Increasing Herpetofauna Data Through Citizen Science in Indonesia

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Abstract. Citizen science has become increasingly popular to collect data on biodiversity as it can cover a large area and is cost-effective. However, gaps in biodiversity data are common especially related to data of herpetofauna, which is not received much attention. Project Amfibi Reptil Kita (ARK) is one of the programs created to collect data on the distribution of the herpetofauna in Indonesia. This research aims to analyse the contribution of citizen science through project ARK in increasing data of herpetofauna in Indonesia for the last four years. Most of the data in ARK (56.3%) were obtained during herpblitz, however, the percentage (43.86%) tend to increase in 2020. In total 433 species were reported consisting of 152 species of amphibian and 281 reptiles. Most of the data (70%) reported were from Java region. The lowest recorded data come from Papua and Maluku region. The most frequently reported amphibian species was Duttaphrynus melanostictus and the reptile species was Bronchocela jubata. A total of 416 member-contributed data in ARK project. The result of ARK has been used to describe new species and model spatial distribution. It shows, ARK has been important in documenting the diversity of herpetofauna in Indonesia.

1. Introduction

In order to track changes in biodiversity, data on the occurrence of species and other variables are needed [1][2]. Biodiversity data in the world is incomplete due to the uneven distribution of research conducted by professionals, i.e. accessibility [3], high costs [4], logistics and time [5]. To increase the amounts of data and get a wider scope of survey, many projects now turn on the help of citizen science [6][7]. Citizen science is a collaboration between scientists and non-scientists in the process of collecting authentic scientific data and then analyzing it [8]. Citizen science can help researchers overcome logistical issues such as accessibility and cost [9]. Citizen science is becoming one of the popular methods used in conservation research by local people and has proven to be a cost-effective source of information for obtaining wildlife data rapidly [10][11].
The use of citizen science as a tool to support conservation activities is emerging as a new and desirable approach, due to low budget requirements and the potential for rapid data distribution [12]. In addition, there is also a community of bird watchers called eBird who is conducting a science project by mobilizing bird watchers to document bird species around the world [13]. Currently, citizen science in the field of conservation in Indonesia is few. Only three citizen science activities were reported: the Indonesian Bird Atlas [14][11], the Asian Waterbird Census managed by Wetland International [15] and the Amphibian Reptile Kita or ARK [16].

The development of ARK is driven by the lack of amphibians and reptile data in Indonesia [17]. Amfibi Reptil Kita (ARK) or Our Amphibian and Reptile, registered in the iNaturalist application since it first launched in 2007, is created to collect data on the distribution of herpetofauna in Indonesia and foster community interest for herpetofauna taxa [16]. This program utilizes citizen science in its data collection process but was designed by the organizers also to increase capacity building of young herpetologists. It is expected that citizen science efforts will increase over the year, however, no analysis has been conducted except for first-year data in 2017 [16]. This research aims to analyse the contribution of citizen science through project ARK in increasing data of herpetofauna in Indonesia for the last four years. For these, we analyzed data for four years to assess the number of data, number of species reported, number of participants and area coverage.

2. Methods
The main material used in this research is data collected in the “Amfibi Reptil Kita” project at iNaturalist application from April 2017 to December 2020. Data were selected starting from April 21, 2017, which is the day of ARK’s official launch to the public and to the end of December 2020. Data were divided by year and region to analyses differences. There are six regions based on the main island of Indonesia and with it are smaller satellite islands: Sumatra, Java, Bali and Nusa Tenggara, Kalimantan, Sulawesi, Papua and Maluku.

Participants can enter data anytime, however, the organizer specifically organized annual activity called GO ARK or Gerakan Observasi Amfibi Reptil Kita (Our Amphibian Reptile Observation Movement) with duration between a week – 1 month (table 1). GO ARK is a bio-blitz type citizen science-based program that aims to invite amateur herpetofauna observers and researchers to report the presence of amphibians and reptiles during designated time. The term has been used since 1996 and adopted by conservationist practitioners in the world. Bioblitz basically a rapid field survey in selected location during a defined period [18][19]. The difference between GO ARK and non-GO ARK is that participants during GO ARK can get points based on the number of data they entered. The highest individual and group who get the most score will be declared as winner. In addition, during the first year GO ARK (2017) and third-year GO ARK (2019), the organizer gave selected groups a small amount of funding to help them to go to the field.

| Year | Date of Bioblitz | Duration (days) | N data | Mean Daily data |
|------|-----------------|----------------|--------|----------------|
| 2017 | April 21 – 27   | 7              | 1231   | 175.9          |
| 2018 | August 1 – 31   | 31             | 999    | 32.2           |
| 2019 | August 3 – 9    | 7              | 1023   | 146.1          |
| 2020 | November 1 – 30 | 30             | 2211   | 73.7           |

iNaturalist is a citizen science platform available as android/iOS app or web-based, that has gained popularity in the past few years [20]. The platform enables people to document species observations by submitting pictures, videos or audio files. Each observation will have a geotag reference, date and audio or visual file. These observations are then identified online by the iNaturalist community or crowdsourcing [20]. The inaturalist data is divided into three categories, namely need_id, casual and
research grade. "Research grade" means that the uploaded data has met the criteria for use in research. Data with research-grade status is also used for GBIF data [21]. GBIF (Global Biodiversity Information Facility) is an international network and data infrastructure funded by the world's governments and aimed at providing anyone, anywhere, open access to data about all types of life on Earth [22]. Data extracted from ARK is entered into spreadsheet. Data that does not have research grade status are omitted. Species recorded are categorized by their IUCN Red list status and Indonesian protection status. To analyses data contribution during herpblitz events GO ARK, data were categorized into GO ARK event and regular submission outside GO ARK.

3. Result and Discussion
There are 10,950 data uploaded to ARK. About 20% of the data is incomplete, old (before April 21st 2017) or has non-research grade data. The final data used in this analysis is 8,042 records. From this data, 3993 data are records of amphibians and 4049 data are records of reptiles. The number of data recorded varies each year, however, data from 2020 surpasses other records (Fig.1a).

![Figure 1](image)

*Figure 1. Number of amphibian and reptile data from ARK 2017 – 2020 (a) and species accumulation.*

The number of species reported over the year increased for both amphibian and reptile (figure 1b). From 142 species of amphibians reported in 2017, the number of species increased to 270 species (increase of 52.6%), whereas from 76 species of reptile reported in 2017, the number increased to 152 species (increase of 50%).

Currently, the number of amphibians and reptiles recorded in Indonesia is 385 amphibians and 723 reptiles [23]. The number is expected to rise as increasing effort to survey in the field is increasing. For instance, after the publication of the 2014 report [23] at least 7 species of amphibians and 4 species of reptiles have been described in Indonesia, one of which *Chirixalus pantaiselatan* [24] based on the finding from GO ARK 2017 [24].

ARK project only contributed 39.48% of amphibian data and 38.86% reptile data from total herpetofauna of Indonesia. However, the data is still valuable to record the distribution of amphibians and reptiles as well for further research, for instance as data source for distribution modelling of certain species [25].

The contribution of amphibian and reptile data in Java is higher compared to other regions. Data from [26] listed 41 amphibians and 186 reptiles in Java. However, the result of ARK reported 45 species of amphibian (109.7%) and 127 species of reptile (68.3%). The higher number of amphibian reported needs to be cautiously noted since data in ARK included species unrecorded in, i.e. *Ranoidea caerulea*, *Polypedates macrotis*, and *Microhyla orientalis*. These species are considered not distributed in Java.
Ranoidea caerulea is distributed in Papua. P. macrotis distributed in Kalimantan and Sumatera, and Microhyla orientalis is described first in Bali [26]. There are several possibilities regarding this record. First, possibility that species might be introduced by humans accidentally or on purpose. Ranoidea caerulea are species popular in pet trade [38] and there is possibility that they escape in the wild. On the other hand, there is another possibility that species is actually distributed in Java but never reported such as in the case of Polypedates pseudotilophus [27] or incorrect identification. There is some scepticism regarding data quality made by citizen science, especially regarding species identification [28]. This problem can be reduced by integrating scientific surveys with citizen science data [29]. The occurrence data of Microhyla orientalis in Java is verified by research by [30]. Data from three other species still need to be verified, however incomplete data from ARK are still valuable. For instance, field observations during GO ARK 2017 by a team of students found five individuals of rhacophorid frogs that were similar to the Chirixalus genus, but did not match the species described in that genus [24]. The data was listed as incomplete (need ID) and is not used in our data analysis. After further research, the species are then described as Chirixalus pantaiselatan, a new species [24]. This finding shows that even uncompleted data could bring new discovery and help in increasing record of species diversity in Indonesia.

Most of the data (70%) reported were from Java region. The lowest recorded data come from Papua and Maluku region. Both for amphibian ($\chi^2 = 509.1, df = 15, n = 3993; P < 0.001$; and reptile ($\chi^2 = 410.9, df = 15, n = 4049; P < 0.001$), the distribution of data from six region is similar, where Java region consistently reported the most data compared to other regions from 2017 to 2020 (table 2).

Table 2. Data distribution and number of species reported at ARK project at iNaturalist’ from six regions of Indonesia.

| Region                | Number of Data | Number of Species |
|-----------------------|----------------|-------------------|
|                       | 2017 | 2018 | 2019 | 2020 | Amphibian | Reptile |
| Sumatra               | 154  | 65   | 235  | 544  | 66         | 111      |
| Java                  | 1113 | 921  | 1143 | 2413 | 44         | 127      |
| Bali and Nusa Tenggara| 45   | 191  | 123  | 83   | 11         | 56       |
| Kalimantan            | 93   | 155  | 314  | 63   | 76         | 84       |
| Sulawesi              | 48   | 46   | 27   | 108  | 17         | 50       |
| Papua and Maluku      | 54   | 62   | 7    | 35   | 16         | 52       |

The imbalance of recorded data which mostly come from Java region, especially from West Java province is written by [31]. Mapping the distribution of herpetofauna data of Java and Bali based on specimens from Museum, it is found that most data come from western part of Java [31] which is arguably caused by the ‘museum effect” where sites near museums had higher sampling effort compared to other sites with no museum [32]. Thus, increasing effort in areas with higher sampling gaps will be needed in the future to increase biodiversity data.

Java region not only obtained the highest data but also had the highest contributor compared to other regions. Java region is still the region with the dominant number of contributors every year. In total, there are 265 contributors from Java region. The second highest contributor came from the Sumatra region (83 contributors), continue with Bali and Nusa Tenggara (57 contributors), Kalimantan (43 contributors), Sulawesi (24 contributors), while only 15 contributors from the Papua and Maluku regions, the lowest number compared to other regions. Number of contributors has a correlation with the amount of data obtained (figure 6). This is indicated by the Java region which has the largest amount of data and at the same time has the highest contributor among other regions.
Both for amphibian ($\chi^2 = 458.9, \ df = 15, \ n = 3993; \ P < 0.001$; and reptile ($\chi^2 = 491.2, \ df = 15, \ n = 4049; \ P < 0.001$), the distribution of data from 6 provinces in Java is similar. Consistently, most reported data came from the provinces of West Java (65%) followed by Yogyakarta (15%), Central Java (10%), East Java (5%) and Banten (3%). The capital city of Jakarta are the province with the lowest data recorded in Java region (2%). This is due to the small number of contributors in the city of Jakarta. Compared with West Java province which has 169 contributors, there are only 15 contributors from the city of Jakarta. The low number of contributors from city of Jakarta could be caused by the lack of herpetofauna monitoring or observation activities involving general public.

A total of 433 species were reported (152 species amphibians and 281 species reptiles). About 79% of amphibian species has been reported were Least Concern (LC) in the IUCN Red List Status (IUCN 2021); eight species had not been evaluated against criteria of IUCN Red List (Kurixalus chaseni, Leptomantis malknusi, Limnonectes conspicillatus, Limnonectes hikaidai, Polypedates iskandari, Pulchrana fantastica, Rhacophorus norhayatii), six species were in Data Deficient (DD) status (Leptobrachella fritinniens, Limnonectes khasianus, Oreophryne frontifasciata, Papurana grisea, Sigaleagephyrus mandailinguensis, Sumaterana crassiovii), seven species were in Near Threatened (NT) status (Alcalus rajaie, Chirixalus vittiger, Limnonectes blythii, Limnonectes malesianus, Limnonectes paramacrodon, Nectialus pictus, Rhacophorus reinwardtii), three species were in Vulnerable (VU) status (Meristogerys jerboa, Microhyla orientalis, Ranoidea rupeppelli), six species were in Endangered (EN) status (Barbourula kalimantanensis, Chirixalus nauli, Chirixalus trilaksonoi, Leptophryne javanica, Meristogenys penrissenensis, Pulchrana centropeninsularis), and two species were Critically Endangered (CR) status (Leptophryne cruentata and Philautus jacobsoni).

From all the reported amphibian species, Duttaphrynus melanostictus was the most common species with a total of 475 data (table 3). The ten most common amphibian recorded were species with Least Concern (LC) status in the IUCN Red List and not protected by Indonesia Regulation.

| Species                  | Status | 2017 | 2018 | 2019 | 2020 | Total |
|--------------------------|--------|------|------|------|------|-------|
| Duttaphrynus melanostictus | LC     | 78   | 79   | 56   | 262  | 475   |
| Polypedates leucomystax  | LC     | 70   | 66   | 70   | 219  | 425   |
| Chalcorana chalconota    | LC     | 73   | 50   | 86   | 151  | 360   |
| Phrynoidis asper         | LC     | 39   | 37   | 41   | 79   | 196   |
| Fejervarya limnocharis   | LC     | 32   | 26   | 37   | 98   | 193   |
| Odorrana hosii           | LC     | 32   | 22   | 62   | 41   | 157   |
| Hylarana erythraea       | LC     | 10   | 13   | 37   | 81   | 141   |
| Limnonectes kuhlii       | LC     | 35   | 29   | 25   | 38   | 127   |
| Leptobrachium hasseltii  | LC     | 36   | 24   | 27   | 29   | 116   |
| Fejervarya cancrivora    | LC     | 10   | 20   | 17   | 66   | 113   |

| LC =Least concern |

Table 3. List of the ten most common amphibian species recorded in ARK project at iNaturalist from 21st April 2017 to 31st December 2020

Half of the reptile species (51.6%) were considered as the Least Concern and 39% had not been evaluated against IUCN Red List criteria. There were four species reported as Critically Endangered (CR) species (Eretmochelys imbricata, Leucocephalon yuwooni, Manouria emys, Ornithia borneensis), five species were Endangered (EN) status (Chelonia mydas, Cuora amboinensis, Heosemys spinosa, Indotestudo forstenii, Pelochelys cantorii), nine species were Vulnerable (VU) status (Amyda cartilaginea, Dermochelys coriacea, Draco fimbriatus, Lepidochelys olivacea, Notochelys platynotan, Ophiophagus Hannah, Pelodiscus sinensis, Siebenrockiella crassicollis, Varanus komodoensis), four
species were Near Threatened (NT) status (*Cyclemys dentata*, *Cyclemys enigmatica*, *Laticauda semifasciata*, *Malayemys subtrijuga*), and four species were recorded as Data Deficient (DD) status (*Chenaspis leucura*, *Dendrelaphis underwoodi*, *Phytolopsis punctate*, *Rhabdophis chrysargoides*). From this, 14 species are protected in Indonesia Regulation which are *Chelonia mydas*, *Chitra chitra javanensis*, *Crocodylus novaeguineae*, *Crocodylus porosus*, *Dermochelys coriacea*, *Eretmochelys imbricata*, *Lepidochelys olivacea*, *Manouria emys*, *Oritia borneensis*, *Varanus auffenbergi*, *Varanus komodoensis*, *Varanus nebulosus*, *Varanus timorensis*, and *Varanus togianus*.

The most frequently reported reptile species was *Bronchocela jubata* with 284 data. Almost all of frequently species reported were Least Concern status in IUCN Red List. However, *Calotes versicolor*, *Hemidactylus platyurus*, and *Dendrelaphis pictus* were commonly reported but have not been evaluated by the IUCN Redlist or NA status (table 4).

| Species                  | Status | 2017 | 2018 | 2019 | 2020 | Total |
|--------------------------|--------|------|------|------|------|-------|
| *Bronchocela jubata*     | LC     | 48   | 42   | 69   | 125  | 284   |
| *Hemidactylus frenatus*  | LC     | 35   | 40   | 33   | 146  | 254   |
| *Eutropis multifasciata* | LC     | 54   | 34   | 38   | 76   | 202   |
| *Calotes versicolor*     | NA     | 20   | 22   | 22   | 130  | 194   |
| *Ahaetulla prasina*      | LC     | 30   | 35   | 49   | 72   | 186   |
| *Hemidactylus platyurus* | NA     | 13   | 30   | 26   | 98   | 167   |
| *Cyrtodactylus marmoratus* | LC    | 55   | 22   | 42   | 46   | 165   |
| *Gekko gecko*           | LC     | 24   | 34   | 17   | 81   | 156   |
| *Dendrelaphis pictus*   | NA     | 18   | 29   | 25   | 78   | 150   |
| *Takydromus sexlineatus*| LC     | 17   | 21   | 20   | 52   | 110   |

LC: Least concern, NA: Not evaluated

Data logged into ARK were mostly take placed during GO ARK (56.3%), except in 2019 (figure 2). However, GO ARK in 2020 has an average of 74 data per day which is lower than data in 2017 (188 data per day). The duration of the event in 2017 only a week compared to entire month for GO ARK 2020 (see table 1). Data from 2020 grew rapidly compared to the previous 3 years. One of the contributing factors was the GO ARK event. In 2020, GO ARK was lasted for one month. Compared to the previous year (2019), the event was held for one week. Implementation for one month caused the participants had more time to enter herpetofauna data. This led to the increasing of ARK data in 2020. A total of 416 member contributed data in Amfibi Reptil Kita ranging from 132 (2019) to 181 (2020). There is a significant correlation between number of contributor and data. Increasing number of contributor lead to increasing number of data (figure 3).

The number of data recorded are correlated with the number of participants. It is not surprising that data in ARK is mostly come Java region as the participants are mostly come from Java. The number of ARK contributors for 4 years is lower compared to AWC which recorded 924 volunteers in the 2015 – 2019 period [15]. However, AWC has been running since 1986 in Indonesia compared to ARK which only started in 2017. In contrast, Big Month 2020 has involved 373 contributors in collecting bird data in Java and Bali, and succeeded in collecting 102, 887 data during January 2020 [33]. Compared to Big Month, data collected through ARK is still far below that figure (8,046 data). It is also worth to mention that data obtained through Big Month 2020 is three times the number recorded in Burungnesia since three years of its release. There might be several reasons why ARK is lower than the other two activities: first, four years is relatively short time to popularize this activity but continuity of the program will
increase the number of participants. Secondly, although there is no data on the Indonesian birdwatcher, however birding are popular in the world [34] and probably more popular than herping. Considered that AWC has been conducted since 1985 in Indonesia, the exposure of bird watching to avid wildlife enthusiast in Indonesia has been longer.

From 416 member, 42.5 % has only contributed data during GO ARK and 25.2% has contribute data more than one year. This shows that annual activities such as GO ARK can be a trigger for the community to be involved in contributing to citizen science as gaming of the activities through and competitions and award systems might increase the interest of participant [35]. This might explain the reason that number of contributors is higher during GO ARK compared to non GO ARK. However, in this modern world, there is also the need to advertise activity through social media as has been shown by Big Month 2020 [33]. Through the year, the number of GO ARK participant are increasing because the event started to be known by public. GO ARK 2020 has started to use social media, i.e. Instagram and facebook post and there is higher number of volunteers and data recorded in 2020 compared to other GO ARK, despite the activity was conducted during Covid-19 restriction. There is a need to conduct a thoroughly analysis on the motivation of volunteers in ARK project to enable the coordinator scientist to retain the volunteer movement.

![Figure 2](image2.png)  
**Figure 2.** ARK and GO ARK data comparison.

![Figure 3](image3.png)  
**Figure 3.** Correlation between number of contributor and data received based on region.

4. **Conclusion**

ARK project contributed 39.48% of amphibian data and 38.86% reptile data from total herpetofauna of Indonesia. However, the data is still valuable as data source for new species discovery and distribution modelling. Data submitted and contributors are still dominated by the Java region. However, there was an increase in participants and data obtained in 2020. This shows that the ARK project has the potential to continue to grow over time.

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