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Atlas of the butterflies and moths of Nigeria, LepiMap report, 2010–2021

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Abstract: Interest in citizen science, notably biodiversity mapping, has soared recently in Africa, owing to several converging factors. First, is the growing recognition that biodiversity is threatened, and second, there is a need for collective effort among the public to improve the state of biodiversity, driven by human activities. Amongst the important biodiversity components is Lepidoptera (butterflies and moths) which underpin crucial roles in the ecosystem. Although Lepidoptera has been a major field of study for the past decades, its ecology and distribution have only recently gained important attention among the public, particularly in West Africa. This paper reports on the number of butterflies and moths recorded for Nigeria on the LepiMap database. The database contains 1578 records from January 2010 up to August 2021, from 98 quarter-degree grid cells of the 1306 grid cells in Nigeria (7.5% of grid cells). There are 1219 recorded identified to species level (77%), with 359 awaiting identifications, mostly moths. The number of Lepidopterans recorded was 219 species belonging to 16 families. The most frequently recorded species were *Catopsilia florella* (28 grid cells, 64 records), *Telchinia serena* (27 grid cells, 61 records), and *Danaus chrysippus alcippus* (23 grid cells, 49 records). One of the most important successes of LepiMap during the last three years in Nigeria was the increase in the number of observers and coverage by 600%, which is crucial to gathering lepidopteran mapping data for conservation action. It is recommended that data collection be geared toward areas having no or low coverage, yet refreshing old records are also important for understanding changes in species composition across grid cells.

Key words: Citizen science, conservation policy, Nigeria checklist, species richness, quarter-degree grid cells
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INTRODUCTION

More than 20 000 species of Lepidoptera have been described in Sub-Saharan Africa and these beautiful terrestrial invertebrates are conspicuous and perhaps amongst the most diverse of all insect species (Van Huis, 2019; Gillot, 2005). They are closely associated with plants and assume a vital role in the ecosystem. Butterflies and moths serve as important chains in the food web and are good biological indicators as well (Fleishman *et al.*, 2000). Despite their small sizes, Lepidopterans are great fliers, and species such as the *Vanessa cardui* have been observed to cover an incredible distance during migration (Stefanescu *et al.*, 2021). This capacity to fly has given Lepidoptera an improved chance of survival over many other organisms (Schowalter, 2016). The flight behaviour has also enhanced the ability of butterflies to discover new food sources, avoid predators and unfavourable weather.

Sadly, in the past several decades, butterflies have suffered large population decreases, in part due to the influence of human disturbances, such as habitat loss, deforestation, and climate change (Devictor *et al.*, 2012). This is evident from the intensive monitoring programs done in Europe (Devictor *et al.*, 2012; Warren *et al.*, 2021). In South Africa, two conservation studies on butterflies were completed in 2013 and 2020, respectively. Mecenero *et al.* (2013) determined that one in five butterfly species in the Southern African region (South Africa, Lesotho and eSwatini) were under threat of becoming extinct. Mecenero *et al.* (2020) subsequently reassessed the conservation status of these threatened butterflies, identified the most important threats that negatively impact these species, and analysed how effectively protected area networks are protecting these butterfly species. Altermatt (2010) highlighted that climate change is responsible for causing geographic range changes, changes in butterflies' population dynamics, and reduced fitness. In Nigeria, as elsewhere on the continent, butterfly populations are in decline because of habitat disturbances, almost all from the forest ecosystems, largely due to deforestation and agricultural expansion (Atu *et al.*, 2013). Because Nigeria is among the most populous countries in the world and urbanisation is surging, butterflies would continue to be threatened. Insufficient data and standardized monitoring protocol would compound the existing challenges to monitoring butterfly populations and conservation.

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This paper provides the first report on what LepiMap – a distribution map for butterflies and moths has accomplished in Nigeria from 1 January 2010 up to 23 August 2021. It gives the checklist of Lepidopterans recorded across quarter-degree grid cells (QDGCs) in Nigeria during this period. A QDGC is a unique identification method for an area on a map based on the geographical coordinate system, defined by latitude and longitude (http://thebdi.org/2019/06/27/quarter-degree-grid-cells-made-simple/). Each QDGC is approximately 27.4 x 27.4 km^2 and divides Nigeria into 1306 squares in which butterfly species are recorded. Even more than that, the paper gives an overview of the historical and recent studies of Lepidoptera in Nigeria. It is hoped that this paper will serve as a baseline study to develop a better understanding of the distribution of Lepidoptera (as more and more records are submitted on the LepiMap) for many years to come in Nigeria, which is fundamental for conservation purposes.

An overview of the history of Lepidoptera research in Nigeria

A great collection of literature on Nigerian Lepidoptera is well documented by early explorers and nature enthusiasts since 1899 (Butler, 1901). However, most of these collections are out of the reach of ordinary people, catalogued by some of the world's oldest museums, or published by scientific journals (e.g., the Nigerian Field and Nigerian Entomological Magazine). However, as indigenous Nigerians are beginning to develop a strong interest in butterflies and increasing environmental awareness driven by citizen science, the need to acknowledge these previous studies and provide a clearer direction for future studies by indigenous Nigerians has become crucial. To contextualise this report, we provide an overview of the studies of Nigerian Lepidoptera during the past 123 years.

From 1901–1949:

- Notable studies reported on the various families of Nigerian Lepidoptera such as Pieridae, Papilionidae, and Nymphalidae; biology, and life histories (Sharpe, 1902; Farquharson, 1922; Haig, 1933; 1936a, 1936b, 1937, 1938a, 1938b).
- Food plants of Nigerian insects (Golding 1931, 1935, 1937, 1940, 1947).

From 1950 onward:

- Checklists on Nigerian butterflies, breeding behaviour, and distribution become apparent (Pring & Roche, 1952; Boorman & Roche, 1957; Boorman & Roche, 1959; Boorman, 1961, 1965, 1973, 1977a, 1977b; St-Leger, 1965, 1984; Rosevear, 1978; Cornes, 1967, 1969; Cornes & Riley, 1970; Cornes *et al.*, 1973; Boorman & Taylor, 1977; Peterson, 1977; Medler 1980; Larsen *et al.*, 1980; Dowsett *et al.*, 1989).
- West African butterflies and moths (Boorman, 1970).
- Taxonomic changes (Larsen, 1969; 1975a, 1975b, 1994, 1995a, 1996a, 1996b; Wojtusiak & Knoop, 1994; Larsen & Boorman 1995; Hecq & Larsen, 1997; Pyrcz *et al.*, 2011; Sáfián *et al.*, 2016; Pyrcz & Sáfián, 2018; Knoop, 1988, 2009, St-Leger, 1969, 1989, 1995).
- Forest Reserves, Game Reserves, and Parks (Hopkins, 1970; Riley & Cornes, 1970a; Riley & Cornes, 1970b; Dike, 1988; Callaghan 1992; Larsen, 1996a, 1997a; Knoop, 1998; Brattström, 2008, 2009a, 2009b, 2010).
- Butterfly migrations (Maclaren, 1952; Larsen, 1968, 1978, 1981,1995b; Reid *et al.*, 1990).

Although we tried to present all the works, it is very likely that some may be missing, particularly unpublished works. This makes it impossible to provide a comprehensive list of the published works on Nigerian Lepidoptera. For example, from 1979 up to the early 1980s, EFI "Ted" Baker collected butterflies from all parts and regions of Nigeria, but he was unable to publish his collections. Nevertheless, the data are mostly curated in the Institute of Agricultural Research (Ahmadu Bello University, Zaria, Nigeria), the University of Ibadan, or Moor Plantation, Ibadan, Nigeria, and the Natural History Museum, London (Jon Baker and Abubakar Ringim, pers. comm.).

From 2000 onward, there have been sporadic studies on butterflies by indigenous researchers, mainly on diversity (for example, Ojianwuna, 2015, Alarape *et al.*, 2015, Sáfián & Warren, 2015, Kemabonta *et al.*, 2015, Yager *et al.*, 2016, Ojianwuna & Amusan, 2019). Of particular interest, Nneji *et al.*, (2020) demonstrated a novel method for assessing moth biodiversity in Nigeria. Their studies showed that DNA barcoding is efficient, more promising, and a vital tool for the identification of Nigerian moths. Very recently, Brattström (2020a, 2020b, 2021c, 2021a, 2021b,) provides updates on the natural histories of the families Papilionidae, Pieridae, Nymphalidae, and Lycaenidae.

Unlike the previous checklist recorded by previous studies, this article not only providse a checklist of the Lepidoptera recorded on the LepiMap database, but species richness recorded across grid cells, and eventually, as more data is collected on the database and analysis is improved, the data will become useful to build distribution maps and species distribution models. It is worth noting that information related to where and when species are last recorded and how species' abundances are changing spatially and temporally is crucial for biodiversity conservation planning and monitoring. It can also be used to develop a national Red List and in assessing the rate of decline in not only rare, but also widely distributed species as was done in South Africa with the SABCA and SALCA studies.

METHODS AND MATERIALS

Description of Nigeria

Nigeria is situated in the West African region and borders the Atlantic Ocean in the Gulf of Guinea. The human population in the country was estimated at 200 million in 2019 (United Nations, 2019). The country has many natural resources and a diverse landscape supporting unique flora and fauna. Nigeria's landscape ranges from semi-desert area and dry savannah in the north/northeast to Guinea savanna, and lowland rainforest in the south, as well as mountains in the south and north-eastern parts (Fig. 1). The climate in Nigeria is very variable yet there are two defined seasons: a dry season and a wet season. The dry season begins from November to May and is accompanied by dust commonly known as Harmattan. The wet season is firmly impacted by the air mass of the South Atlantic Ocean, which alludes to the southwest or Tropical Maritime, beginning from May to October (Eludoyin & Adelekan, 2013).

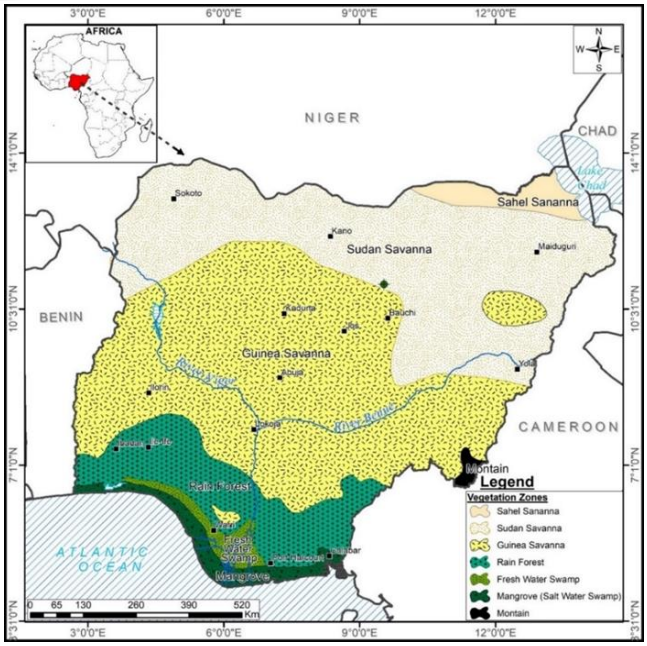

Figure 1 – Map of Nigeria showing different vegetation zones

What is LepiMap?

LepiMap is a citizen science project launched in May 2007 by the Animal Demography Unit (ADU), now coordinated by the Fitzpatrick Institute of African Ornithology, University of Cape Town, and the Biodiversity and Development Institute (BDI), South Africa (http://vmus.adu.org.za). The primary aim of LepiMap is to determine the distribution and conservation priorities of butterflies and moths on the African continent, including building 21st century distribution maps. LepiMap is a joint project of the ADU, The Lepidopterists' Society of Africa (LepSoc), and the BDI. LepiMap is a continuation of the butterfly Virtual Museum (VM) that contributed to SABCA, and then also to SALCA.

The method of uploading the photographic records on the LepiMap database involves the use of a digital camera, or phone to snap butterflies and moths and upload them into the database at http://vmus.adu.org.za. The step-by-step process of the submission can be found at www.youtube.com/watch?v=ZuBujknZ4Pg. Once a record is submitted from a particular QDGC but not identified to the species level, the colour of the QDGC will change from colourless to yellow, but the number of species will be counted as zero. Hence, in a grid cell with only one record, if the record has not been identified to species level, the grid cell on the map will appear yellow with a zero. As more records are submitted from that QDGC and they are identified, the colour of the grid cell will become progressively darker in shades of red and the number of identified species will appear in the QDGC (e.g., Figs 2 & 3). Identifications of the butterfly and moth species on LepiMap are done by an expert panel, and the taxonomic nomenclature follows Williams (2022).

Data and utilisation

The data used in this article are derived from the LepiMap database available at http://vmus.adu.org.za, and is a product of an extensive biomapping activity from 2019 to 2021. The Nigerian Bird Atlas Project (NiBAP) was the first citizen science project in the country with the goal of mapping the distribution of birds occurring in Nigeria, the

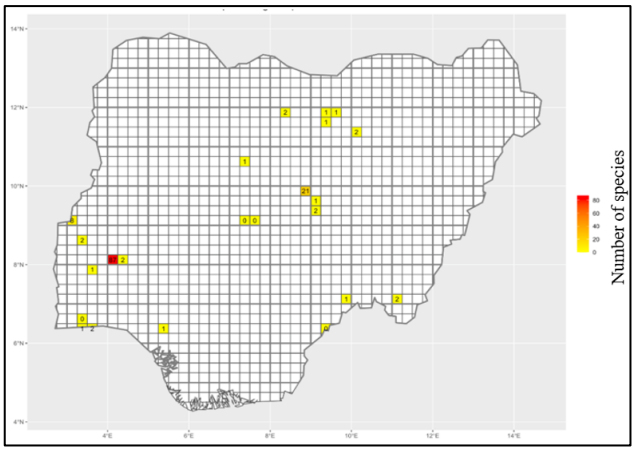

Figure 2 – Lepidoptera species richness recorded on LepiMap database (up to November 2017) from 21 QDGCs, 1.6% (n = 1306) of the total number of QDGCs in Nigeria.

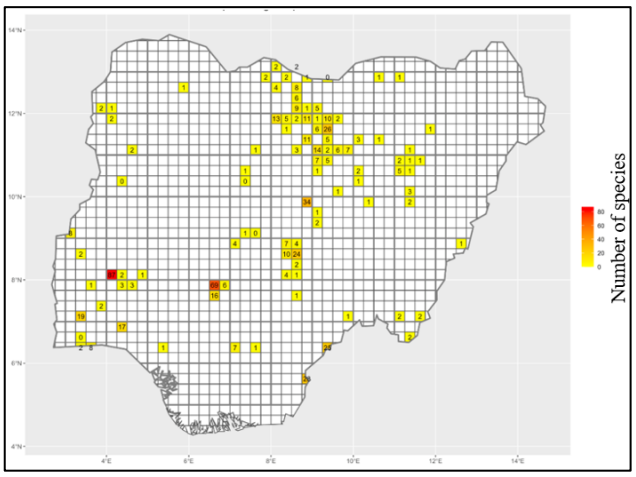

Figure 3 – Lepidoptera species richness recorded on the LepiMap database (up to 23 August 2021) from 98 QDGCs, 7.5% (n = 1306) of the total number of QDGCs in Nigeria.

continuous engagement in this exciting project has allowed the authors to accumulate Lepidoptera records during many of the bird atlas expeditions. However, the LepiMap database also contains butterfly records prior to November 2017 which were mostly recorded by visitors to Nigeria, and these are also included in the results.

Fig. 2 above is a Lepidoptera species richness map of Nigeria prior to November 2017, while Fig. 3 is a Lepidoptera species richness map of Nigeria up to August 2021. Impressively, between November 2017 and August 2021, the data submitted by citizen scientists improved by 600%. This corresponds to the period when biomapping was introduced to citizen scientists in Nigeria during the first workshop on Atlasing and Bird Monitoring in Africa at A.P. Leventis Ornithological Research Institute. QDGC's with more than 20 species improved from 2 to 6 while the number of QDGC's with records improve from 23 to 98.

The ggplot2 in R statistics (R Development Core Team, 2019) was used to generate the richness maps. The process involves creating a quarter-degree grid, binding it to a shapefile of the country (Nigeria), and then assigning each LepiMap record to its respective grid cell based on the altitudinal/longitudinal midpoint of the grid cell. A colour

gradient is assigned to show where richness is greatest. It should be noted that the data are currently insufficient to generate species distribution maps; thus, the maps presented are showing species richness in each grid cell. Grid cells lacking coloration do not have a single record.

RESULTS

What is the progress so far?

The data consisted of 1578 records from 98 QDGCs (7.5% of the 1306 QDGCs in Nigeria) submitted by citizen scientists from Nigeria between 1 January 2010 to 23 August 2021. Three observers contributed 1129 (over 72%) photographic records to the LepiMap database over the reporting period. The total number of citizen science observers for the reporting period is 21 (Table 1), compared with only 3 observers prior to November 2017, increasing the number of observers and coverage by 600%. Of the 1578 records, 1219 (77%) records had been identified to the level of species and the remainder (359 records, 23%) are still awaiting identification. These unidentified records are mostly moths. The identified records comprise 219 species of butterflies and moths belonging to 16 families (see Appendix). For butterflies identified to species level, the percentage of the total butterflies in Nigeria (over 1300 species) is approximately 14%. Even though not all submitted records are identified to species level, most of the photographic records have been identified to family or genus levels. A total of 1208 grid cells (92.5%) still have no records of Lepidoptera in Nigeria. Most of these grid cells have no active butterfly mappers in the area, are inaccessible, or are in insurgent areas.

Table 1 – The data presented in this table show the 21 LepiMap observers who submitted records for the reporting period (1 January 2010 to 23 August 2021) in Nigeria.

Observer	Records	Species	QDGC	ID O/S
Abubakar, H.M.	21	13	4	3
Atabo, L.	284	86	16	25
Atama, N.	1	1	1	0
Braimoh, B.	32	10	6	15
Brooks M	1	1	1	0
Cronje, P.*	22			
Dickinson, R.*	481			
Elisha, E.B.	3	2	1	1
Gurumse, W.P.	7	3	1	4
Ibrahim, J.I.	14	13	1	1
Magaji, A.S.	14	10	2	0
Muhammad, J.	6	5	2	0
Muhammad, S.I.	5	3	3	1
Nyam, L.	1	1	1	0
Okafor, C.	11	9	1	2
Owolabi, B.	10	8	4	1
Ringim, A.S.	364	125	60	48
Tende, T.	8	7	5	1
Underhill L.G.*	8			
Uwatt, A-A.	5	4	1	1
Wilson, M.*	1		1	

* Non-Nigeria citizen scientists that have an unconfirmed number of records from Nigeria.

Of the species recorded since January 2010, five species have not been recorded for more than 10 years (Table 2). A further three species: *Charaxes cynthia cynthia*, *Charaxes etesipe etesipe*, and *Charaxes varanes vologeses* have single records except for *C. e. etesipe* with two records and were all last recorded in September 2011 (Appendix).

Table 2 – The five species of Lepidoptera not recorded for more than 10 years in Nigeria. Some scientific names have been abbreviated

Family	Species and common name	Date last recorded
Nymphalidae	*Pseudacraea b. boisduvalii* Boisduval's False Acraea	2010.01.16
Lycaenidae	*Borbo f. fatuellus* Long-horned Swift	2010.01.18
Hesperiidae	*Fresna netopha* Common Acraea Skipper	2010.05.04
Hesperiidae	*Anthene liodes monteironis* Liodes Hairtail	2010.05.04
Hesperiidae	*Meza meza* Common Missile	2010.09.19

The most frequently recorded species were *Catopsilia florella* (28 grid cells, 64 records), *Telchinia serena* (27 grid cells, 61 records), and *Danaus chrysippus alcippus* (23 grid cells, 49 records). The 10 most recorded species via LepiMap in Nigeria are presented below in Fig. 4, with examples in Figs 5 and 6.

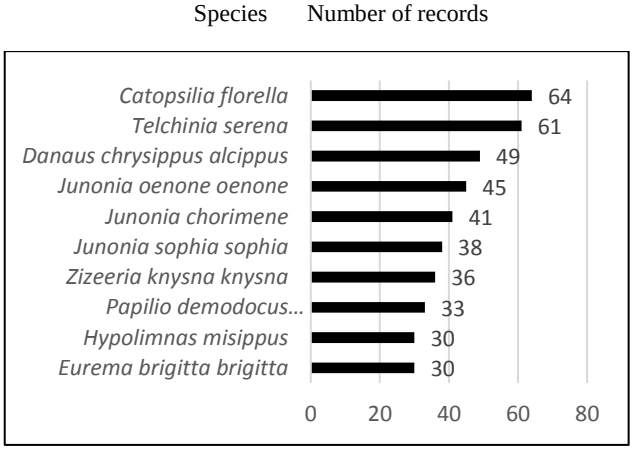

Figure 4 – The ten most recorded species on LepiMap in Nigeria. Note: The genus name *Eurema* has been replaced by *Terias.*

Figure 5 –*Catopsilia florella* has the most records (64) in the Nigerian LepiMap database, and is well camouflaged amongst the leaves. This record from Dambatta, Kano state is curated at: https://vmus.adu.org.za/?vm=LepiMAP-724531.

Figure 6 –*Telchinia serena* has the second most records (62) in the Nigerian LepiMap database. This record from Dutse, Jigawa State is curated at: https://vmus.adu.org.za/?vm=LepiMAP-724975.

The highest Lepidoptera species records in the 98 QDGCs with records in Nigeria was 87 (NE_008004AA, Fig. 7), containing the town of Ogbomosho (Oyo State, SW Nigeria) about 230 km northeast of Lagos. The area around Ogbomosho is forest under pressure from logging, agriculture, and urbanisation. All the 481 Lepidoptera records from here were submitted by Rob Dickinson prior to 2017.

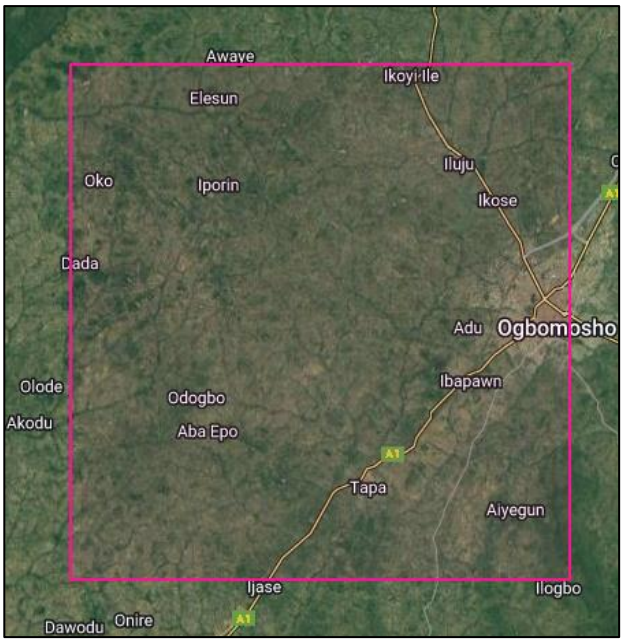

Figure 7 – Satellite image of QDGC NE_008004AA, with 87 recorded species up to 23 August 2021 – Ogbomosho and surrounds.

The second highest species records were in QDGC NE-007006DC (Fig. 8) where Lokoja is located (capital of Kogi State – 200 km southwest of Abuja) at the confluence of the Niger and Benue rivers. The area is more mountainous with Guinea Savannah forest vegetation types and transitions between rainforest and savannah in some intact areas (See Fig. 8). All the Lepidoptera records from here were submitted by Lucky Atabo post-2017.

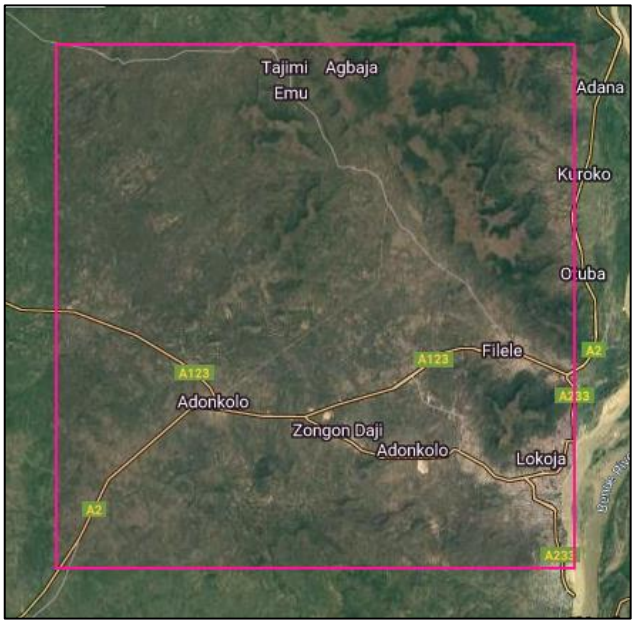

Figure 8 - Satellite image of QDGC NE_007006DC with 69 recorded species up to 23 August 2021 – Lokoja and surrounds.

DISCUSSION

Previous studies showed that the occurrence of some butterfly species is more common than others and widely distributed throughout the year, while some fly only seasonally (Stamp, 1980; Fleishman *et al.*, 2000). Some species are extremely rare across a wider landscape but could be common in specific areas. *Cacyreus virilis*, for instance, is known to be rare in West Africa but common on the Jos Plateau in Nigeria (Brattström, 2020c).

The range of some recorded species is restricted around the Mambilla and Obudu mountain ranges in the northeast/south-south of the country (e.g., *Precis silvicola*, *Tuxentius margaritaceus*, *Junonia gregorii*, and *Uranothauma nubifer nubifer*), respectively. *Celaenorrhinus dargei* is also only known from the Obudu Plateau (Brattström, 2020a, 2020b), whereas *Vanessula milca* does occur on these plateaus, it can also be found in the lowland forests of Cross River (Brattström, 2021b). By contrast, *Precis antilope* and many others are also found on the two plateaus but have a wide distribution range as it is also present in the Savanna habitats (Brattström, 2020b). While many species are forest specialists including members of the genera *Euphaedra*, *Protogoniomorpha*, *Papilio*, *Bicyclus*, *Terias*, several species like *Cacyreus lingeus*, *Anthene liodes*, *Anthene larydas*, *Salamis cacta*, *Hypolimnas anthedon anthedon*, *Protogoniomorpha parhassus*, *Nepheronia argia argia*, *Junonia terea*, *Papilio cynorta*, *Papilio nireus nireus* occur in degraded habitats and transition zones between forests and savannah. *Papilio demodocus* is a species found everywhere from savannah to urban areas and deep forests (Brattström, 2021c). Several species such as *Junonia stygia*, *Junonia hierta*, *Junonia chorimene*, *Junonia oenone*, *Tuxentius cretosus*, *Eronia cleodora*, *Graphium angolanus*, *Colotis protomedia* (found only in Sudan Savannah in the north-eastern country) are mostly species of the Sudan and Guinea savannah (Brattström, 2021b). While most *Colotis* species are also found in Sudan Savannah, some members occur in the southern parts of the country. A few species

Figure 9 – From left to right, top to bottom: *Mylothris chloris chloris, Charaxes epijasius, Colotis danae eupompe, Acraea rogersi, Aterica galene galena, Kallimoides rumia jadyae, Iolaus ismenias, Charaxes eurinome eurinome, Anthene lunulata grosei.*

have affinities to swampy habitats, e.g., *Leptotes pulchra*, which is considered local and rare in West Africa (Brattström, 2020c).

While migration is not that common among butterflies, *Vanessa cardui*, performs long-distance seasonal migrations between Africa and Europe (Talavera & Vila, 2017; Cuadrado, 2021). Astonishingly, populations of this butterfly can be found throughout the year in Nigeria, particularly during the dry season in various habitat types, such as Savannah. However, the species rarely penetrate intact forests (Brattström, 2021b). *C. florella* and *Lampides boeticus* are other species that undertake true migrations, especially in response to changes in rain patterns, making them appear in some areas only during some parts of the year. Even so, *L. boeticus* is found on the Jos Plateau all year round (Brattström, 2021a). Some of the records submitted to LepiMap from various locations across Nigeria are shown in Fig. 9 above.

Species not recorded on LepiMap Nigeria

Borbo f. fatuellus is one of the most common skippers in West Africa with very broad habitat tolerance but identifying skippers or looking for them continues to pose challenges even among skilled lepidopterists making it possible to miss some species in the field. It is important to know that many genera such as skippers are also hard to identify to the species level from photographic records, resulting in patchy recordings (Oskar Brattström and Abubakar Ringim, pers. comm.). This results in the subsequent low identification rate of these records to species level on the LepiMap database. Of note, *Leptotes* sp. is extremely hard to identify without DNA analysis or dissection, and only *L. pulchra* can be told apart from wing patterns in Nigeria (Brattström, 2021a).

Likewise, another probable reason for the low records of some species could be due to a lack of interest from some collectors to sample other butterfly habitats like drier forests. *Pseudacraea b. boisduvalii* and *Meza meza*, which appear to be the most common of the larger forest skippers, prefer transitional habitats, making it easy to miss this species in intact forests where most biomapping activities are carried out. Although Larsen recorded *P. b. boisduvalii* as common in the forest/Savannah transition zone, for several years, only about half a dozen were observed around Zaria, and observations from Ibadan, Gambari, and Acharu Forest near Anyigba over the river from Lokoja yielded few individuals within a four-day period (Jon Baker and Abubakar Ringim, pers. comm.), perhaps owing to the very short field visit. Elsewhere, *P. b. boisduvalii* may be uncommon but widespread, particularly in the forested areas in the south, where it was recorded by Steve

Collins (Jon Baker and Abubakar Ringim, pers. comm.). It is suspected that it also occurs in Okomu and Cross River Forests as well. With only a single record of *Hypolimnas salmacis* on the database, the species appears to be a large and quite common butterfly but has a preference to edge forests and rarely penetrates intact rainforest, as is the case with *Junonia sophia*. It is likely that *H. salmacis* is rarely encountered because it spends most of its activity pattern resting or perched underneath large leaves and will only be encountered when flushed out of its resting place (Brattström, 2021b). The species can also be found in dense savannah areas. *Tarucus* sp. is also another genus that is difficult to identify to species level, members of this genus are mostly found in northern Nigeria, mostly in mixed swarms close to their host plant, *Zizyphus sp.* (Brattström, 2020c). Moreover, *Lepidochrysops* sp. that are adapted to dry habitats in the north are thought to be the most complex of all African butterfly genera (Brattström, 2020c).

What are the priority areas for data collection?

There has been tremendous growth recorded in the LepiMap database in the last three-year period in Nigeria, however, there are large parts of the country that still have no LepiMap records. The greater collection of Lepidoptera on the LepiMap database from the northern parts of the country is attributable to the serious commitment by the very few citizen scientists in the region, and the data were mostly collected during bird atlas expeditions based on incidental observations. Most of the initial records prior to 2017 on the database were collected by a handful of nature enthusiasts during their official visits to Nigeria. It is, therefore, worth noting that the impressive increase in coverage and submissions to the LepiMap database and the rise in the number of contributors over the three-year period is largely attributed to the biodiversity awareness raising and participation in citizen science projects during the start of the NiBAP in 2015. Overall, the LepiMap coverage is mostly converged in areas where there is active participation in birding activities and where bird atlas trips have been conducted in the country.

Other factors responsible for the poor biomapping records and coverage across the country are attributed to:

1.) Security challenges in certain parts of Nigeria restrict citizen scientists to go out for biomapping activities, particularly areas in the far northeast and the Niger Delta regions.

2.) Inaccessibility, very remote areas, and rough terrains in some grid cells, such as Mambilla Plateau and the Niger Delta region.

3.) Lack of awareness and importance of biomapping and citizen science activities.

4.) Lack of resources to acquire gadgets, e.g., good cameras for biomapping activities.

5.) Funds required to undertake biomapping expeditions.

As citizen science activities continue to expand in Nigeria, we anticipate a wider coverage and increased submission on the LepiMap database following planned increased biomapping awareness and the formation of the LepSoc West Africa branch (more details available at https://www.dropbox.com/s/3l3uu5xuvukckuo/Butterflies%20conservation%20in%20West%20Africa.pdf?dl=0).

CONCLUSIONS & RCOMMENDATIONS

The increase in the number of observers (from 3 in 2010 to 21 observers in 2021) and coverage of 600% on the LepiMap in Nigeria highlights great enthusiasm. A critical factor is the general growing interest in citizen science in the country since the launch of the Nigerian Bird Atlas Project and the subsequent introduction of the Virtual Museum to upload Lepidoptera photographic records to create a long-term database of butterflies and moths and in the future enable up-to-date distribution models of these species in Nigeria. It is recommended that data collection be geared towards areas where no records have been submitted from, although refreshing older species records from previously visited areas are also important to understand changes in species composition across grid cells.

It is recommended that nature enthusiasts and citizen scientists use the electronic guides on Nigerian butterflies (Brattström, 2020a, 2020b, 2021a, 2021b; available freely at www.bicyclus.se) to improve their general understanding of Lepidoptera studies and conservation. We are aware that many nature enthusiasts have a backlog of photographic records, but because every record is important and any record uploaded on the LepiMap database counts towards biodiversity conservation, they are encouraged to upload these records on the database. It is also recommended that citizen scientists join the LepSoc Africa (www.lepsocafrica.org) to learn about the study and conservation of African Lepidoptera, the African Butterfly Database (https://abdb-africa.org) is also valuable in improving the general knowledge about the biology and distribution of African Lepidoptera.

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APPENDIX

Table 3 – 219 Lepidopteran taxa recorded in Nigerian LepiMap from 98 quarter degree grid cells (QDGCs) between 1 January 2010 and 23 August 2021. Data are: the number of QDGCs in which each taxon has been recorded; total records in LepiMap; and last date recorded. Notes: 1) Records with an asterisk are only identified to family or genus level. 2) Taxonomy follows Williams (2022).

Species code	Family	Scientific name	QDGCs	Records	Last recorded
649970	Brahmaeidae	*Dactyloceras bramarbas*	1	1	30-03-2018
649980	Brahmaeidae	*Dactyloceras lucina*	1	1	15-06-2018
531920	Choreutidae	*Brenthia* sp.*	1	1	01-09-2014
540610	Crambidae	*Trichophysetis whitei*	1	1	13-11-2014
632540	Crambidae	*Prophantis smaragdina*	1	1	23-04-2015
629630	Crambidae	*Cadarena pudoraria*	1	1	05-11-2015
620050	Crambidae	*Achyraco elatalis*	1	1	21-05-2016
517150	Erebidae	*Siccia caffra*	1	1	01-09-2014
652330	Erebidae	*Chiromachla- leuconoe*	1	3	13-09-2014
656060	Erebidae	*Euproctoides acrisia*	2	2	13-11-2014
523100	Erebidae	*Dysgonia torrida*	2	3	19-05-2016
651780	Erebidae	*Afrowatsonius marginalis*	1	13	24-05-2016
539100	Erebidae	*Amata aliciaalicia*	1	1	14-05-2018
652210	Erebidae	*Balacra rubrostriata*	1	1	17-05-2018
651810	Erebidae	*Alpenus maculosa*	2	3	20-08-2018
514190	Erebidae	*Amphicallia* sp.*	2	2	20-08-2018
522040	Erebidae	*Chalciope pusilla*	1	1	20-08-2018
525060	Erebidae	*Hypopyra capensis*	1	1	28-11-2019
539150	Erebidae	*Amata cerbera*	1	1	13-05-2020
539690	Erebidae	*Euchromia amoena*	1	1	17-05-2020
522660	Erebidae	*Cyligramma fluctuosa*	3	4	25-07-2020
517850	Erebidae	*Utetheisa pulchella*	4	4	04-03-2021
522890	Erebidae	*Dysgonia angularis*	1	1	10-05-2021
522020	Erebidae	*Chalciope delta*	1	1	21-06-2021
522710	Erebidae	*Cyligramma latona*	5	5	25-06-2021
555880	Eupterotidae	*Jana* sp.*	1	1	14-05-2018
635240	Geometridae	*Scopula deserta*	1	1	12-11-2014
659640	Geometridae	*Somatina vestalis*	1	1	12-11-2014
634910	Geometridae	*Scopula* sp.*	4	4	14-11-2014
472350	Hesperiidae	*Borbo fatuellus fatuellus*	1	1	18-01-2010
474240	Hesperiidae	*Osmodes* sp.*	1	1	01-05-2010
476690	Hesperiidae	*Fresna netopha*	1	1	04-05-2010
475000	Hesperiidae	*Meza meza*	1	1	19-09-2010
470530	Hesperiidae	*Sarangesa bouvieri*	1	2	28-09-2010
468180	Hesperiidae	Hesperiidae sp.	1	1	04-11-2015
474030	Hesperiidae	*Pardaleodes incerta murcia*	1	2	22-05-2016
470990	Hesperiidae	*Spialia* sp.*	1	1	01-12-2017
470760	Hesperiidae	*Sarangesa phidyle*	1	1	23-11-2019
474510	Hesperiidae	*Acleros* sp.*	1	1	26-11-2019
469830	Hesperiidae	*Celaenorrhinus dargei*	2	2	03-02-2020
472530	Hesperiidae	*Pelopidas thrax*	1	1	22-04-2020
473820	Hesperiidae	*Ceratrichia lewisi*	2	2	20-05-2020
468540	Hesperiidae	*Pyrrhochalcia iphis iphis*	2	2	03-07-2020
671592	Hesperiidae	*Apallaga* sp.*	1	1	06-07-2020
472280	Hesperiidae	*Borbo borbonica borbonica*	1	1	16-10-2020
470410	Hesperiidae	*Eretis lugens*	1	1	09-11-2020
473320	Hesperiidae	*Gorgyra* sp.*	1	1	09-11-2020
468280	Hesperiidae	*Coeliades forestan forestan*	5	9	29-11-2020
475990	Hesperiidae	*Gretna waga*	1	1	17-01-2021
472520	Hesperiidae	*Pelopidas mathias*	4	5	22-05-2021
471150	Hesperiidae	*Ernsta dromus*	1	1	22-05-2021
470620	Hesperiidae	*Sarangesa loelius*	2	2	24-06-2021

Species code	Family	Scientific name	QDGCs	Records	Last recorded
472410	Hesperiidae	*Torbenlarsenia gemella*	3	4	25-06-2021
472100	Hesperiidae	*Afrogegenes hottentota*	1	1	02-07-2021
471340	Hesperiidae	*Spialia spio*	2	4	04-07-2021
476870	Hesperiidae	*Platylesches moritili*	1	2	14-07-2021
472101	Hesperiidae	*Afrogegenes* sp.*	1	1	14-07-2021
469100	Hesperiidae	*Tagiades flesus*	2	9	05-08-2021
475120	Hesperiidae	*Andronymus caesar caesar*	1	1	13-08-2021
461030	Lycaenidae	*Anthene liodes monteironis*	1	1	04-05-2010
452380	Lycaenidae	*Iolaus pollux pollux*	1	1	04-09-2014
464720	Lycaenidae	*Zizula hylax*	1	1	10-05-2016
464960	Lycaenidae	*Eicochrysops hippocrates*	2	2	14-03-2019
464310	Lycaenidae	*Tuxentius margaritaceus*	1	1	14-03-2019
463670	Lycaenidae	*Cacyreus lingeus*	2	11	05-04-2019
460860	Lycaenidae	*Anthene larydas*	2	3	19-09-2019
461490	Lycaenidae	*Anthene sylvanus*	1	1	09-11-2019
446600	Lycaenidae	*Citrinophila* sp.*	1	1	03-07-2020
455520	Lycaenidae	*Pilodeudorix camerona*	1	1	03-07-2020
445650	Lycaenidae	*Larinopoda aspidos*	1	1	11-08-2020
463730	Lycaenidae	*Cacyreus virilis*	1	1	13-11-2020
465310	Lycaenidae	*Euchrysops malathana*	3	3	29-11-2020
464360	Lycaenidae	*Tarucus* sp.*	1	1	10-12-2020
464510	Lycaenidae	*Tarucus theophrastus*	1	1	12-12-2020
458640	Lycaenidae	*Axiocerses harpax harpax*	2	2	31-01-2021
464820	Lycaenidae	*Azanus moriqua*	1	1	09-04-2021
454150	Lycaenidae	*Hypolycaena philippus philippus*	11	18	15-05-2021
464650	Lycaenidae	*Zizina otis antanossa*	4	9	22-05-2021
461090	Lycaenidae	*Anthene lunulata grosei*	3	3	22-05-2021
463550	Lycaenidae	*Uranothauma nubifer nubifer*	1	1	23-05-2021
463230	Lycaenidae	*Lampides boeticus*	4	7	07-06-2021
464470	Lycaenidae	*Tarucus rosacea*	1	1	21-06-2021
452840	Lycaenidae	*Iolaus ismenias*	6	6	25-06-2021
440160	Lycaenidae	*Lachnocnema* sp.*	2	2	25-06-2021
460430	Lycaenidae	*Anthene amarah amarah*	6	6	26-06-2021
440300	Lycaenidae	*Lachnocnema emperamus*	2	2	26-06-2021
463950	Lycaenidae	*Leptotes* sp.*	11	14	28-06-2021
454470	Lycaenidae	*Deudorix antalus*	5	5	30-06-2021
464605	Lycaenidae	*Zizeeria knysna knysna*	16	36	03-07-2021
451060	Lycaenidae	*Myrina silenus silenus*	2	3	06-07-2021
464240	Lycaenidae	*Tuxentius cretosus nodieri*	1	1	11-07-2021
455510	Lycaenidae	*Pilodeudorix caerulea*	1	1	01-08-2021
592030	Metarbelidae	Family Metarbelidae	1	1	08-06-2017
506750	Noctuidae	*Heraclia africana*	1	1	06-09-2014
663440	Noctuidae	*Aecgocera rectilinea*	2	2	04-06-2021
600750	Notodontidae	*Antheua simplex*	1	1	12-09-2014
422270	Nymphalidae	*Pseudacraea boisduvalii boisduvalii*	1	1	16-01-2010
425720	Nymphalidae	*Euphaedra* sp.*	1	8	28-09-2010
437020	Nymphalidae	*Charaxes tiridates tiridates*	1	1	04-11-2011
435360	Nymphalidae	*Charaxes cynthia cynthia*	1	1	08-11-2011
433150	Nymphalidae	*Charaxes etesipe etesipe*	1	3	09-11-2011
430790	Nymphalidae	*Bebearia sophus sophus*	1	5	26-08-2014
425940	Nymphalidae	*Euphaedra medon medon*	1	4	27-08-2014
436640	Nymphalidae	*Charaxes protoclea protoclea*	1	1	03-09-2014
413630	Nymphalidae	*Telchinia pharsalus*	1	1	07-09-2014
437030	Nymphalidae	*Charaxes tiridates tiridates*	1	2	15-09-2014
411190	Nymphalidae	*Acraea eginaegina*	1	3	18-09-2014
414370	Nymphalidae	*Telchinia oreas oboti*	1	1	21-10-2015
413820	Nymphalidae	*Telchinia sotikensis karschi*	1	1	21-10-2015

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409680	Nymphalidae	*Amauris damocles*	1	9	04-11-2015
434640	Nymphalidae	*Charaxes (Charaxes)* sp.*	1	1	18-05-2016
435130	Nymphalidae	*Charaxes boueti*	1	2	19-05-2016
412760	Nymphalidae	*Telchinia acerata*	1	1	22-05-2016
425950	Nymphalidae	*Euphaedra medon medon*	2	3	08-06-2017
434020	Nymphalidae	*Charaxes plantroui*	1	1	23-11-2017
432950	Nymphalidae	*Charaxes catachrous*	1	1	24-11-2017
432270	Nymphalidae	*Charaxes* sp.*	1	1	09-12-2017
432550	Nymphalidae	*Charaxes achaemenes monticola*	2	3	19-12-2017
413890	Nymphalidae	*Telchinia uvui balina*	1	1	18-05-2018
415080	Nymphalidae	*Gnophodes parmeno*	2	3	14-03-2019
437850	Nymphalidae	*Vanessula milca buechneri*	2	3	14-03-2019
435760	Nymphalidae	*Charaxes fulvescens fulvescens*	1	2	14-03-2019
428230	Nymphalidae	*Euphaedra losinga wardi*	1	2	14-03-2019
416530	Nymphalidae	*Bicyclus mandanes*	1	1	14-03-2019
425650	Nymphalidae	*Pseudargynnis hegemone*	1	1	14-03-2019
418740	Nymphalidae	*Ypthimomorpha itonia*	1	1	14-03-2019
439020	Nymphalidae	*Precis silvicola*	1	1	04-04-2019
414860	Nymphalidae	*Lachnoptera anticlia*	1	1	05-04-2019
409020	Nymphalidae	*Sevenia garega*	1	1	05-04-2019
411890	Nymphalidae	*Acraea rogersi*	1	1	19-09-2019
430440	Nymphalidae	*Bebearia cocalia katera*	1	1	19-09-2019
420510	Nymphalidae	*Cymothoe beckeri beckeri*	1	1	19-09-2019
413430	Nymphalidae	*Telchinia lycoa lycoa*	1	1	26-11-2019
438770	Nymphalidae	*Precis actia*	1	1	27-11-2019
416160	Nymphalidae	*Bicyclus dorothea dorothea*	2	2	28-11-2019
438720	Nymphalidae	*Protogoniomorpha parhassus*	4	4	14-12-2019
427680	Nymphalidae	*Euphaedra edwardsii edwardsii*	1	1	01-01-2020
425550	Nymphalidae	*Aterica galena galene*	3	15	03-02-2020
437790	Nymphalidae	*Kallimoides rumia jadyae*	1	3	03-02-2020
436690	Nymphalidae	*Charaxes protoclea protonothodes*	1	1	03-02-2020
438250	Nymphalidae	*Junonia gregorii*	1	1	03-02-2020
409440	Nymphalidae	*Amauris niavius niavius*	3	5	07-03-2020
424010	Nymphalidae	*Euriphene* sp.*	1	1	16-05-2020
439340	Nymphalidae	*Hypolimnas salmacis salamacis*	1	1	16-05-2020
438440	Nymphalidae	*Junonia stygia*	1	1	16-05-2020
434340	Nymphalidae	*Charaxes eurinome eurinome*	3	5	31-05-2020
408630	Nymphalidae	*Ariadne enotrea enotrea*	1	1	31-05-2020
423730	Nymphalidae	*Neptis quintilla*	1	1	08-06-2020
438600	Nymphalidae	*Salamis cacta*	1	1	08-06-2020
410760	Nymphalidae	*Acraea neobule*	1	1	21-06-2020
408470	Nymphalidae	*Byblia* sp.*	2	2	23-06-2020
435240	Nymphalidae	*Charaxes castor castor*	1	1	05-07-2020
422810	Nymphalidae	*Neptis* sp.*	2	4	06-07-2020
425540	Nymphalidae	*Aterica galena galene*	1	1	06-07-2020
430680	Nymphalidae	*Bebearia oxione oxione*	1	1	06-07-2020
671410	Nymphalidae	*Bicyclus sanaos*	1	1	12-07-2020
439415	Nymphalidae	*Catuna* sp.*	1	1	12-07-2020
427030	Nymphalidae	*Euphaedra (Euphaedra)* sp.*	1	1	12-07-2020
427890	Nymphalidae	*Euphaedra harpalyce harpalyce*	1	1	12-07-2020
424600	Nymphalidae	*Euriphene incerta incerta*	1	1	11-08-2020
410950	Nymphalidae	*Acraea zetes zetes*	2	6	30-08-2020
423440	Nymphalidae	*Neptis morosa*	1	1	25-09-2020
409390	Nymphalidae	*Tirumala petiverana*	5	6	09-11-2020
421240	Nymphalidae	*Cymothoe herminia herminia*	1	1	01-12-2020
436010	Nymphalidae	*Charaxes epijasius*	7	7	27-02-2021
408520	Nymphalidae	*Byblia anvatara crameri*	2	7	14-06-2021

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408500	Nymphalidae	*Byblia anvatara acheloia*	1	1	24-06-2021
439300	Nymphalidae	*Hypolimnas misippus*	14	30	25-06-2021
415130	Nymphalidae	*Melanitis leda*	9	10	25-06-2021
409270	Nymphalidae	*Danaus chrysippus alcippus*	23	49	26-06-2021
438050	Nymphalidae	*Vanessa cardui*	3	3	27-06-2021
411840	Nymphalidae	*Acraea pseudegina*	5	12	03-07-2021
414940	Nymphalidae	*Phalanta phalantha aethiopica*	4	4	03-07-2021
434200	Nymphalidae	*Charaxes viola viola*	1	1	03-07-2021
432240	Nymphalidae	*Hamanumida daedalus*	11	12	04-07-2021
438340	Nymphalidae	*Junonia oenone oenone*	12	45	05-07-2021
438280	Nymphalidae	*Junonia hierta cebrene*	12	21	11-07-2021
413770	Nymphalidae	*Telchinia serena*	27	61	14-07-2021
438200	Nymphalidae	*Junonia chorimene*	15	41	14-07-2021
435170	Nymphalidae	*Charaxes brutus brutus*	2	7	14-07-2021
411620	Nymphalidae	*Acraea caecilia*	3	4	14-07-2021
437110	Nymphalidae	*Charaxes varanes vologeses*	3	4	14-07-2021
427460	Nymphalidae	*Euphaedra lutescens*	3	3	14-07-2021
438460	Nymphalidae	*Junonia terea terea*	5	21	18-07-2021
415790	Nymphalidae	*Bicyclus* sp.*	2	3	29-07-2021
438420	Nymphalidae	*Junonia sophia sophia*	7	38	07-08-2021
439130	Nymphalidae	*Hypolimnas anthedon anthedon*	4	23	07-08-2021
438380	Nymphalidae	*Junonia orithya madagascariensis*	18	20	12-08-2021
438970	Nymphalidae	*Precis octavia octavia*	8	9	12-08-2021
413200	Nymphalidae	*Telchinia encedon encedon*	5	6	12-08-2021
438790	Nymphalidae	*Precis antilope*	8	15	17-08-2021
438990	Nymphalidae	*Precis pelarga*	5	10	17-08-2021
429030	Nymphalidae	*Euphaedra themis*	2	4	17-08-2021
413050	Nymphalidae	*Telchinia bonasia*	2	4	17-08-2021
423820	Nymphalidae	*Neptis serena serena*	2	3	17-08-2021
417160	Nymphalidae	*Bicyclus vulgaris*	3	5	21-08-2021
400090	Papilionidae	*Papilio* sp.*	1	2	16-01-2010
400330	Papilionidae	*Papilio cynorta*	1	1	11-05-2020
401340	Papilionidae	*Papilio nireus nireus*	1	1	11-08-2020
401350	Papilionidae	*Papilio nireus nireus*	2	3	10-06-2021
402120	Papilionidae	*Graphium angolanus baronis*	1	1	24-06-2021
400530	Papilionidae	*Papilio demodocus demodocus*	14	33	25-06-2021
402430	Papilionidae	*Graphium leonidas leonidas*	4	4	25-06-2021
400380	Papilionidae	*Papilio dardanus dardanus*	3	7	08-08-2021
402130	Papilionidae	*Graphium angolanus baronis*	10	13	12-08-2021
402910	Pieridae	*Terias (Terias)* sp.*	1	2	24-08-2014
406700	Pieridae	*Mylothris josi*	1	1	14-11-2014
403400	Pieridae	*Nepheronia buquetii buquetii*	1	1	06-05-2016
403590	Pieridae	*Pinacopteryx eriphia tritogenia*	1	1	03-12-2017
404000	Pieridae	*Colotis daira stygia*	1	1	07-12-2017
403950	Pieridae	*Colotis celimene sudanicus*	1	1	21-07-2018
404970	Pieridae	*Leptosia alcesta alcesta*	1	1	16-05-2020
404680	Pieridae	*Colotis protomedia*	1	3	28-06-2020
402950	Pieridae	*Terias desjardinsii regularis*	1	1	03-07-2020
407460	Pieridae	*Belenois calypso calypso*	1	1	06-07-2020
403000	Pieridae	*Terias floricola leonis*	2	2	12-07-2020
403330	Pieridae	*Nepheronia argia argia*	1	1	10-08-2020
404130	Pieridae	*Colotis euippe euippe*	2	15	24-09-2020
403510	Pieridae	*Eronia cleodora*	4	4	24-10-2020
404300	Pieridae	*Colotis evarne*	1	1	31-10-2020
405650	Pieridae	*Mylothris aburi*	1	1	13-11-2020
407450	Pieridae	*Belenois aurota*	15	23	12-12-2020
403780	Pieridae	*Colotis antevippe antevippe*	4	4	02-01-2021

Species code	Family	Scientific name	QDGCs	Records	Last recorded
407620	Pieridae	*Belenois gidica gidica*	1	1	30-04-2021
405200	Pieridae	*Appias epaphia epaphia*	5	14	05-06-2021
403080	Pieridae	*Terias hecabe solifera*	10	13	05-06-2021
403120	Pieridae	*Catopsilia florella*	28	64	25-06-2021
403720	Pieridae	*Colotis* sp.	1	3	25-06-2021
404020	Pieridae	*Colotis danae eupompe*	5	6	26-06-2021
405880	Pieridae	*Mylothris chloris chloris*	11	23	06-07-2021
407530	Pieridae	*Belenois creona creona*	7	11	14-07-2021
402930	Pieridae	*Terias brigitta brigitta*	20	30	20-07-2021
406610	Pieridae	*Mylothris rhodope*	1	1	28-07-2021
405410	Pieridae	*Appias sylvia sylvia*	2	2	01-08-2021
407470	Pieridae	*Belenois calypso calypso*	3	23	13-08-2021
621210	Saturniidae	*Bunaea alcinoe*	1	1	21-06-2020
621020	Saturniidae	Family Saturniidae	1	1	04-10-2020
668090	Saturniidae	*Pseudimbrasia deyrollei*	1	1	03-06-2021
626730	Sphingidae	*Cephonodes hylasvirescens*	1	1	21-05-2016
625940	Sphingidae	Family Sphingidae	1	1	24-04-2017
670820	Sphingidae	*Agrius convolvuli*	1	1	10-04-2020
627350	Sphingidae	*Lophostethus dumolinii*	1	1	11-08-2020
627400	Sphingidae	*Macroglossum trochilus*	1	1	20-09-2020
626830	Sphingidae	*Daphnis nerii*	1	1	04-06-2021