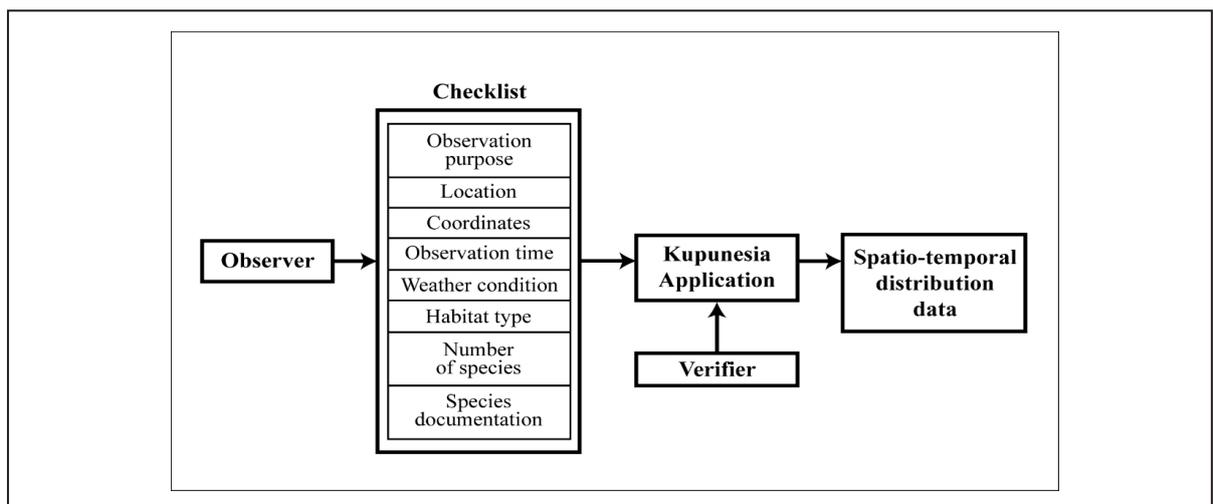


**Figure 2.** The operational framework of the use of Kupunesia App by observers and verifiers.

# RESULTS

## Contributors to Kupunesia

The Kupunesia App is being developed in three stages: before launch, beta version, and within one month after the launch period (Table 1). The Kupunesia team prepared all personally owned data before the launch and collected photos from butterfly watcher photographers who were willing to have their butterfly photos included in the App (741 species, 1249 photos from 70 photographers). Following that, from 23 August until 7 September 2022, the beta version of the Kupunesia App was released, with up to 32 registrants ready to test out its features. There was an increase in the number of photos taken by the registrants from the observation checklist trial during the beta version period to 1426 photos of 837 species. During the first month of the launch of Kupunesia App, over 500 users downloaded the App. Within one month after the launch, Kupunesia App contains an Identification Field Guide page or "Panduan Identifikasi" with 1488 photographs of 869 butterfly species that were taken by 90 photographers. During this time, 284 people registered, 101 of them contributed observational data, and 304 observation checklists were collected.

**Table 1.** List of citizen science contributions in developing and optimizing the use of the Kupunesia App

| Category | Before Launching | Beta Version | After one month of launching | Description |
|---|---|---|---|---|
| Number of species recorded on the Identification Field Guide page | 741 | 837 | 869 | species |
| Number of photos used in the Identification Field Guide page | 1249 | 1426 | 1488 | photos |
| Photographer | 70 | 80 | 90 | people |
| Registrant | 0 | 32 | 284 | people |
| Contributor | 0 | 16 | 101 | people |
| Total checklist (1 November – 3 December 2022) | 0 | 93 | 304 | checklist |

## Coverage across butterfly families & geography

There are variations in the number of contributed photos used for species documentation of Kupunesia App Identification Field Guide page (Fig. 3). Contributed photos for the Papilionidae family are the most complete (93.6%). However, contributed photos across other families are still lacking, such as the Pieridae family (57.2%), Nymphalidae (51.2%), Lycaenidae (19%), Riodinidae (28.6%), and Hesperiidae (31.6%).
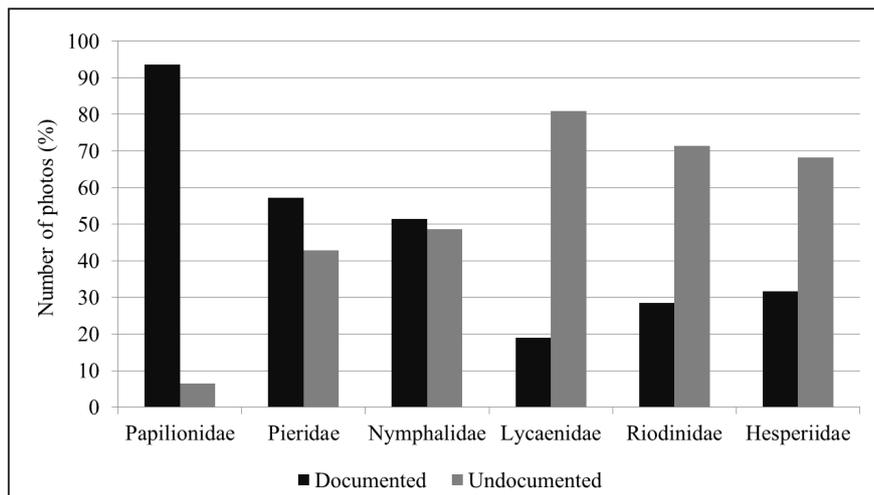
**Figure 3.** Percentage of the number of photos available across butterfly families on the Kupunesia App Identification Field Guide page.

After mapping the points of observation submitted by the contributors from all regions of Indonesia (Fig. 4), it is clear that many regions are already represented in the App. Observations on the island of Java are the highest compared to those of other islands. A total of 117 location points on Java Island have been observed, while there are still very few locations from Papua (only 2 points) and none from Maluku.
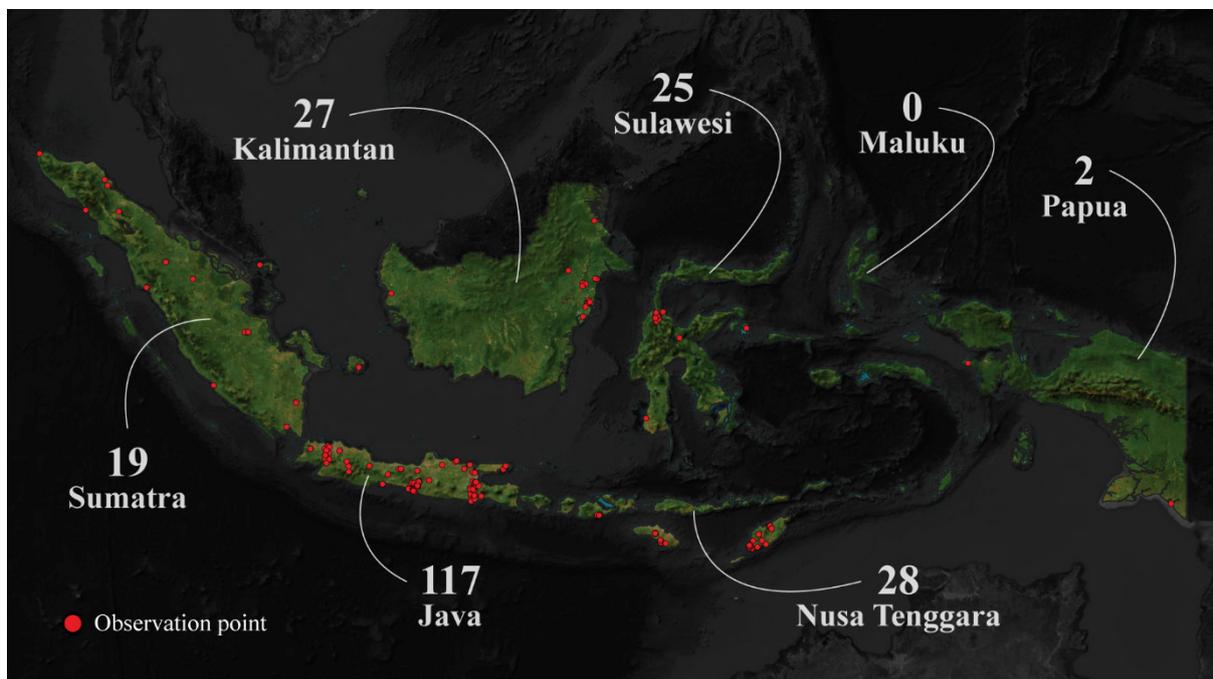


**Figure 4**. Location of observation points recorded in the Kupunesia App in the period of 1 November – 3 December 2022.

## Significant records

Within a very short period since the launch, the involvement of citizen scientists using the Kupunesia App has already resulted in new distribution records of two butterfly species (Table 2).  A contributor, Rhamdany Harahap, had reported the occurrence of *Melanitis phedima* and *Papilio demolion* from Sumbawa. Based on previous records, *Melanitis phedima* and *Papilio demolion* are distributed from the Indo-China region to Indonesia. This discovery represents a promising result of the usage of Kupunesia App.

**Table 2.** A new distribution record of species resulted from contributor's data on the Kupunesia App

| Species | Distribution | New record of distribution | Contributor |
|---|---|---|---|
| *Melanitis phedima* | India, Sri Lanka, Bhutan, Bangladesh, Myanmar, China, Japan, Vietnam, Thailand, Singapore, Malaysia, Philippines, Indonesia (Sumatra, Nias, Enggano, Java, Sulawesi) (Aoki et al., 1982) | Sumbawa | Rhamdany Harahap |
| *Papilio demolion* | Cambodia, Laos, Vietnam, Thailand, Singapore, Malaysia, Brunei, Philippines, Indonesia (Sumatra, Nias, Kalimantan, Java, Lombok) (Tsukada & Nishiyama, 1982) | Sumbawa | Rhamdany Harahap |

## DISCUSSION

### Motivations

The advancement of cellular phone technology, ease of communicating through social media, and success of the earlier developed Burungnesia App, inspired us to develop the Kupunesia App. This App was created primarily due to the dedication of the team who have voluntarily and relentlessly worked to gather and verify data and build the Identification Field Guide page. As the App is used more widely, some improvements may need to be made based on user needs.

The enthusiasm of citizen scientists since the launch of the Kupunesia App has been promising as indicated by the number of entries in the first month. Citizen scientists from many areas of Indonesia have shown interest and shared butterfly photographs on the App and accumulated data to the system. Just like the founders of the App and all supporting teams, they also have dedicated their time voluntarily and have made their leisurely time in nature more valuable for butterflies. We are hopeful that this new platform will help to accelerate data collection of Indonesian butterflies and bring us closer to our common goals and vision for the advancement of the knowledge of Indonesian butterflies.

### Species Identification

The availability of the Identification Field Guide page in Kupunesia App has greatly assisted users in making an identification. New beginners can use the Identification Field Guide page to familiarize themselves with the species before they are ready to make an observation

record on the App. Of the 896 species that have photographs, the Papilionidae family has a high percentage of species that have photographs compared to species that do not have photographs, which means that this family has been extensively explored by observers. This is understandable because Papilionidae is a family whose members are most attractive in terms of color patterns and size. The interesting color patterns have also caused some species to be sought after by collectors so some species are protected by Indonesian law and regulated by CITES, i.e., all species of *Troides* and *Ornithoptera* (Peggie, 2011b). However, the number of species from the Lycaenidae family that do not have photographs is very large compared to the species that have photographs, even though members of this family are quite numerous in Indonesia, with around 772 species. Due to their relatively small size and some difficulty in identification, members of this family are often overlooked by observers or photographers. Meanwhile, references with complete descriptions and clear illustrations of several members of Lycaenidae and Hesperiidae are urgently needed, so that they become opportunities and lessons learned in identifying species.

The participation of butterfly enthusiasts and citizen scientists all over Indonesia will support the identification of cryptic species, and we are hopeful about this. The Kupunesia App has been running for a little over a month since its launch, and there have been additional photos of 59 species on the Identification Field Guide page from 837 species to 896 species. Meanwhile, the number of photos has increased from 1426 to 1488, also with an increase in the number of photographers from 80 people to 90 people. We are hopeful that this increase will continue as there is increasing enthusiasm from public to participate in observing and monitoring butterflies. This is an opportunity for all butterfly observers to spread enthusiasm and education about caring for butterflies so that citizen science can become socially contagious.

The prospect of uncovering new species records and distributions can also be seen from the usage of the Kupunesia App as highlighted by the record of *M. phedima* (of Nymphalidae family) and *P. demolion* (of Papilionidae family) from Sumbawa Island. This event shows the role of citizen science in adding new knowledge and reducing exploration and research costs by researchers. Such platforms have the power to engage a lot of volunteers to make observations at a scale and resolution that is virtually impossible for a single researcher to achieve (Kobori et al., 2016). The development of studies related to butterflies can be accelerated with the help of citizen science observations of butterflies.

The accumulation of data recording of the occurrence of butterfly species from various areas in Indonesia will pave the way towards a more complete mapping of the distribution of Indonesian butterflies. Further data analysis can indicate population distributions and trends (Dennis et al., 2017) that can contribute to butterfly conservation and management efforts. Assessment of the conservation status and rarity of various butterfly species, or other aspects such as mapping the habitat of butterflies and their host plants (Jain et al., 2021) can become more affordable and attainable.

The involvement of citizen science needs to be considered for the success and sustainability of the program (Cunha et al., 2017). In this case, the enthusiasm of butterfly enthusiasts needs to be maintained and considered, through several breakthroughs that must

be pursued. Reciprocity, for example by transferring knowledge through training and learning about butterfly identification, needs to be done regularly to maintain interest. Program planning is needed to optimize the contribution of citizen science (Wang et al., 2016) so that it can be carried out effectively and sustainably. Besides the App, we also have a WhatsApp group in which members can share their photos of the day, ask for identification or simply share the beauty and enjoy. Discussions on other aspects such as butterfly behavior and host plants often follow photo sharing, which has been edifying for members of the group.

It is hoped that this new way of mainstreaming the interest of involving citizen science can accelerate the advancement of knowledge about Indonesian butterflies, for example by making an Indonesian Butterfly Atlas like the one that has been pioneered for Indonesian birds.

## CONCLUSION

The Kupunesia App has been developed and has attracted citizen scientists to participate in data collecting through their leisurely activities in nature. This new direction toward the acceleration of data acquisition of Indonesian butterflies is very promising, and engagement needs to be maintained for sustainability.

## ACKNOWLEDGMENTS

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