Translated into English by the 1st author from a published article in Indonesian language, entitled: **PERAN SAINS WARGA UNTUK AKSELERASI PEROLEHAN DATA KUPU-KUPU DI INDONESIA TERKAIT PROJECT BIFA-GBIF**
Published on 27 December 2021 at *Berita Biologi* 20 (2): 325-334.
https://e-journal.biologi.lipi.go.id/index.php/berita_biologi/article/view/4264/pdf
DOI: 10.14203/beritabiologi.v20i1.3991

CITIZEN SCIENCE PARTICIPATION TO ACCELERATE BUTTERFLY DATA ACQUISITION IN INDONESIA RELATED TO BIFA-GBIF PROJECT

Djunijanti Peggie[*1*], Muhammad Rasyidi[1], Imti Yazil Wafa[2], dan Karyadi Baskoro[3]

[1]Museum Zoologicum Bogoriense, Kantor Pusat Riset Biologi, Badan Riset dan Inovasi Nasional, Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor 16911, Indonesia
[2]Sahabat Kupu-kupu Indonesia, Komunitas Penggiat Kupu-kupu Indonesia
[3]Departemen Biologi, FSM, Universitas Diponegoro, Jl. Prof. Soedarto SH No. 1, Semarang, Indonesia
email: kupu2indonesia@gmail.com; peggie94@yahoo.com

ABSTRACT

Citizen science participation in the scope of biodiversity data acquisition has increased globally. Data on the occurrence of butterflies are usually obtained through specimen inventories, which are costly and labor intensive. Without compromising the importance of specimens, data acquisition on the occurrence records of butterflies from various areas in Indonesia through butterfly photos can be pursued through the contribution of citizen science. This initiative was carried out as part of the BIFA-GBIF project. The involvement of citizen science is very effective in increasing the acquisition of data. More than 1,000 photographs of butterflies were received from 29 persons contributing to the initiative, and 810 entries have been processed resulting in records of 222 butterfly species. This initiative opens up more opportunities in the future.

Key words: data acquisition, citizen science, Indonesian butterfly enthusiasts, occurrence records

INTRODUCTION

Indonesia is known to have a very high wealth of biodiversity. It is estimated that there are 2,200 butterfly species in Indonesia, many of which are endemic to certain islands in Indonesia (Peggie, 2014). The Museum Zoologicum Bogoriense (MZB) has been a depository center for various Indonesian fauna collections since 1894, including butterfly specimens. All butterfly specimens were dry preserved. The MZB butterfly collection includes mounted specimens and folded specimens in glassine or tracing paper envelopes. The number of butterfly specimens in MZB is estimated at 60,000 specimens and less than 5% of those digitized before 2019.

Technical support and grant funds were obtained from the Biodiversity Information Funds for Asia (BIFA) from the Japanese Ministry of Environment managed through the Secretariat of the Global Biodiversity Information Facility (GBIF) in 2019/2020 (Project ID BIFA4_037) and 2020/2021 (Project ID BIFA5_018). This support has made it possible to curate, organize and digitize butterfly specimens from the families Papilionidae, Pieridae, Riodinidae, and the MZB butterfly type specimens. Specimen data has also been mobilized by uploading to GBIF so that it can be accessed globally. More than 21,000 data entries have been uploaded to GBIF and have resulted in occurrence records on the map of Indonesia in GBIF.

Data collection on MZB butterfly specimens revealed that about 20% of Indonesian butterflies have not been represented or have no specimens in the MZB collection. Representative specimens for each species from various distribution areas are also still inadequate. Inventory of specimens from various areas has become the primary effort (Kristensen et al., 2007) that has been carried out so far to obtain data on the presence of butterflies, and there are still gaps in butterfly inventory efforts globally (Girardello et al., 2019). Constraints on funding sources are the main factor that makes collection development slow and even stagnant.

In addition to the inventory of specimens, data on occurrence can be obtained through photographs of butterflies. Obtaining data on butterfly diversity in an area can also be done without taking a specimen. Of course this is complementary and does not eliminate the important aspect of depositing specimens in museums. In many developed countries, programs for recording and collecting data on the occurrence of butterflies have been going on 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). In the last decade, citizen science has developed globally (Tulloch et al., 2013). 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). In Malaysia, the movement to count butterflies or Butterfly Count started in 2015 (Wilson et al., 2015).

The citizen science movement for biodiversity data collection in Indonesia has been initiated in the field of avifauna, with the final output being the Indonesian Bird Atlas (Taufiqurrahman et al., 2016). This was followed by the herpetofauna field through the Our Amphibian Reptile Observation Movement, GO-ARK (Indonesian Herpetology Organizer, 2018). Indonesian butterfly enthusiasts have also emerged, both those who are members of the offline community and online through social media, including the Facebook group Butterflies of Indonesia and the Community of Indonesian Butterfly Friends. 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 Indonesian Butterfly Friends is a community consisting 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. This initiative aims to mobilize the participation of citizen science, namely outdoor photography enthusiasts, especially those who like to photograph butterflies in nature. The involvement of citizen science in accelerating data acquisition regarding the presence of butterflies in various areas in Indonesia is described here.

MATERIALS AND METHODS

The materials used are photographs of butterflies from reliable sources, taken in various areas in Indonesia. This photo needs to be accompanied by basic data regarding the location where it was taken, the time it was taken, and the name of the photo taker.

The methodology carried out in this initiative includes (1) interaction with citizen science, especially butterfly photography enthusiasts; (2) photo identification of butterflies; (3) data entry into data sheets; (4) giving a QR code to the photo; (5) process data to LIPI and GBIF servers; (6) continued communication to butterfly enthusiasts. Interaction is done by registering enthusiasts through community networks; invite butterfly enthusiasts or enthusiasts to attend workshops; interact in workshops about the program and its benefits; invite butterfly enthusiasts to donate or submit photos of butterflies, in this case via google drive. Photo identification of butterflies is carried out at the species or subspecies level 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) included determining male or female if the species was dimorphic, which marked a difference between males and females. The data entry process is carried out by preparing the data sheet to be compatible with the Darwin Core GBIF

format; re-naming the photo files with the label LEPI.IMG.XXX, where XXX is the number of the data, which is entered sequentially; perform data entry into the data sheet and fill in the location data contained in the EXIF photo data, or perform coordinate data searches / georeferencing based on the location where the photo was taken. Giving a QR code (Quick Response code) to photos is done by preparing the code and adding it to the data sheet. The process of uploading data and associated media in the form of photos is carried out to the server, in this case the LIPI server, and then the data is uploaded to GBIF so that it can be accessed globally. Follow-up communication is carried out to provide information to butterfly enthusiasts. Update or updating of data and evaluation is carried out when necessary.

RESULTS

Data collection on enthusiasts is carried out through the butterfly community network. The existence of a community of butterfly enthusiasts who are members of social media also supports the acceleration of data acquisition. During this pandemic, various activities that were previously difficult to do due to time constraints become possible, including doing useful relaxing activities such as photographing butterflies in the area around the house.

The invitation to butterfly enthusiasts to participate has been carried out through two workshops supported by BIFA-GBIF. Informal follow-up is also carried out through social media. At the first BIFA Workshop on February 24, 2019 at Widyasatwaloka, LIPI Cibinong, there were 25 participants from Jakarta, Bogor, Tangerang, Bekasi, Bandung, and Garut. At the second workshop on September 18, 2021, through the Zoom meeting, 40 participants from various areas in Indonesia were able to attend.

At the workshop, a program of activities was presented which involved collecting data on butterfly specimens and also collecting data through photographs of butterflies. The process of identifying the photo certainly has a higher level of difficulty than the identification of the specimen. Not all parts of the butterfly can be seen at the time of photo taking, so some important clues in the identification process are not available. Therefore, it is also conveyed that taking photos showing the upper and lower wing surfaces will be very helpful in the identification process, especially for species that are difficult to identify.

Data on the presence of butterflies through photographs with valid location information submitted by this butterfly enthusiast has accelerated the acquisition of data on the distribution of butterflies in various areas in Indonesia (Figure 1). The latitude and longitude coordinates are recorded in EXIF (Exchangeable Image File Format) photos on smartphones and some cameras (Figure 4). For photos taken with a camera that is not equipped with a GPS sensor, geo-reference is needed, i.e. looking for a suitable location point using Google Maps. This search was carried out based on locations informed by butterfly enthusiasts. This can be in the form of the name of the location recorded in the file name, file folder, or on a separate document stating the location where the photo was taken (Figure 2). Data regarding the time of capture and the name of the photo taker also provide information that can be used for further analysis.

Figure 1. Data of butterfly occurrence based on butterfly photos contributed by butterfly enthusiasts as displayed on GBIF (https://www.gbif.org/dataset/4d236e9c-fa04-4a94-9356-382c9f7c84c0)

A total of 29 workshop participants sent photos of butterflies. This processed photo data was recorded from 146 different locations in 21 provinces in Indonesia. This collection of photos covers the period from May 2009 to November 2021 (Table 1). The occurrenceID data in Table 1 is the data contained in the QR code that has been entered in the previous butterfly photo. The provision of this QR code is to make it easier for users to access detailed data related to the butterfly photo, namely by scanning this QR code using a smartphone or scanner connected to a computer. This QR code technology application has also previously been used in BIFA 4 and BIFA 5 projects. Even though they have been given a QR code label, the photo works of butterfly enthusiasts remain their copyright with their names in the recordedBy column and in the GBIF metadata. An example of using a QR code is shown in Figure 3.

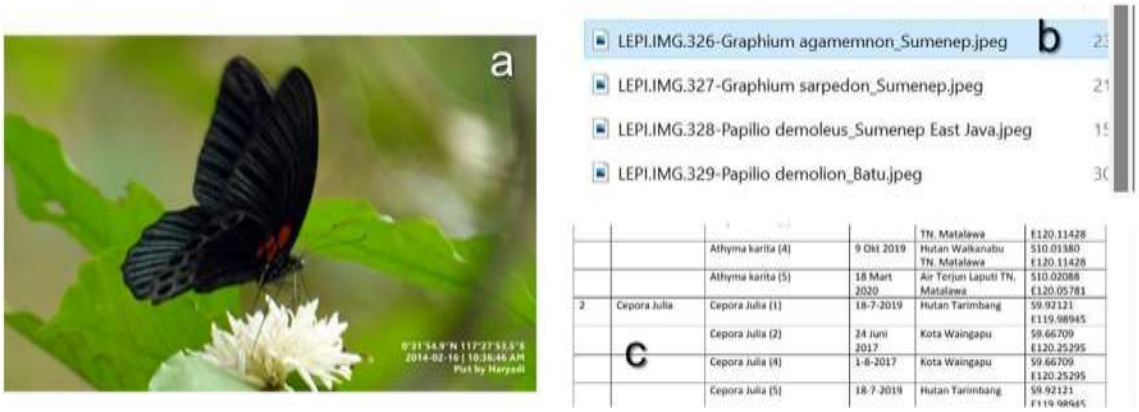

Figure 2. Location data can be obtained through: a. coordinate points that are directly listed on photos taken via smartphones with settings in certain applications, b. information on the name of the photo file which was then georeferenced to get the coordinates, c. information obtained from photo contributors given as separate files.

Figure 3. An example of a photo sent by a butterfly enthusiast: a. Original photo by butterfly enthusiast, b. Photo that has been given a QR code.

Table 1. An example of part of the data sheet compiled from butterfly photo data, the names of the contributors are shown in the last column

occurrenceID	Species (and subspecies)	eventDate (year-month-date)	locationRemarks	Decimal Latitude	Decimal Longitude	recordedBy
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.504	*Danaus affinis artenice*	2020-05-19	Tambak Karangagung, Tuban	-6.899734	112.168687	Abdul Mutholib Shahroni
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.111	*Appias olferna olferna*	2020-04-16	Situ Cihuni, Tangerang Selatan	-6.266367	106.628745	Agung Nugroho
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.760	*Papilio euchenor euchenor*	2021-10-05	Jayapura	-2.564965	140.610986	Ahmad Kholik
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.653	*Discophora sondaica symphronia*	2021-09-11	Blok Gading, Medan	3.620096	98.593563	Akhmad Junaedi Siregar
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.11	*Graphium sarpedon*	2019-04-01	Yogyakarta	-7.803249	110.339825	Diki M. Chaidir
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.765	*Idea durvillei theia*	2018-04-26	Halmahera, Sidangoli	0.383983	127.884972	Djunijanti Peggie
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.656	*Erites elegans elegans*	2017-01-21	Sungai Wain, Kalimantan Timur	1.148049	116.765036	Edi Sopiyan
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.508	*Euploea camaralzeman malayica*	2017-10-08	Goa Margo Tresno, Nganjuk	-7.446001	111.93354	Farid Kamal Muzaki
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.128	*Troides helena helena*	2018-10-13	Kondang Merak. Malang	-8.396573	112.517979	Fariq Izzudien Ash Shidiq
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.131	*Graphium agamemnon agamemnon*	2021-09-15	Cimahi	-6.886215	107.523612	Gibran Amalio Pranata
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.99	*Danaus chrysippus bataviana*	2021-09-09	Perum GCC Bogor	-6.445511	106.779225	Guntoro

http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.403	*Graphium antiphates itamputi*	2016-08-01	TN. Kutai, Kaltim	0.3608316	117.017205	Haryadi
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.700	*Charaxes galaxia scipio*	2020-10-20	Muara Padadita, Waingapu, Sumba	-9.6395	120.2699	Heri Andri
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.515	*Euploea midamus sophia*	2021-08-28	Taman Hutan Kota Langsa Aceh	4.490631	97.94383	Herlina Putri Endah Sari
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.516	*Danaus chrysippus bataviana*	2019-12-24	Lengkong Gudang Timur	-6.292973	106.683871	Ida Amal
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.521	*Ideopsis juventa juventa*	2017-04-30	Pantai Kondang Merak	-8.396573	112.517979	Imti Yazil Wafa
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.576	*Parantica aspasia philomela*	2013-09-15	Curug Semirang, Gunung Ungaran	-7.166287	110.378896	Karyadi Baskoro
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.582	*Danaus affinis artenice*	2021-02-10	Sumenep Regency	-7.009536	113.849544	Lutfi Irwansyah
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.345	*Meandrusa payeni ciminius*	2021-09-20	Taman Kupu-kupu Gita Persada Lampung	-5.420914	105.188624	Martinus
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.374	*Appias lyncida enarete*	2013-09-27	Sintang	0.143783	111.517269	Muhammad Iqbal
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.584	*Idea stolli alcine*	2017-01-28	Semboja	-0.991722	116.909324	Nana Sutrisna
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.586	*Ideopsis juventa tawaya*	2019-09-29	TWA Wera, Halmahera	-1.044172	119.850726	Nur Herjayanti
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.588	*Idea durvillei nike*	2021-08-14	Kampung Ugar, Jayapura	-2.647207	132.482323	Purwanto
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.590	*Danaus chrysippus chrysippus*	2015-12-06	Kamang Baru	-0.756898	101.309159	Syahid Kesuma
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.392	*Papilio gigon gigon*	2020-01-21	Bantimurung-Bulusaraung, Sulawesi Selatan	-4.79086	119.8326	Taufiq Ismail
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.396	*Appias olferna olferna*	2019-03-16	Camp Hulu Cai, Ciawi	-6.701891	106.884113	Wanda Everdine Kambey
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.399	*Ixias venilia venilia*	2018-09-20	Desa G. Gangsir, Jawa Timur	-7.61877	112.71655	Yohanes Agus Sunarko
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.8	*Cupha erymanthis synnara*	2016-04-27	Cagar Alam Pangandaran	-7.704768	108.647009	Yuni Arum Sari
http://inabif.lipi.go.id/kehati/mzb/LEPI.IMG.46	*Parantica aspasia philomela*	2018-12-25	Curug Cikaracak	-6.75492	106.87178	Yusnia Eka Putri

Notes:
The table attributes are displayed according to the Darwin Core standard used by GBIF;
The minus sign (-) in latitude data indicates south latitude

Figure 4. Information of a photo taken using a smartphone and some cameras showing EXIF data like this example.

From the processed data of 810 data entries to date, there are 222 different species from various families: Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Riodinidae and Hesperiidae. This processed data has been uploaded to GBIF and is publicly accessible so that it is useful. The GBIF web address can be scanned in Figure 5 or by using the link below:

https://www.gbif.org/dataset/4d236e9c-fa04-4a94-9356-382c9f7c84c0

Figure 5. Access to this data on the GBIF link can be obtained by scanning this QR code.

DISCUSSION

The importance of owning and maintaining specimen collections has been raised and valuations reviewed (Bradley et al., 2014) regarding knowledge of biodiversity, extinction, climate change, disease emergence. However, the constraints of funding cuts occur almost all over the world for the development of collections. When additional data from butterfly specimens is difficult to obtain due to limited funding sources, additional data through photographs of butterflies can be very useful. Acceleration of data acquisition can be achieved because of the contribution and active role of citizen science, especially butterfly enthusiasts (Kristensen et al., 2007; Wilson et al., 2020). With the involvement of citizen science, data on the presence of butterflies in previously unrecorded locations can become available. Without compromising the importance of the specimen, these data can function similarly to museum specimens, as long as they are accompanied by valid data regarding the location, time of the photograph, and the name of the photo recorder.

The interest and attention of the people in Indonesia towards butterflies has begun to increase in the last 10 years. This is very likely due to 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.

This initiative shows that people's scientific enthusiasm for butterflies in their surrounding area is very high. The invitation to participate in sending photos of butterflies was very well received, and in a relatively short time, less than 1 month, more than 1,000 photos were taken in 21 provinces in Indonesia. The state of pandemic restrictions that does not allow face-to-face meetings for even workshops has provided an unexpected boost. The use of virtual meeting technology (via zoom meetings) is able to eliminate distance barriers for participants from various areas in Indonesia to be able to join. This is an extraordinary achievement in accelerating the acquisition of Indonesian butterfly data. To further speed up the data entry process, the ideal condition is to submit a photo that has been equipped with the coordinates of the photo (Figure 3a) using a smartphone by downloading a certain application. In photos taken using a camera that is not equipped with a GPS sensor, it is hoped that location information can be included in the photo name or in the photo folder.

The accumulation of data recording the presence of butterflies from various areas in Indonesia will make the step towards mapping the distribution of butterflies in Indonesia closer. Further data analysis of the collected citizen science data can describe population distributions and trends (Dennis et al., 2017) and can contribute to and have implications for 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.

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. Efforts to bring knowledge about butterflies to the Indonesian people have been carried out by publishing introduction books and identification guide books (Peggie and Amir, 2006; Peggie, 2011, 2014) and need to be communicated further to synergize positively with the butterfly community. Informal forums can be used to establish this interaction. The sense of belonging in the community and the pleasure of contributing to the development of science also make the efforts worth the results. The momentum for accelerating butterfly data acquisition needs to be maintained and improved.

It is hoped that this initiative can be a program that advances the development of knowledge about Indonesian butterflies, for example by making an Indonesian Butterfly Atlas like the one that has been pioneered for Indonesian birds. Of course, program planning is needed to optimize the contribution of citizen science (Wang Wei et al., 2016) so that it can be carried out effectively and sustainably.

CONCLUSION

The participation of citizen science has accelerated the acquisition of records of the existence of various species of Indonesian butterflies. More than 1,000 photographs of butterflies have been received from 29 participants, and 810 entries have been processed resulting in data recording of 222 butterfly species.

ACKNOWLEDGMENTS

This initiative is supported by a Biodiversity Information Funds for Asia (BIFA) grant from the Japanese Ministry of Environment managed through the Secretariat of the Global Biodiversity Information Facility (GBIF) and the Center for Biological Research, Indonesian Institute of Sciences (LIPI). We extend our deepest gratitude to the Indonesian butterfly enthusiasts, both those whose names are listed in Table 1 or who will participate later upon learning of this initiative.

REFERENCES

Aoki, T., Yamaguchi, S. and Uemura, Y., 1982. Satyridae. Libytheidae. In: Tsukada, E. ed. *Butterflies of the South East Asian Islands.* III. Plapac Co. Ltd., Japan, 500 pp.

Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J., 2009. Citizen science: A developing tool for expanding science knowledge and scientific literacy. *Bioscience, 59*, pp. 977–984. https://doi.org/10.1525/bio.2009.59.11.9

Bradley, R.D., Bradley, L.C., Garner, H.J. and Baker, R.J., 2014. Assessing the value of natural history collections and addressing issues regarding long-term growth and care. *BioScience, 64*(12), pp. 1150–1158. https://doi.org/10.1093/biosci/biu166

Cunha, D.G.F, Marques, J.F., de Resende, J.C., de Falco, P.B., de Souza, C.M. and Loiselle, S.A., 2017. Citizen science participation in research in the environmental sciences: key factors related to projects' success and longevity. *Anais da Academia Brasileira de Ciências* (Annals of the Brazilian Academy of Sciences), *89*(3 Suppl.): pp. 2229–2245. http://dx.doi.org/10.1590/0001-3765201720160548

D'Abrera, B., 1986. *Butterflies of the Oriental Region*. Part 3. *Lycaenidae* and *Riodinidae*. Hill House, Melbourne, 672 pp.

D'Abrera, B., 1990. *Butterflies of the Australian Region.* Third (revised) edition. Hill House, Melbourne, 416 pp.

Dennis, E.B., Morgan, B.J.T., Brereton, T.M., Roy, D.B. and Fox, R., 2017. Using citizen science butterfly counts to predict species population trends. *Conservation Biology, 31*(6), pp. 1350–1361. DOI: 10.1111/cobi.12956

Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., Phillips, T. and Purcell, K., 2012. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment, 10*, pp. 291-297.

Girardello, M., Chapman, A., Dennis, R., Kaila, L., Borges, P.A.V. and Santangeli, A., 2019. Gaps in butterfly inventory data: A global analysis. *Biological Conservation, 236,* pp.289-295.

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S. and Vohland, K., 2021. What Is citizen science? The challenges of definition. In: Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R. and Wagenknecht, K., eds. *The Science of Citizen Science.* pp. 13-34. Springer, Springer Nature Switzerland, 529 pp.

Jain, A., Zeng, Y. and Webb, E.L., 2021. Critical dependence of butterflies on a non-native host plant in the urban tropics*. Frontiers in Ecology and Evolution, 9,* pp*.* 655012. doi: 10.3389/fevo.2021.655012

Kristensen, N.P., Scoble, M.J. and Karsholt, O., 2007. Lepidoptera phylogeny and systematics: the state of inventorying moth and butterfly diversity. *Zootaxa, 1688*, pp. 699–747.

Maruyama, K., 1991. *Butterflies of Borneo*. Hesperiidae. Vol. 2, No. 2. Tobishima Corp., Japan, 84 pp. (English version), 89 pp. (Japanese version), 39 pls.

McKinley, D.C., Miller-Rushing, A.J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., and Soukup, M. A., 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation,* (208), pp. 15–28. https://doi.org/10.1016/j.biocon.2016.05.015

Morishita, K., 1981. Danaidae. In: Tsukada, E. ed. *Butterflies of the South East Asian Islands*. II. Plapac Co. Ltd., Japan, pp. 439–628, pls. 85–162.

Peggie, D. and Amir, M., 2006. *Practical Guide to the Butterflies of Bogor Botanic Garden* / *Panduan Praktis Kupu-kupu di Kebun Raya Bogor,* Puslit Biologi, LIPI dan Nagao Natural Environment Foundation, Bogor, 126 pp.

Peggie, D., 2011. *Precious and Protected Indonesian Butterflies* / *Kupu-kupu Indonesia yang Bernilai dan Dilindungi*. Bidang Zoologi (Museum Zoologi Bogor), Pusat Penelitian Biologi & Nagao Natural Environment Foundation Japan, Cibinong, 72 pp.

Peggie, D., 2014. *Mengenal Kupu-kupu.* Pandu Aksara Publishing, Jakarta, 78 hal. ISBN: 978-602-7773-20-2.

Penggalang Herpetologi Indonesia, 2018. Gerakan Observasi Amfibi Reptil Kita GO-ARK. http://perhimpunanherpetologi.com/gerakan-observasi-amfibi-reptil-kita-go-ark/

Prudic, K.L., McFarland, K.P., Oliver, J.C., Hutchinson, R.A., Long, E.C., Kerr, J.T. Larrivée, M., 2017. eButterfly: Leveraging massive online citizen science for butterfly conservation. *Insects 8,* pp. 53. doi:10.3390/insects8020053 http://www.mdpi.com/journal/insects

Seki, Y., Takanami, Y. and Otsuka, K., 1991. *Butterflies of Borneo*. *Lycaenidae*. Vol. 2, No. 1. Tobishima Corp., Japan, 114 pp. (English version), 139 pp. (Japanese version), 69 pls.

Taufiqurrahman, I., Budi, N.S., Rudyanto, Baskoro, K., Iqbal, M., and Rahmat, A., 2016. Atlas Burung Indonesia: a national bird atlas project for the world's largest archipelago. *Birding Asia*, *25*, pp. 90-91.

Tsukada, E. and Nishiyama, Y., 1982. Papilionidae. In: Tsukada, E. ed. *Butterflies of the South East Asian Islands.* I. (Translated into English by Morishita, K), Plapac Co. Ltd., Japan, 457 pp.

Tsukada, E., 1985. Nymphalidae (I). In: Tsukada, E. ed. *Butterflies of the South East Asian Islands.* IV. Plapac Co. Ltd., Japan, 558 pp.

Tsukada, E., 1991. Nymphalidae (II). In: Tsukada, E. ed. *Butterflies of the South East Asian Islands.* V. Azumino B.R.I., Japan, 576 pp.

Tulloch, A.T., Possingham, H., Joseph, L., Szabo, J., and Martin, T., 2013. Realising the full potential of citizen science monitoring programs. *Biological Conservation,* (165), pp. 128–138. DOI: 10.1016/j.biocon.2013.05.025

Wang Wei, J., Lee, B.P.Y-H. and Bing Wen, L., 2016. Citizen science and the urban ecology of birds and butterflies - A systematic review. *PLoS ONE, 11*(6), e0156425. doi:10.1371/journal.pone.0156425

Washitani, I., Nagai, M., Yasukawa, M. and Kitsuregawa M., 2020. Testing a butterfly commonness hypothesis with data assembled by a citizen science program "Tokyo Butterfly Monitoring". *Ecological Research*, pp. 1–8. https://doi.org/10.1111/1440-1703.12161

Wilson, J., Jisming-See, S., Brandon-Mong, G., Lim, A., Lim, V., Lee, P. and Sing K., 2015. Citizen Science: The First Peninsular Malaysia Butterfly Count. *Biodiversity Data Journal, 3*, e7159. doi: 10.3897/BDJ.3.e7159

Wilson, J.S., Pan, A.D., General, D.E.M. and Koch, J.B., 2020. More eyes on the prize: An observation of a very rare, threatened species of Philippine Bumble bee, *Bombus irisanensis*, on iNaturalist and the importance of citizen science in conservation biology. *Journal of Insect Conservation, 24*, pp. 727-729. https://doi.org/10.1007/s10841-020-00233-3

Yata, O., 1981. Pieridae. In: Tsukada, E. ed. *Butterflies of the South East Asian Islands*. II. Plapac Co. Ltd., Japan, pp. 205–438, pls.1–84.