

**PREPRINT**

*Author-formatted, not peer-reviewed document posted on 02/07/2021*

DOI: <https://doi.org/10.3897/arphapreprints.e70930>

---

**Geographical and temporal  
distribution of hawkmoth  
(Lepidoptera: Sphingidae) species  
in Africa**

**Esther Kioko, Alex Musyoki, Augustine Luanga, Mwinzi Kioko,   
Esther Mwangi,  Lawrence Monda**

# Geographical and temporal distribution of hawkmoth (Lepidoptera: Sphingidae) species in Africa

Esther N Kioko<sup>‡</sup>, Alex Mutinda Musyoki<sup>‡</sup>, Augustine E Luanga<sup>‡</sup>, Mwinzi Duncan Kioko<sup>‡</sup>, Esther W Mwangi<sup>‡</sup>, Lawrence Monda<sup>‡</sup>

<sup>‡</sup> National Museums of Kenya, Nairobi, Kenya

Corresponding author: Esther N Kioko ([kiokoesther08@gmail.com](mailto:kiokoesther08@gmail.com))

## Abstract

### Background

Hawkmoths consist of both diurnal and nocturnal species that are an important component of tropical ecosystems, with significant roles as major pollinators of both crops and wild flora. Pollinators are in decline world-wide and there is need for baseline data to inform their conservation strategies. Species data from Museum collections have been shown to be of great value as a tool for prioritising conservation actions in Africa. The National Museums of Kenya (NMK) has a large active entomology collection that is in continuous growth. The NMK's collection of hawkmoths had not been digitized till 2017. This moth family Sphingidae includes about 1400 species and 200 genera worldwide with about 70% of these species occurring in Africa. These moth species can also be used as indicators in biodiversity assessments as they can be easily sampled and identified. However, hawkmoths have rarely been surveyed over the long term for this purpose. Long-term datasets are of unquestionable significance for understanding and monitoring temporal changes in biodiversity. These hawkmoth data have addressed one of the most significant challenges to insect conservation, the lack of baseline information concerning species diversity and distribution and have provided key historic hawkmoth species diversity and distribution data that can be used to monitor their populations in the face of climate change and other environmental degradation issues that are facing the world today. The publication of the hawkmoth species occurrence data records in GBIF has enhanced data visibility to a wider audience promoting availability for use.

## New information

The hawkmoth (Lepidoptera: Sphingidae) collection at the National Museums of Kenya was digitized in 2017 – 2020 and this paper presents details of species occurrence records as in the insect collection at the NMK, Nairobi, Kenya.

The collection holds 5,095 voucher specimens consisting of 87 genera, and 208 species. The collection covers the period between 1904 and 2020.

The geographical distribution of the hawkmoths housed at the NMK covers East Africa at 75%, West Africa at 7%, Southern Africa at 6.9%, Indian Ocean Islands at 4.5%, Central Africa at 4%, Horn of Africa 1.6%, North Africa 0.2% and East-Central Africa at 0.1%.

## Keywords

hawkmoths, Sphingidae, species, diversity, distribution, Africa, National Museums of Kenya.

## Introduction

Hawkmoths are strong flying Lepidoptera which include many pollinating species that typically feed nocturnally but a few feed diurnally at pale-colored flowers with long corollas and a sweet scent (Miller 1997, Johnson and Raguso 2015, Johnson et al. 2016). Increasing attention to pollinators and their role in providing ecosystem services has revealed a paucity of studies on long-term population trends of most insect pollinators in many parts of the world (Young et al. 2017, Chiquetto-Machado et al. 2018). Insect pollinators have been undergoing a decline in abundance, occurrence, and diversity in many parts of the world (Biesmeijer et al. 2006, Ollerton et al. 2014, Macgregor et al. 2016). Using existing records of hawkmoths in museum and private collections over a 112-year period, Young et al. (2017) detected declines in eight species of northeastern U.S. hawkmoth pollinators. Museums therefore have long-term datasets of unquestionable significance for understanding and monitoring temporal changes in biodiversity and that can address one of the most significant challenges to insect conservation, the lack of baseline information concerning species diversity and distribution (Lampe and Striebing 2005, Summerville and Crist 2003). Hawkmoth declines may have ecological effects on both the plants pollinated by these species and vertebrate predators of the moths (Young et al. 2017). Some of the plants pollinated by hawkmoths including orchids are rare (Shevick and Bowles 1986, Martins and Johnson 2007) highlighting the potential conservation consequences of hawkmoth population declines especially in Africa where 70% of the species occur (Kawahara et al. 2009, Ballesteros-Mejia et al. 2013). Though hawkmoths play important roles in the ecosystem in pollination and as indicator species, data on their diversity, temporal and geographic distribution in Africa is limited. The National Museums of Kenya has a large active entomology collection that is in continuous growth (Kioko et al.

2020). The NMK's collection of hawkmoths had not been digitized till 2017 (Kioko et al. 2021). This project was undertaken to excavate data from the NMK collection to avail data on the spatial and geographical coverage of hawkmoth species in Africa.

## General description

**Purpose:** To create an online freely accessible, openly licensed resource for users.

## Project description

**Title:** Digitizing the hawkmoth voucher specimens housed at the National Museums of Kenya.

**Personnel:** Data mining from the National Museums of Kenya collection and additional field data from the Taita Hills ecosystem that forms the northernmost Eastern Arc Mountains was done by Esther N. Kioko, Alex M. Musyoki, Augustine Luanga, Duncan Mwinzi and others. Bioinformatics support for online publication of the data was provided by Esther W. Mwangi and Lawrence Monda.

**Funding:** The project is supported by the JRS Biodiversity Foundation, USA, with co-funding provided by National Museums of Kenya.

## Sampling methods

**Study extent:** The digitized hawkmoth voucher specimens are all from Africa with several regions: East Africa at 75%, West Africa at 7%, Southern Africa at 6.9%, Indian Ocean Islands at 4.5%, Central Africa at 4%, Horn of Africa 1.6%, North Africa 0.2% and East-Central Africa at 0.1%. as shown in Fig. 1. The leading records for East Africa consists of 2,566 from Kenya, 829 from Uganda and 427 from Tanzania.

**Sampling description:** The hawkmoth specimens housed at the NMK Invertebrate collection are as a result of multiple field expeditions and research projects. Most of the specimens lack information on the sampling protocol and, in case a certain method was used, then it was not indicated on the specimen label. The specimens were first catalogued and pinned; they were then preserved by drying in an oven.

**Quality control:** Once the specimens are brought to the invertebrate collection, tax experts revised the associated metadata i.e. species name (taxonomy) and locality. The geographical coordinates that were lacking, as is the case with old museum specimens, were obtained using a geo-referencing web service GEOLocate (Rios 2014) by use of available textual locality data. Verification of the taxonomic names was done by checking against various references (Carcasson 1967, D'Abrera 1986, Kitching and Cadiou 2000, Kitching 2017).

## Geographic coverage

**Description:** The digitized hawkmoth voucher specimens are all from different regions within Africa as follows: East Africa at 75%, West Africa at 7%, Southern Africa at 6.9%, Indian Ocean Islands at 4.5%, Central Africa at 4%, Horn of Africa 1.6%, North Africa 0.2% and East-Central Africa at 0.1%. as shown in Fig. 1.

**Coordinates:** -35.174 and 37.44 Latitude; -17.578 and 52.383 Longitude.

## Taxonomic coverage

**Description:** At the National Museums of Kenya there are 5,095 hawkmoth voucher specimens that have been digitized and published in GBIF through the Integrated Publishing Tool (Kioko et al. 2021). The specimens consist of 243 species belonging to 87 genera, with the leading genera in occurrence records being: *Temnora* at 699, *Nephele* at 535, *Hippotion* at 510, *Polyptychus* at 358 and *Agrius* at 210. Among the species, *Hippotion celerio* is the most abundant with 403 records, *Agrius convolvuli* at 210, *Leucophebia afra* at 137, *Euchloron megaera* at 121, *Nephele comma* at 107, *Hippotion eson* at 103, *Acherontia atropos* at 100, *Andriasa contraria* at 94 and *Cephonodes hylas* at 85.

**Taxa included:**

Rank	Scientific Name	Common Name
family	Sphingidae	Hawkmoths

## Temporal coverage

**Notes:** The digitized hawkmoth collections date from 1904 to 2020. The years 1960-1964 recorded the highest values at 1,689 followed by 2010 – 2020 with 857 records while the period 1900-1909 recorded the least at 4 records (Fig. 2). The voucher specimens were collected throughout the year with the highest month of collection being April with 696 records, followed by December with 570 while the months with least collection records were November with 235 and September with 234 (Fig. 3).

## Collection data

**Collection name:** Invertebrate Zoology Section Collection, National Museums of Kenya

**Specimen preservation method:** Pinned

**Curatorial unit:** Species collecting event.

## Usage licence

**Usage licence:** Creative Commons Public Domain Waiver (CC-Zero)

**IP rights notes:** This work is licensed under a Creative Commons Attribution Non Commercial (CC-BY-NC) 4.0 License.

## Data resources

**Data package title:** Occurrence data of hawkmoths (Lepidoptera: Sphingidae) in the National Museums of Kenya Zoological Collection

**Resource link:** <https://www.gbif.org/dataset/302155f9-49a6-4ee2-a01b-293067ddee2>

**Alternative identifiers:** 302155f9-49a6-4ee2-a01b-293067ddee2, [http://ipt.museums.or.ke/ipt/resource?r=hawkmoth\\_nmk\\_i](http://ipt.museums.or.ke/ipt/resource?r=hawkmoth_nmk_i)

**Number of data sets:** 1

**Data set name:** Occurrence data of hawkmoths (Lepidoptera: Sphingidae) in the National Museums of Kenya Zoological Collection

**Download URL:** <https://www.gbif.org/dataset/302155f9-49a6-4ee2-a01b-293067ddee2>

**Data format:** Excel

**Description:** This resource is a digitized format of data on the occurrence of hawkmoth species housed in the Zoology department, National Museums of Kenya insect collection. The data provides baseline information on the distribution of different hawkmoth species and can be used for future ecology studies on hawkmoths as well as monitoring of population trends in various habitats.

Column label	Column description
occurrenceID	An identifier for the Occurrence
basisOfRecord	The specific nature of the data record
eventDate	The date-time when the event was recorded
year	The four-digit year in which the Event occurred, according to the Common Era Calendar
month	The integer month in which the Event occurred
day	The integer day of the month on which the Event occurred
scientificName	The full scientific name, with authorship and date information if known

higherClassification	A list (concatenated and separated) of taxa names terminating at the rank immediately superior to the taxon referenced in the taxon record
kingdom	The full scientific name of the kingdom in which the taxon is classified
phylum	The full scientific name of the phylum or division in which the taxon is classified
class	The full scientific name of the class in which the taxon is classified
order	The full scientific name of the order in which the taxon is classified
family	The full scientific name of the family in which the taxon is classified
genus	The full scientific name of the genus in which the taxon is classified
specificEpithet	The name of the first or species epithet of the scientificName
taxonRank	The taxonomic rank of the most specific name in the scientificName
nomenclaturalCode	The nomenclatural code (or codes in the case of an ambiregnal name) under which the scientificName is constructed
decimalLatitude	The geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic center of a Location
decimalLongitude	The geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic center of a Location
geodeticDatum	The ellipsoid, geodetic datum, or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude as based
verbatimCoordinateSystem	The coordinate format for the verbatimLatitude and verbatimLongitude or the verbatimCoordinates of the Location
georeferencedBy	A list (concatenated and separated) of names of people, groups, or organizations who determined the georeference (spatial representation) for the Location
georeferencedDate	The date on which the Location was georeferenced
higherGeography	A list (concatenated and separated) of geographic names less specific than the information captured in the locality term
continent	The name of the continent in which the Location occurs
country	The name of the country or major administrative unit in which the Location occurs
countryCode	The standard code for the country in which the Location occurs
locality	The specific description of the place
type	The set of classes specified by the Darwin Core Type Vocabulary, used to categorize the nature or genre of the resource
language	The language in which the resource is written
institutionID	An identifier for the institution having custody of the object(s) or information referred to in the record

institutionCode	The name (or acronym) in use by the institution having custody of the object(s) or information referred to in the record
collectionID	An identifier for the collection or dataset from which the record was derived
collectionCode	The name, acronym, coden, or initialism identifying the collection or data set from which the record was derived
catalogNumber	An identifier (preferably unique) for the record within the data set or collection
IndividualCount	The number of individuals represented present at the time of the Occurrence
organismQuantity	A number or enumeration value for the quantity of organisms
organismQuantityType	The type of quantification system used for the quantity of organisms

## Additional information

Kioko E, Musyoki A, Luanga A, Sese J, Nyangena L, Mwinzi D (2021): Occurrence data of hawkmoths (Lepidoptera: Sphingidae) in the National Museums of Kenya Zoological Collection. v1.7. National Museums of Kenya. Dataset/ Occurrence. [http://ipt.museums.or.ke/ipt/resource?r=hawkmoth\\_nmk\\_i&v=1.7](http://ipt.museums.or.ke/ipt/resource?r=hawkmoth_nmk_i&v=1.7)

## Acknowledgements

We acknowledge and thank the JRS Biodiversity Foundation for the financial support that has facilitated this work. We thank the NMK management for the support that was given to this work.

## Author contributions

Esther Kioko conceived the study, collected field and collection data and wrote the manuscript, Alex Mutinda collected field and collection data, analyzed data, reviewed and edited the manuscript, A. Luanga, and D. Mwinzi collected field and collection data and reviewed manuscript, Esther Mwangi and Lawrence Monda provided bioinformatics skills, reviewed and edited the manuscript. All authors contributed to the manuscript.

## References

- Ballesteros-Mejia L, Kitching IJ, Jetz W, Nagel P, Beck J (2013) Mapping the biodiversity of tropical insects: species richness and inventory completeness of African sphingid moths. *Global Ecology Biogeography* 22 (586595): 586-59. <https://doi.org/10.1111/geb.12039>
- Biesmeijer JC, Roberts SPM, Reemer M, Ohlemüller R, Edwards M, Peeters T, Schaffers AP, Potts SG, Kleukers R, Thomas CD, Settele J, Kunin WE, et al. (2006)

- Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313 (5785): 351-4. <https://doi.org/10.1126/science.1127863>
- Carcasson R (1967) Revised catalogue of the African Sphingidae (Lepidoptera) with Descriptions of the East African Species. *Journal of The East Africa Natural History Society and National Museum XXVI* (3): 1-14. URL: [https://www.biodiversitylibrary.org/content/part/EANHS/XXVI\\_No.3\\_115\\_1\\_1967\\_Carcasson.pdf](https://www.biodiversitylibrary.org/content/part/EANHS/XXVI_No.3_115_1_1967_Carcasson.pdf)
  - Chiquetto-Machado P, Amorim F, Duarte M (2018) Long-term stability of the hawkmoth fauna (Lepidoptera, Sphingidae) in a protected area of Brazilian Atlantic Rain Forest. *Journal of Insect Conservation* 22 (2): 277-286. <https://doi.org/10.1007/s10841-018-0061-0>
  - D'Abrera B (1986) *Sphingidae Mundi: hawk moths of the world: based on a checklist by Alan Hayes and the collection he curated in the British Museum (Natural History)*. EW Classey Ltd, 226 pp. [ISBN 9780860960225]
  - Johnson S, Raguso R (2015) The long-tongued hawkmoth pollinator niche for native and invasive plants in Africa. *Annals of Botany* 117 (1): 25-36. <https://doi.org/10.1093/aob/mcv137>
  - Johnson S, Moré M, Amorim F, Haber W, Frankie G, Stanley D, Cocucci A, Raguso R (2016) The long and the short of it: a global analysis of hawkmoth pollination niches and interaction networks. *Functional Ecology* 31 (1): 101-115. <https://doi.org/10.1111/1365-2435.12753>
  - Kawahara A, Mignault A, Regier J, Kitching I, Mitter C (2009) Phylogeny and biogeography of hawkmoths (Lepidoptera: Sphingidae): Evidence from five nuclear genes. *PLOS One* 4 (5). <https://doi.org/10.1371/journal.pone.0005719>
  - Kioko E, Musyoki A, Luanga A, Kioko M, Mwangi E, Monda L (2020) Swallowtail butterflies (Lepidoptera: Papilionidae) species diversity and distribution in Africa: The Papilionidae collection at the National Museums of Kenya, Nairobi, Kenya. *Biodiversity Data Journal* 8 <https://doi.org/10.3897/bdj.8.e50664>
  - Kioko E, Musyoki A, Luanga A, Sese J, Nyangena L, Mwinzi D (2021) Occurrence data of hawkmoths (Lepidoptera: Sphingidae) in the National Museums of Kenya Zoological Collection. Version 1.7. National Museums of Kenya. 1.7. GBIF. Release date: 2021-5-25. URL: <https://www.gbif.org/dataset/302155f9-49a6-4ee2-a01b-293067ddee2d>
  - Kitching IJ, Cadiou J (2000) *Hawkmoths of the world. An annotated and illustrated revisionary checklist (Lepidoptera: Sphingidae)*. Cornell University Press URL: <http://zoobank.org/32574dd1-5433-4241-8539-70b1e2633402>
  - Kitching IJ (2017) *Sphingidae taxonomic inventory*. URL: <http://sphingidae.myspecies.info/>
  - Lampe K, Striebing D (2005) How to digitize large insect collections — preliminary results of the DIG project. *African Biodiversity* 385-393. [https://doi.org/10.1007/0-387-24320-8\\_38](https://doi.org/10.1007/0-387-24320-8_38)
  - Macgregor CJ, Evans DM, Fox R, Pocock MJO (2016) The dark side of street lighting: impacts on moths and evidence for the disruption of nocturnal pollen transport. *Global Change Biology* 23 (2): 697-707. <https://doi.org/10.1111/gcb.13371>
  - Martins DJ, Johnson SD (2007) Hawkmoth pollination of aerangoid orchids in Kenya, with special reference to nectar sugar concentration gradients in the floral spurs. *American Journal of Botany* 94 (4): 650-9. <https://doi.org/10.3732/ajb.94.4.650>

- Miller WE (1997) Diversity and evolution of tongue length in hawkmoths (Sphingidae). *Journal of the Lepidopterists' Society* 51: 9-31. URL: [https://images.peabody.yale.edu/lepsoc/jls/1990s/1997/1997-51\(1\)9-Miller.pdf](https://images.peabody.yale.edu/lepsoc/jls/1990s/1997/1997-51(1)9-Miller.pdf)
- Ollerton J, Erenler H, Edwards M, Crockett R (2014) Extinctions of aculeate pollinators in Britain and the role of large-scale agricultural changes. *Science* 346 (6215): 1360-1362. <https://doi.org/10.1126/science.1257259>
- Rios NE (2014) Georeferencing natural history collections data: The GEOLocate Project. Digitization Workshop.
- Sheviak CJ, Bowles ML (1986) The prairie fringed orchids: a pollinator-isolated species pair. *Rhodora* 88: 267-290.
- Summerville K, Crist T (2003) Determinants of lepidopteran community composition and species diversity in eastern deciduous forests: roles of season, eco-region and patch size. *Oikos* 100 (1): 134-148. <https://doi.org/10.1034/j.1600-0706.2003.11992.x>
- Young B, Auer S, Ormes M, Rapacciuolo G, Schweitzer D, Sears N (2017) Are pollinating hawk moths declining in the Northeastern United States? An analysis of collection records. *PLOS One* 12 (10). <https://doi.org/10.1371/journal.pone.0185683>

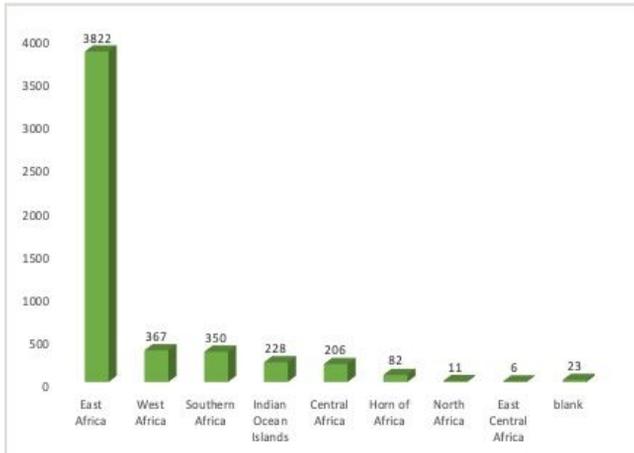


Figure 1.

Geographic coverage of the hawkmoth voucher specimens housed at the National Museums of Kenya.

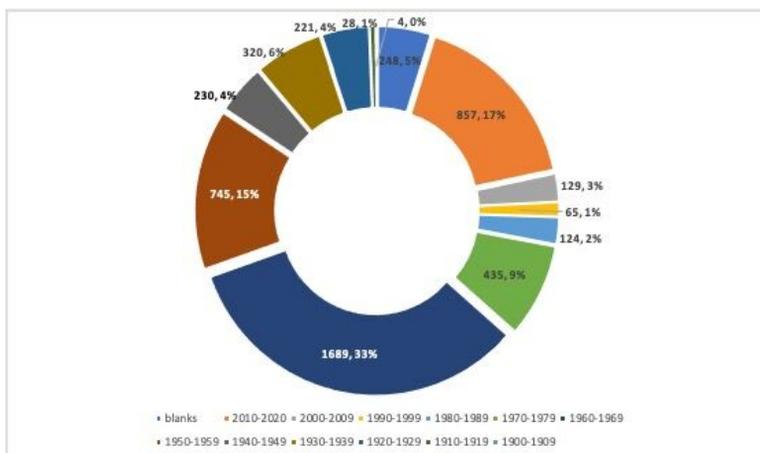


Figure 2.  
Temporal abundance of hawkmoth collection at National Museums of Kenya.

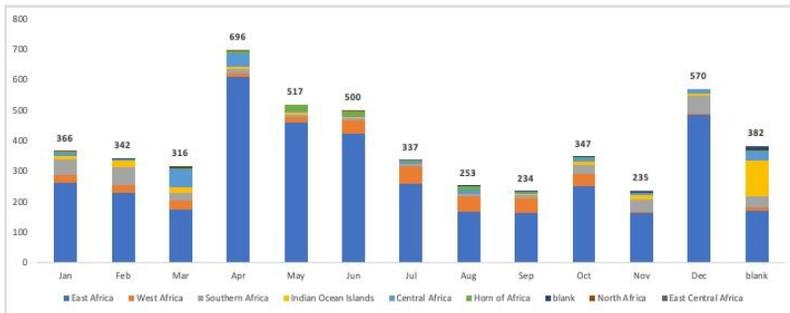


Figure 3.

Monthly abundance of hawkmoth collection at National Museums of Kenya.