

Insights into 260 years of taxonomic research gained from the Catalogue of Afrotropical Bees

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Abstract

We analysed country-scale distribution records of solitary bees (i.e. excluding *Apis mellifera*) in countries in the Afrotropical Region, excluding the southern Arabian Peninsula and Socotra. Although different country estimates of bee species numbers can be explained by differences in climate, vegetation or topography, we concluded that the observed differences are mainly due to differences in sampling effort or taxonomic research intensity in different countries. We characterised three eras of bee taxonomy. The highest rate of species description per annum occurred during the first half of the 20th Century, before generic revisions were prevalent, and when the focus was on consolidating knowledge and developing identification keys. We also researched the locations of type specimens, which included all primary types and syntypes. Most types are housed in western Europe. We describe the Catalogue of Afrotropical Bees (CAB), a biodiversity information system and related GBIF checklist that is the system's standardised, published output. In the revised CAB, all Afrotropical bee genera have been given common names, many of which are new.

Keywords

Apoidea, taxonomy, biodiversity informatics, natural history collections, specimens, Afrotropical Region

Introduction

We describe research strengths and gaps in the taxonomy of non-*Apis* bees ('bees') across most of the Afrotropical Region. We used data extracted from the Catalogue of Afrotropical Bees (CAB) that had been digitised from species descriptions. The work reported below is an example of how data from natural history collections can be transformed into useful biodiversity information that may be applied in different research contexts.

Development of the CAB as a biodiversity information system

The CAB was developed to represent rich, species-level data about Afrotropical bees found in literature. The basic unit of information is a taxon citation, meaning that the CAB is a page-level index of scientific literature on Afrotropical bees, most of which is the output of 260 years of taxonomic research. The CAB is updated regularly and will be useful for future taxonomic research, studies in pollination ecology in the Afrotropical Region or in any research that depends on bee taxonomy.

An important purpose of data published on the GBIF Data Portal from the CAB is to validate bee names and integrate specimen-records from distributed databases (e.g. to relate junior synonyms to senior synonyms). Integrating online data is a major challenge in biodiversity informatics (Jetz et al. 2012).

Specific use-cases of the online CAB, which make it a basic starting point for bee research in any context, include: finding the valid name corresponding to any junior synonym or understanding the nomenclatorial history of any species; generating a list of countries in which a bee species has been recorded or a list of bee species from a given country; generating a list of pages in research articles on which a bee name is cited; finding the type depositories and details of the type designation of bee type specimens; finding the host-plants, nest-plants, parasites or hosts of bee species for which this information was found in literature; finding the common names of Afrotropical bee genera, which were recently added to the CAB.

Objectives

We queried the CAB to analyse and summarise the number of bee species recorded from each country in the Afrotropical Region, mainly to test whether knowledge of the country-scale distribution of bees is lacking. Data from the CAB were supplemented with specimen-records downloaded from the GBIF Data Portal.

We summarised the main periods of research in Afrotropical bee taxonomy and the taxonomic contributions of the main contributors, to try to explain the knowledge gaps we found in the observed country-scale distribution of bees.

We also summarised knowledge of bee type depositories.

In biodiversity informatics our objectives were:

1. To promote awareness of the CAB in the scientific community and explain its development and potential uses;
2. To promote the general need to mobilise (publish or share) high-quality, standardised species-level data, including rich taxonomic data and rich ecological data such as host relationships, which can potentially be used in ecological studies (e.g. pollination studies).

Material and methods

The CAB consists of a customised Specify biodiversity database (Specify Software 2019), for data storage, and a linked Microsoft Access file for queries and automated routines to analyse and summarise the data in the Specify database.

Literature references and bee names had been written on index cards for many years before data capture switched to a digital document. The data from the document were eventually migrated to the Specify database prior to publication of the Catalogue of Afrotropical Bees (Eardley and Urban 2010). During the migration process, the data were extensively cleaned, resulting in a much improved version of the CAB. The Specify database is now used to update the CAB by cataloguing new records of taxon descriptions, nomenclatorial acts, taxonomic acts, authors, articles, country records and ecological information.

VBA scripts in the Microsoft Access file were used to transform nomenclatorial acts and other data (e.g. synonymies, ecological relationships and references to countries, articles and authors), captured as raw data in the Specify database, into an annotated checklist-type Darwin Core Archive. The Darwin Core Archive is a set of text files that express concepts named by standardised terms (Biodiversity Information Standards 2019). The Darwin Core Archive was published on the GBIF Data Portal via an Integrated Publishing Toolkit server. We followed the GBIF best-practice guidelines to publish checklists (Remsen et al. 2010). The CAB is accessible by the following hyperlink: <https://www.gbif.org/dataset/da38f103-4410-43d1-b716-ea6b1b92bbac>

To find country records of Afrotropical bees other than those of the CAB, we searched the GBIF Data Portal for records of the 6 families of Apoidea. We assumed that specimens represented by downloaded GBIF records had been correctly identified.

Results and discussion

Information system development

A significant finding in developing and using the CAB (Figure 1) is that we were able to represent meaningful units of taxonomic research, specifically a citation of

SPECIES | HETEROTYPIC SYNONYM

Megachile reicherti Brauns, 1929

Published in: Brauns, 1929. Neue und auffallende Apidae aus Süd-Afrika. Zeitschrift für Wissenschaftliche Insektenbiologie 24: 130-143
In: Catalogue of Afrotropical Bees

Synonym of *Megachile murina* Friese, 1913

Term	Value
acceptedNameUsagelD	110455
http://rs.tdwg.org/dwc/terms/acceptedNameUsagelD	
subgenus	Chalicodoma
http://rs.tdwg.org/dwc/terms/subgenus	
genus	Megachile
http://rs.tdwg.org/dwc/terms/genus	
kingdom	Animalia
http://rs.tdwg.org/dwc/terms/kingdom	
class	Insecta
http://rs.tdwg.org/dwc/terms/class	
taxonid	109859
http://rs.tdwg.org/dwc/terms/taxonid	
taxonomicStatus	heterotypic synonym
http://rs.tdwg.org/dwc/terms/taxonomicStatus	
order	Hymenoptera
http://rs.tdwg.org/dwc/terms/order	
taxonRank	species
namePublishedIn	Brauns, H. 1929. Neue und auffallende Apidae aus Süd-Afrika. Zeitschrift für Wissenschaftliche Insektenbiologie 24: 130-143
http://rs.tdwg.org/dwc/terms/namePublishedIn	
specificEpithet	reicherti
http://rs.tdwg.org/dwc/terms/specificEpithet	
taxonRemarks	Synonymy: Senior synonym is <i>Megachile</i> (<i>Chalicodoma</i>) <i>murina</i> Friese, by Eardley, C.D. 2012. A taxonomic revision of the southern African species of dauber bees in the genus <i>Megachile</i> Latreille (Apoidea: Megachilidae). <i>Zootaxa</i> 3460: 1-139.
http://rs.tdwg.org/dwc/terms/taxonRemarks	
scientificNameAuthorship	Brauns, 1929
http://rs.tdwg.org/dwc/terms/scientificNameAuthorship	
namePublishedInYear	1929
http://rs.tdwg.org/dwc/terms/namePublishedInYear	
acceptedNameUsage	<i>Megachile</i> (<i>Chalicodoma</i>) <i>murina</i> Friese, 1913
http://rs.tdwg.org/dwc/terms/acceptedNameUsage	
nomenclaturalStatus	valid
http://rs.tdwg.org/dwc/terms/nomenclaturalStatus	
family	Megachilidae
http://rs.tdwg.org/dwc/terms/family	

Figure 1. Part of a typical CAB species page showing basic taxonomic information, including the original name and description article, as well as the senior synonym. The standardised metadata terms, constituting the 'dictionary' of biodiversity concepts, are visible on the left.

a taxon on a page and the specific taxonomic meaning of this citation (e.g. whether it was of nomenclatorial importance and what kind of nomenclatorial act it signified). It was also significant that we were able to customise a Specify database for the purpose of creating a richly annotated checklist of species for publication, both as standardised online data as well as a textual report for conventional publication. The advantage of the textual report is that it can be formatted to show the nomenclatorial history of the species, i.e. to update the checklist of Eardley and Urban 2010 at the click of a button.

By representing nomenclatorial acts (e.g. an original description or a new combination) and taxonomic acts (e.g. a synonymy or a change in taxonomic rank) – as records in the Specify taxoncitation table – we were able to execute a query to sum-

Table 1. A summary of the nomenclatorial and taxonomic acts published in taxonomic articles since 2010.

Year	New combination	Corrected name	Invalid name	New name	Rank change: species to subspecies	Rank change: subspecies to species	Rank change: subgenus to genus	Valid description	Synonymy	Removal from synonymy
2010	36	91		1	4	29		11		
2011	17			1				3	10	
2012	2							23	60	
2013	2	1						8	102	
2014	8		1		1			70	48	
2015								7		2
2016						1	6	5		2
2017	1							3	1	
2018	1					1		5	7	
Total	67	92	1	2	5	31	6	135	228	4

marise all the taxonomic work that has been done since the previous publication of the CAB almost a decade ago (Table 1). A list of species descriptions published since 2010 is given in Appendix 1 and a list of species synonymised or removed from synonymy since 2010 is given in Appendix 2. Taxonomists should find this summarising capability of such a database design useful in their work, especially in compiling a regional, richly annotated checklist of species.

Digitally available knowledge of Afrotropical bees

Of the 1.03 million GBIF specimen-records of bees tagged with country names that we downloaded, only 39 176 (3.8%) were from countries in the Afrotropical Region (Table 2). Specimen-records downloaded from the GBIF Data Portal therefore made a small contribution to the dataset that we used in the analysis presented below.

Country-scale distribution

The analysis of country-scale distribution presented below is for valid species-level names only (i.e. not including junior synonyms or subspecies). We included species described up to and including 2018.

Records of bees other than *Apis mellifera* have been reported from 45 of the 47 African countries or territories constituting the Afrotropical Region as defined by Crosskey and White (1977) (i.e. not from Mayotte nor Guinea-Bissau). The CAB reported 2 783 valid species from the Afrotropical Region. The following introduced species were included in the analysis: *Hylaeus perhumilis* (South Africa), *Megachile semivestita* (Zanzibar) and *Megachile multidentis* (Democratic Republic of Congo).

Table 2. The numbers of African bee specimen-records (containing the country name) published on the GBIF Data Portal by various institutions.

Publishing institution	Number of records
South African National Collection of Insects, Pretoria, South Africa	16 282
Albany Museum, Grahamstown, South Africa	10 671
Kansas University, Lawrence, USA	8 967
Iziko South African Museum, Cape Town, South Africa	1 567
Durban Natural Science Museum, Durban, South Africa	917
Unknown	296
iNaturalist	269
Albany Museum, Grahamstown, South Africa	129
US Department of Agriculture	63
C.A. Triplehorn Insect Collection, Columbus, USA	4
Lund University, Lund, Sweden	3
Muséum national d'Histoire naturelle, Paris, France	3
National Museum of Natural History, Washington DC, USA	2
Natural History Museum, London, UK	2
www.naturgucker.info	1
Total	39 176

The countries of origin of the following 7 valid species remain unknown and they were therefore not included in the country counts: *Thyreus calcaratus*, *Xylocopa ditypa*, *Halictus frontalis*, *Lipotriches quartinae*, *Megachile mastrucatella*, *Megachile mediana* and *Heriades glomerans*.

i) Species-per-country

The 2 776 species with country records were expanded to 7 196 species-per-country combinations. The number of species-per-country records (a potential indication of species richness) ranged from 4 (São Tomé and Príncipe) to 1258 (South Africa, 65 of which were contributed by the GBIF dataset) (Table 3). The GBIF specimen-records added 382 new species-per-country records (combinations of 242 species and 33 countries – see Appendix 3), representing 5% of the data overall. The GBIF country records that agreed with those from the CAB numbered 1 312 or 19% of the total species-per-country records, which again underscores the importance of the CAB country-scale distribution data.

Thirty-four of the 45 countries (76%) had fewer than 200 species (or 7% of Afrotropical species) per country (Table 3). The most species-rich country (South Africa, with 1258 species or 45% of Afrotropical species) had almost twice as many species as the country in second place (Democratic Republic of the Congo, with 640 species or 23% of Afrotropical species) (Table 3). In terms of the percentage of species-per-country records, South Africa had more records than each of the country groups that included 3, 5 and 19 countries, and almost as many as the group containing 11 countries. These observations support the conclusion that knowledge of the country-scale distribution of bees is lacking.

There are other online sources of taxonomic data or species-level information about Afrotropical bees (Atlas Hymenoptera 2019, Discover Life 2019). Discover Life

Table 3. The numbers of species-per-country records and the numbers and proportions of species recorded, stratified into country groups.

Country	Number of species-per-country records	Total species-per-country records (%)	Number of species represented (%)
South Africa	1258	1258 (17.5)	1258 (45)
Democratic Republic of Congo	640	640 (8.9)	640 (23)
Zimbabwe	429	429 (6)	429 (15)
3 countries with > 300 species < 400	Tanzania (389), Kenya (387), Namibia (367)	Total 1143 (15.9)	425 (15)
5 countries with > 200 species < 300	Malawi (268), Uganda (241), Madagascar (236), Ethiopia (231), Cameroon (229)	Total 1205 (16.7)	518 (19)
11 countries with > 100 species < 200	Mozambique (199), Gabon (177), Nigeria (176), Zambia (164), Angola (157), Botswana (149), Senegal (128), Sudan (114), Liberia (106), Republic of the Congo (105), Ghana (101)	Total 1576 (21.9)	369 (13)
19 countries with > 10 species < 100	Somalia (92), Sierra Leone (88), Equatorial Guinea (87), Togo (69), Guinea (60), Lesotho (58), Burundi (52), Ivory Coast (51), Niger (47), Gambia (46), Rwanda (45), Burkina Faso (43), Central African Republic (43), Eritrea (36), Chad (31), Benin (23), Seychelles (18), Eswatini (15), Comoros (12)	Total 916 (12.7)	216 (8)
4 countries with > 1 species < 10	Djibouti (9), Mauritius (9), Réunion (7), São Tomé and Príncipe (4)	Total 29 (0.4)	10 (0.3)
Total		7196 (100)	2 776

reports 1 161 species of bees in South Africa, 610 species in the Democratic Republic of Congo and 400 species in Zimbabwe. These numbers are close to our numbers in Table 3 (not including the 65 species records counted for South Africa that were found on the GBIF Data Portal rather than in published literature).

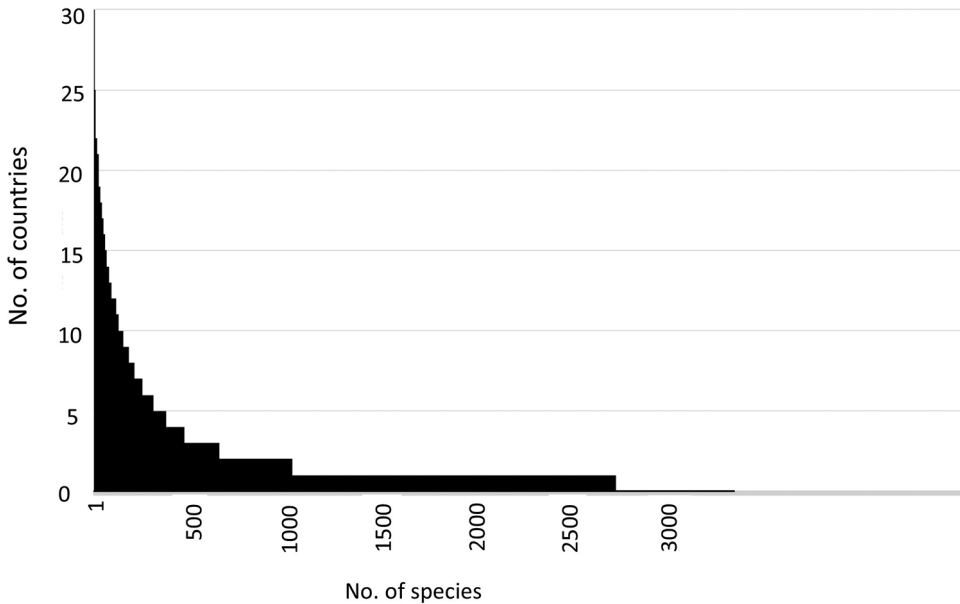
ii) Countries-per-species

Frequencies of the numbers of countries in which bee species have been recorded had a skewed distribution, with 62% of species occurring in only one country and a further 14% occurring in only two countries (Figure 2 and Table 4). Rather than indicating endemism, we interpreted this as support for the conclusion that country-scale knowledge of the distribution of bees is lacking.

Either the observed country-scale distribution is a true reflection or an artifact of different sampling effort or research intensity between different countries. Bee species richness is known to differ greatly between regions with different topography, climate or vegetation (Michener 1979, White 1983). We found that many of the countries with very low bee species numbers (e.g. Ivory Coast) had diverse climatic regions and vegetation types. Further, neighbouring countries of similar sizes at similar latitudes, which have similar vegetation and climatic conditions (White 1983), had very different numbers of species. For example, Ghana (area 238 535 km²) had 101 species and Ivory Coast (322 463 km²) had 51 species.

Table 4. The frequency distribution of countries-per-species records.

No. countries	No. species	% species
1	1 725	62
2–9	898	32
10–19	129	5
≥ 20	24	1

**Figure 2.** The frequency distribution of countries-per-species records.

Taxonomic research intensity

i) Afrotropical bee taxonomists and regional taxonomic work

The analysis of activity by taxonomists included all described taxa (i.e. counting both senior and junior synonyms as well as subspecies described before 1961).

In the Afrotropical Region there have been only four resident bee taxonomists. Three of them lived in South Africa (H. Brauns, V. Whitehead and C. Eardley) and the fourth (A. Pauly) lived and worked in Madagascar and Gabon and currently resides in Belgium. Other collectors did not study their own material but made it available to taxonomists. H. Brauns, for example, did not describe many species but he did collect for H. Friese who described numerous species from South Africa. Similarly, J. Ogilvie and A. Mackie collected mostly in South Africa for T.D.A. Cockerell. The fact that South Africa has four large bee collections (Table 6) is an indication that collecting effort has been greater in South Africa than in other African countries. There have also been a number of revisionary studies that included only the southern African

bee fauna, as tabulated in Eardley et al. (2010). The bee fauna of Madagascar was the focus of several collectors in the past, as indicated by de Saussure (1892) and Pauly et al. (2001). The latter is a revisionary study that makes Madagascar arguably the best studied country in the Afrotropical Region.

In other countries with high numbers of species records, i.e. DRC, Zimbabwe, Namibia, Kenya and Tanzania, there were correspondingly high collecting efforts. In the DRC, collecting was apparently driven through the Musée royal de l'Afrique centrale, Brussels (MRAC). In Zimbabwe, P.A. Sheppard and R. Stevenson, among others, collected extensively. Staff at the National Museum of Namibia, Windhoek (NMNW), undertook numerous collecting expeditions. During the earlier part of the 20th Century, a number of collectors collected extensively in Tanzania and Kenya. Species recorded from the above-mentioned countries, as well as South Africa, account for 49% of the known species-per-country records in the Afrotropical Region. This shows that countries known to have focused collection efforts have higher recorded numbers of bee species than those with less intensive or no known collecting efforts.

Even with the intensive effort to collect and conduct research on the taxonomy of South African bees, a recent study suggested that a number of bee species may remain undiscovered in South Africa. Substantiating this claim, Melin and Colville (2019) noted that two-thirds of South Africa has been under-sampled for bees and about 98% of the country has received little survey effort. These authors expressed concern over the decline in capacity for taxonomic research on insects, both globally and locally, and emphasised the urgent need for exploration to document this ecologically and economically important group.

ii) Authorship of taxonomic descriptions

Table 5 shows the number of species described by each author who described 10 or more species. Cockerell worked mostly on material from South Africa and the DRC, publishing 1772 taxonomic descriptions of bees (38%). Friese wrote the second highest number of taxonomic descriptions (655 species or 14%), and he received much of his material from Brauns' South African collection. He also received much material from Tanzania. Nine authors, including Cockerell and Friese, each described over 100 species.

iii) Taxonomic descriptions over time

Whereas taxonomic research is an ongoing process, the description of new species may be used as an indicator of taxonomic activity over time.

Between 1758 and 2018 (260 years) 4654 taxonomic descriptions of Afrotropical bees were published. Three eras can be discerned (Figure 3). During the first era, up to the late 1800s, taxonomic publications largely comprised faunal works containing descriptions of many new species, and few keys and species comparisons were made. The era that followed (from the late 1800s up to 1965) included taxonomic descriptions, species comparisons and keys, but few revisions. In this era the period of maximum pro-

Table 5. The number of bee species described per author (valid species plus species or subspecies now synonymised), for 10 or more taxa per author.

Author	Number of taxon descriptions (%)
Cockerell	1772 (38)
Friese	655 (14)
Strand	273 (6)
Pauly	198 (4)
Vachal, Pasteels	190 (4)
Smith	151 (3)
Benoist	145 (3)
Eardley	112 (2)
Blüthgen	79
Cameron	77
Michener	56
Kuhlmann	54
Brauns	51
Brooks, Mavromoustakis	43
Timmermann	40
de Saussure	33
Gerstaecker, Gribodo	30
Lepeletier	29
Meade-Waldo	26
Fabricius	24
Alfken	21
Enderlein, Whitehead	20
Radoszkowski, Magretti	18
Steiner	17
Dathe	16
LeVeque, Schletterer	13
Davies	11
Stadelmann	10
< 10 taxa per author	490 (11)
	4654

ductivity was during 1903–1947 when 3 236 species (70%) were described, peaking in 1937 with the description of 319 new species (Figure 3). In only 18 of these years were 50 or more species described per year. This was the period when Cockerell and Friese were most productive. Between them they described 2 407 species and the first major revision (Friese 1909) was produced. The era of revisionary studies began in 1965 with Pasteels' revision of *Megachile* (Pasteels 1965) and it continues to the present. A large number of genera have been revised or partly revised since 1965. Some of these studies include part of the region or certain subgenera within a genus (Eardley et al. 2010). This was a period of consolidation when many species names were synonymised and new distribution records were added to the knowledge about existing species.

Bee type material depositories

Taxonomists have to study type material in order to determine the correct name of a species. The locations of type depositories are therefore important from a logistical

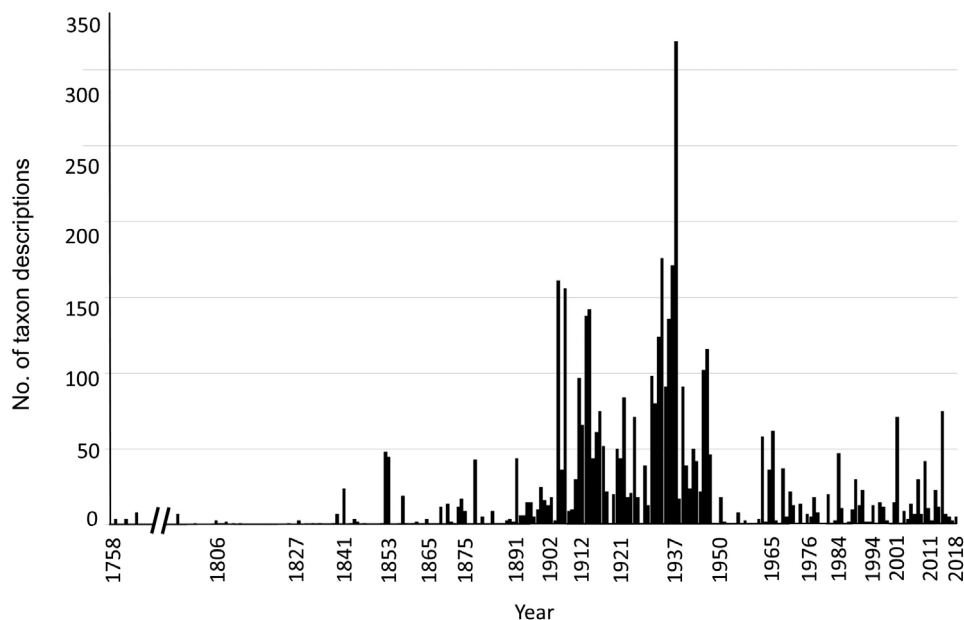


Figure 3. The number of taxon descriptions since 1758.

point of view. We found the type depositories of 4261 bee type specimens or type series (including subspecies) (Table 6 and Figure 4). An additional 393 types or type series have either been lost or their type depositories remain unknown or uncertain, making a total of 4654 types or type series.

Cockerell, the most prolific author of new bee species-level taxa, deposited most of his type material in the Natural History Museum, London (NHML), and this museum has the largest holding of Afrotropical bee types (1607 types, Table 6 and Figure 4). Most of Friese's material is today housed in the Museum für Naturkunde der Humboldt-Universität, Berlin, Germany (ZMHB) (the remainder is distributed among a number of museums, Rasmussen and Ascher 2008). ZMHB has the second highest number of type specimens (919 types).

Eighty-one per cent of types are housed in Europe, 11% in Africa (9% in South Africa) and 8% in North and Central America.

Standardisation and publication of high-quality biodiversity data

Continuous updating and publication of the CAB will allow the data to be shared with researchers and other users of biodiversity information. The CAB is different from other online sources of information about Afrotropical bees because it is published on the GBIF Data Portal. This also implies that the data are both standardised (Biodiversity Information Standards) and integrated with other distributed data, allowing the user to find more data more easily. Standardisation of data is particularly important (Wieczorek et al. 2012, Walls et al. 2014). This refers to the practice of

Table 6. The total number of primary types per depository, for 10 or more types per depository (Depository codes from The Insect and Spider Collections of the World 2019).

Depository	Code	No. of types
Natural History Museum, London, United Kingdom	NHML	1607
Museum für Naturkunde der Humboldt-Universität, Berlin, Germany	ZMHB	919
Musée royal de l'Afrique centrale, Tervuren, Belgium	MRAC	325
Museum national d'Histoire naturelle, Paris, France	MNHN	284
American Museum of Natural History, New York, USA	AMNH	206
Ditsong National Museum of Natural History	TMSA	142
South African National Collection of Insects, Pretoria, South Africa	SANC	118
Iziko South African Museum, Cape Town, South Africa	SAMC	113
Institut royal des Sciences naturelles de Belgique, Brussels, Belgium	RBINS	56
Dr A. Pauly's private collection, Gembloux, Belgium	PC	55
Snow Entomological Museum, University of Kansas, Lawrence, Kansas, USA	SEMC	38
Naturhistorisches Museum, Basel, Switzerland	NHMB	30
Naturhistoriska Riksmuseet, Stockholm, Sweden	NHRS	30
National Museum of Namibia, Windhoek, Namibia	NMNW	29
Albany Museum, Grahamstown, South Africa	AMGS	29
Deutsches Entomologisches Institut, Müncheberg, Germany	DEI	24
Museum of Comparative Zoology, Cambridge, MA, USA	MCZC	22
United States National Museum, Washington, USA	USNM	21
California Academy of Sciences, San Francisco, USA	CAS	21
Uppsala University, Uppsala, Sweden	UUZM	14
Station Centrale Zoologie Agricole, Versailles, France	INRA	12
National Museum, Bulawayo, Zimbabwe	NMBZ	12
Durban Natural Science Museum, Durban, South Africa	DMSA	10
University Museum of Natural History, Oxford, United Kingdom	OXUM	10
< 10 types per depository		134
Total		4 261

renaming database fields according to community-debated and agreed lists of standard terms (e.g. Taxon:scientificName) organised into broad classes, e.g. Occurrence, Event or Taxon. These classes and their terms function to organise the concepts and knowledge of biodiversity in a way that is compatible with the latest web technology, specifically that of Linked Open Data (Berners-Lee et al. 2001). This is a way to use the web as 'a web of linked data' rather than 'a web of linked, differently formatted documents'. Central to this technology is the use of Uniform Resource Identifiers (URI), akin to the web URL, to name or identify things or resources (represented by data) on the web. Since URIs identify data values or concepts uniquely (i.e. without ambiguity), the URIs can be thought of as a dictionary of terms (Figure 1) to describe and structure, or organise, the concepts and knowledge used in Biodiversity Science. This technology will enable machines to do much of the drudge-work needed to find, integrate and prepare data for analysis. The technology may even allow machines to interpret data on behalf of experts. It is important to publish high-quality data if such endeavours are to be successful.

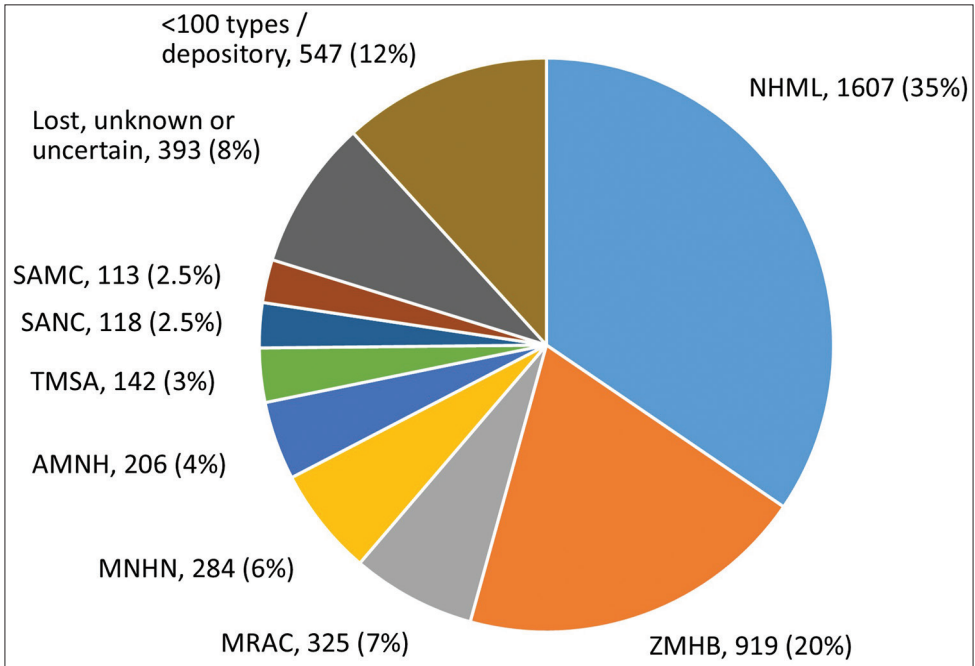


Figure 4. The numbers of bee types (specimens or series) per depository shown as the percentage of the total number of types. See the first eight rows of Table 6 for the names of depositories.

In the latest version of the CAB, all the genera of Afrotropical bees have common names. If a genus already had a common name this name was used, but genera that are endemic to the Afrotropical Region were given new names (keeping in mind existing genus names). Common names are important when communicating with citizen scientists or learners.

Conclusions and recommendations

Country-scale distribution

We found evidence strongly suggesting that knowledge of the country-scale distribution of Afrotropical bees is lacking. It is unlikely that similar, neighbouring countries at the same latitude would differ by a factor of two in their numbers of bee species, or that 76% of species would occur in only two countries. Probably, country differences in collecting effort or taxonomic research are responsible for the observed differences in species numbers between countries. Increased taxonomic capacity is therefore essential for a better understanding of the species richness and diversity patterns reflected by Afrotropical bees. The most important group of pollinators are worthy of far greater investment in mobilisation, to the GBIF Data Portal, and preservation, of African data.

Type specimen examination

It is difficult to produce useful taxonomic revisions, including reliable identification keys of Afrotropical bees, without studying type material. The logistics involved in studying types in different museums is influenced by the size of the museums' holdings and the distances between them. Imaging of types and their labels will help taxonomists studying African bees, but usually it is necessary to examine type specimens. As 82% of types are housed in Europe, travel to this region is essential for revisionary taxonomic research. South Africa (9% of types) and the USA (8% of types) have significant type depositories and also need to be visited by bee taxonomists.

Future taxonomic work

The taxonomic revisions of today are based on comparative morphology. Although morphology is indispensable in understanding and documenting species richness, future taxonomists will have to unravel complexities in species identity to which morphology cannot allude, such as separating sibling species and determining the limits between intra-specific and inter-specific variation. The obvious tools to do this are in molecular biology.

Future system development

A well-designed, standardised biodiversity data management system is essential for scientific research. This will be especially important for the inclusion of additional data, such as associations with other species and biogeography. The biodiversity information system and content of the CAB will continue to be developed, updated and kept abreast of developing biodiversity metadata standards. For example, for validation purposes, the system needs to include literature citations of records of ecological associations, to allow their veracity to be evaluated.

The information system currently relies on a prototype system component, developed using Microsoft Access, to condense the data from the Specify database. This component needs to be developed into a reliable application with a convenient user-interface. Further, the data in the Specify database need to be migrated to a schema that will more precisely reflect the concepts and practices of taxonomy. Ultimately, the reason to digitise any data is to preserve its structure, integrity and safety, so that it may continue to be used.

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Appendix I

The species of Afrotropical bees described in each year since 2010.

Year	Species	Reference
2010	<i>Chiasmognathus sabeliensis</i>	Engel, M.S. 2010. A new species of the bee genus <i>Chiasmognathus</i> from southwestern Niger (Hymenoptera: Apidae). <i>Acta Entomologica Musei Nationalis Pragae</i> 50(1): 273–278
2010	<i>Liotrigona kinzelbachi</i>	Koch, H. 2010. Combining morphology and DNA barcoding resolves the taxonomy of Western Malagasy <i>Liotrigona</i> Moure, 1961 (Hymenoptera: Apidae: Meliponini). <i>African Invertebrates</i> 51(2): 413–421
2010	<i>Patellapis (Chaetalictus) itigiensis</i>	Kuhlmann, M. and A. Pauly. 2010. New Afrotropical species of the bee subgenus <i>Patellapis (Chaetalictus)</i> with notes on additional species (Hymenoptera: Halictidae). <i>Zootaxa</i> 2674: 33–50
2010	<i>Patellapis (Chaetalictus) kahuziensis</i>	Kuhlmann and Pauly 2010
2010	<i>Patellapis (Chaetalictus) knersvlaktei</i>	Kuhlmann and Pauly 2010
2010	<i>Patellapis (Chaetalictus) rutshuruensis</i>	Kuhlmann and Pauly 2010
2010	<i>Patellapis (Chaetalictus) upembae</i>	Kuhlmann and Pauly 2010
2010	<i>Samba (Atrosamba) gessorum</i>	Michez, D., C.D. Eardley, M. Kuhlmann and K. Timmermann. 2010. The bee genera <i>Haplomelitta</i> and <i>Samba</i> (Hymenoptera: Anthophila: Melittidae): phylogeny, biogeography and host plants. <i>Invertebrate Systematics</i> 24: 327–347
2010	<i>Samba (Metasamba) rubiginis</i>	Michez et al. 2010
2010	<i>Samba (Prosamba) spinosa</i>	Michez et al. 2010
2010	<i>Samba (Samba) ascheri</i>	Michez et al. 2010
2011	<i>Afroheriades hyalinus</i>	Griswold, T. and V.H. Gonzalez. 2011. New species of the Eastern Hemisphere genera <i>Afroheriades</i> and <i>Noteriades</i> (Hymenoptera, Megachilidae), with keys to species of the former. <i>Zookeys</i> 159: 65–80

Year	Species	Reference
2011	<i>Hoplitis (Anthocopa) conchophila</i>	Kuhlmann, M., F.W. Gess, F. Koch and S.K. Gess. 2011. Southern African osmiine bees: taxonomic notes, two new species, a key to <i>Wainia</i> , and biological observations (Hymenoptera: Anthophila: Megachilidae). <i>Zootaxa</i> 3108: 1–24
2011	<i>Wainia (Caposmia) gessorum</i>	Kuhlmann et al. 2011
2012	<i>Chalicodoma (Pseudomegachile) gibbsi</i>	Gonzalez, V.H. and M.S. Engel. 2012. African and southeast Asian <i>Chalicodoma</i> (Hymenoptera: Megachilidae): new subgenus, new species, and notes on the composition of <i>Pseudomegachile</i> and <i>Largella</i> . <i>Annales Zoologici</i> 62(4): 599–617
2012	<i>Chalicodoma (Pseudomegachile) strangei</i>	Gonzalez and Engel 2012
2012	<i>Dasygoda (Dasygoda) riftensis</i>	Michez, D. and A. Pauly. 2012. A new species of the palaeartic genus <i>Dasygoda</i> Latreille 1802 (Hymenoptera: Dasygodaidae) from the Great Rift Valley in Ethiopia. <i>Zootaxa</i> 3181: 63–68
2012	<i>Lasioglossum (Capalictus) hantamense</i>	Pauly, A., J. Gibbs and M. Kuhlmann. 2012. <i>Capalictus</i> , a new subgenus of <i>Lasioglossum</i> Curtis, 1833 from South Africa, with description of three new species (Hymenoptera, Apoidea, Halictidae). <i>European Journal of Taxonomy</i> 28: 1–28
2012	<i>Lasioglossum (Capalictus) tigrinum</i>	Pauly et al. 2012
2012	<i>Lasioglossum (Capalictus) timmermanni</i>	Pauly et al. 2012
2012	<i>Megachile (Callomegachile) soutpansbergensis</i>	Eardley, C.D. 2012a. A taxonomic revision of the southern African species of dauber bees in the genus <i>Megachile</i> Latreille (Apoidea: Megachilidae). <i>Zootaxa</i> 3460: 1–139
2012	<i>Megachile (Chalicodoma) gessorum</i>	Eardley 2012a
2012	<i>Megachile (Chalicodoma) richtersveldensis</i>	Eardley 2012a
2012	<i>Megachile (Chalicodoma) sarahae</i>	Eardley 2012a
2012	<i>Megachile (Creightonella) serrula</i>	Eardley, C.D. 2012b. A taxonomic revision of the southern African species of the subgenus <i>Creightonella</i> Cockerell (Apoidea: Megachilidae: <i>Megachile</i> Latreille). <i>Zootaxa</i> 3159: 1–35
2012	<i>Megachile (Pseudomegachile) gessi</i>	Eardley 2012a
2012	<i>Megachile (Pseudomegachile) namibensis</i>	Eardley 2012a
2012	<i>Megachile (Pseudomegachile) pseudotaraxis</i>	Eardley 2012a
2012	<i>Megachile (Pseudomegachile) taraxis</i>	Eardley 2012a
2012	<i>Rediviva steineri</i>	Kuhlmann, M. 2012a. Two new species of the South African endemic bee genus <i>Rediviva</i> Friese (Hymenoptera: Apoidea: Melittidae). <i>Zootaxa</i> 3517: 71–78
2012	<i>Rediviva whitebeadi</i>	Kuhlmann 2012a
2012	<i>Redivivoides capensis</i>	Kuhlmann, M. 2012b. Revision of the South African endemic bee genus <i>Redivivoides</i> Michener, 1981 (Hymenoptera: Apoidea: Melittidae). <i>European Journal of Taxonomy</i> 34: 1–34
2012	<i>Redivivoides eardleyi</i>	Kuhlmann 2012b
2012	<i>Redivivoides kamieskroonensis</i>	Kuhlmann 2012b
2012	<i>Redivivoides karooensis</i>	Kuhlmann 2012b
2012	<i>Redivivoides namaquaensis</i>	Kuhlmann 2012b

Year	Species	Reference
2012	<i>Redivivoides variabilis</i>	Kuhlmann 2012b
2013	<i>Anthidioma obibense</i>	Griswold, T. and V.H. Gonzalez. 2013. A new species of the rare African wool-carder bee genus <i>Anthidioma</i> (Hymenoptera: Megachilidae) from Namibia. <i>African Entomology</i> 21(1): 177–180
2013	<i>Eupetersia avontuurensis</i>	Kuhlmann, M. 2013. <i>Eupetersia avontuurensis</i> nov. sp., first record of the bee genus in the South African winter rainfall region (Hymenoptera, Apoidea, Halictidae). <i>Entomofauna: Zeitschrift für Entomologie</i> 34(14): 185–192
2013	<i>Liotrigona baleensis</i>	Pauly, A. and Z.A. Hora. 2013. Apini and Meliponini from Ethiopia (Hymenoptera: Apoidea: Apidae: Apinae). <i>Belgian Journal of Entomology</i> 16: 1–35
2013	<i>Liotrigona gabonensis</i>	Pauly, A. and E.C.F. Faber Anguilet. 2013. Description de <i>Liotrigona gabonensis</i> sp. nov., et quelques corrections à la synonymie des espèces africaines de mélipones (Hymenoptera : Apoidea : Apinae : Meliponini). <i>Belgian Journal of Entomology</i> 15: 1–13
2013	<i>Megachile (Eutricharaea) gobabeensis</i>	Eardley, C.D. 2013. A taxonomic revision of the southern African leaf-cutter bees, <i>Megachile</i> Latreille <i>sensu stricto</i> and <i>Heriadopsis</i> Cockerell (Hymenoptera: Apoidea: Megachilidae). <i>Zootaxa</i> 3601: 1–133
2013	<i>Megachile (Eutricharaea) goegabensis</i>	Eardley 2013
2013	<i>Thrinchostoma (Thrinchostoma) uluguruensis</i>	Pauly, A. and C.D. Eardley. 2013. A Revision of Afrotropical <i>Thrinchostoma</i> de Saussure, 1890 (Hymenoptera: Apoidea: Halictidae). <i>Belgian Journal of Entomology</i> 12: 1–76
2013	<i>Thrinchostoma (Thrinchostoma) upembae</i>	Pauly and Eardley 2013
2014	<i>Hylaeus (Deranchylaeus) amharicus</i>	Dathe, H.H. 2014. Studies on the systematics and taxonomy of the genus <i>Hylaeus</i> F. (8) Revision of the Afrotropic subgenus <i>Hylaeus (Deranchylaeus)</i> Bridwell (Hymenoptera: Anthophila, Colletidae). <i>Zootaxa</i> 3874: 1–84
2014	<i>Hylaeus (Deranchylaeus) bernhardi</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) camerunensis</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) chimani</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) eardleyi</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) gessianus</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) izikosalis</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) nottoni</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) oromialis</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) pamelaae</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) paulyi</i>	Dathe 2014
2014	<i>Hylaeus (Deranchylaeus) venustus</i>	Dathe 2014
2014	<i>Lipotriches (Armatriches) baldocki</i>	Pauly, A. 2014. Révision des abeilles des graminées en Afrique tropicale (Genre <i>Lipotriches</i> Gerstaecker 1858; Hymenoptera Apoidea Halictidae Nomiinae). <i>Belgian Journal of Entomology</i> 20: 1–393
2014	<i>Lipotriches (Armatriches) voiensis</i>	Pauly 2014
2014	<i>Lipotriches (Cubitriches) edenuvalensis</i>	Pauly 2014

Year	Species	Reference
2014	<i>Lipotriches (Cubitriches) guillarmodi</i>	Pauly 2014
2014	<i>Lipotriches (Cubitriches) kamieskroonensis</i>	Pauly 2014
2014	<i>Lipotriches (Cubitriches) karoensis</i>	Pauly 2014
2014	<i>Lipotriches (Cubitriches) mamalapiensis</i>	Pauly 2014
2014	<i>Lipotriches (Cubitriches) nyikaensis</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) cassiae</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) garambensis</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) irwini</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) notabilis ituriensis</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) rossi</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) saegeri</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) snizeki</i>	Pauly 2014
2014	<i>Lipotriches (Lipotriches) tentrediniformis</i>	Pauly 2014
2014	<i>Lipotriches (Patellotriches) salamae</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) acanthospermi</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) brachysoma elinocturna</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) clypeomonstrosa</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) gemma</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) gongeti</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) hyparrheniae</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) kwiapensis</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) paludis</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) predonta</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) pseudoclavata</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) rozenorum</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) seydeli</i>	Pauly 2014
2014	<i>Lipotriches (Rhopalomelissa) subaurata</i>	Pauly 2014
2014	<i>Lipotriches (Stellotriches) eardleyi</i>	Pauly 2014

Year	Species	Reference
2014	<i>Lipotriches (Stellotriches) ewasoensis</i>	Pauly 2014
2014	<i>Lipotriches (Stellotriches) baregensis</i>	Pauly 2014
2014	<i>Lipotriches (Stellotriches) justiciae</i>	Pauly 2014
2014	<i>Lipotriches (Stellotriches) karibibensis</i>	Pauly 2014
2014	<i>Lipotriches (Stellotriches) maliensis</i>	Pauly 2014
2014	<i>Lipotriches (Tegumelissa) gusenleitneri</i>	Pauly 2014
2014	<i>Lipotriches (Tegumelissa) jadotwillensis</i>	Pauly 2014
2014	<i>Lipotriches (Tegumelissa) shimbaensis</i>	Pauly 2014
2014	<i>Lipotriches (Tegumelissa) usambarae</i>	Pauly 2014
2014	<i>Lipotriches haladai</i>	Pauly 2014
2014	<i>Lipotriches muyengaensis</i>	Pauly 2014
2014	<i>Lipotriches nasalis</i>	Pauly 2014
2014	<i>Lipotriches upembensis</i>	Pauly 2014
2014	<i>Melitta (Afromelitta) richtersveldensis</i>	Michez, D., M. Kuhlmann and S. Dellicour. 2014. Validation of some species- and genus-group names in <i>Melitta</i> (Hymenoptera: Melittidae). <i>Bee Biology, Ecology, Evolution, & Systematics</i> 44: 1–8
2014	<i>Melitta (Plesiomelitta) avontuurensis</i>	Michez et al. 2014
2014	<i>Scrapter exiguus</i>	Kuhlmann, M. 2014. Revision of the ‘euryglossiform’ species of the Afrotropical bee genus <i>Scrapter</i> Lepeletier & Serville, 1828 (Hymenoptera: Apoidea: Colletidae). <i>European Journal of Taxonomy</i> 95: 1–69
2014	<i>Scrapter gessorum</i>	Kuhlmann 2014
2014	<i>Scrapter inexpectatus</i>	Kuhlmann 2014
2014	<i>Scrapter luteistigma</i>	Kuhlmann 2014
2014	<i>Scrapter minutissimus</i>	Kuhlmann 2014
2014	<i>Scrapter minutuloides</i>	Kuhlmann 2014
2014	<i>Scrapter minutus</i>	Kuhlmann 2014
2014	<i>Scrapter nanus</i>	Kuhlmann 2014
2014	<i>Scrapter nigerrimus</i>	Kuhlmann 2014
2014	<i>Scrapter nigritarsis</i>	Kuhlmann 2014
2014	<i>Scrapter papkuilsi</i>	Kuhlmann 2014
2014	<i>Scrapter pygmaeus</i>	Kuhlmann 2014
2014	<i>Scrapter roggeveldi</i>	Kuhlmann 2014
2014	<i>Scrapter spinipes</i>	Kuhlmann 2014
2014	<i>Scrapter ulrikae</i>	Kuhlmann 2014
2015	<i>Hylaeus (Alfhenylaeus) euphorbiae</i>	Dathe, H.H. 2015. Studies on the systematics and taxonomy of the genus <i>Hylaeus</i> F. (9) Supplement to the taxonomy and distribution of Afrotropical <i>Hylaeus</i> F. species (Hymenoptera: Anthophila, Colletidae). <i>Beiträge zur Entomologie (Berlin)</i> 65(1): 9–26
2015	<i>Hylaeus (Cornylaeus) adamauanis</i>	Dathe 2015

Year	Species	Reference
2015	<i>Hylaeus (Deranchylaeus) haladanius</i>	Dathe 2015
2015	<i>Hylaeus (Pumilaesus) pumilus</i>	Dathe 2015
2015	<i>Plesianthidium (Spinanthidium) namaquaense</i>	Eardley, C.D. and T.L. Griswold. 2015. Taxonomic revision of <i>Plesianthidium</i> Cameron (Apoidea: Megachilidae: Anthidiini), an endemic southern African bee genus. <i>Zootaxa</i> 3973(1): 1–56
2015	<i>Plesianthidium (Spinanthidium) richtersveldense</i>	Eardley and Griswold 2015
2015	<i>Samba (Samba) turkana</i>	Packer, L. and D. Martins. 2015. A new species of <i>Samba</i> s. str. (Hymenoptera: Melittidae) from the Turkana Basin, Kenya with observations on the function of the metatibial spur in females. <i>Zootaxa</i> 3918(2): 261–272
2016	<i>Fidelia (Fideliopsis) whiteheadi</i>	Litman, J.R., C.D. Eardley and M. Kuhlmann. 2016. A new species of <i>Fidelia</i> Friese, 1899 (Hymenoptera, Megachilidae), with a key to the species of the genus. <i>European Journal of Taxonomy</i> 174: 1–18
2016	<i>Maynenomia adamaouaensis</i>	Pauly, A. and Y.B. Soukontoua. 2016. Deux nouvelles espèces d'abeilles du Massif de l'Adamaoua au Cameroun (Hymenoptera: Apoidea: Halictidae: Nomiinae). <i>Belgian Journal of Entomology</i> 39: 1–9
2016	<i>Maynenomia tchuenguemi</i>	Pauly and Soukontoua 2016
2016	<i>Patellapis (Chaetalictus) mpalaensis</i>	Pauly, A. 2016. Description de <i>Patellapis</i> (<i>Chaetalictus</i>) <i>mpalaensis</i> sp. nov. et redescription de <i>P. (C.) virungae</i> Timmermann, 2009 de l'Afrique orientale et centrale (Hymenoptera: Apoidea: Halictidae). <i>Belgian Journal of Entomology</i> 36: 1–11
2016	<i>Serapista aspernigra</i>	Eardley, C.D. and T. Griswold. 2016. Taxonomic revision of the Afrotropical bee genus <i>Serapista</i> Cockerell (Hymenoptera: Apoidea: Megachilidae: Megachilinae: Anthidiini). <i>Zootaxa</i> 4111: 334–364
2017	<i>Haetosmia ethiopiensis</i>	Müller, A. and T. Griswold. 2017. Osmiine bees of the genus <i>Haetosmia</i> (Megachilidae, Osmiini): biology, taxonomy and key to species. <i>Zootaxa</i> 4358: 351–364
2017	<i>Mermiglossa voicola</i>	Ascher, J.S. and M.S. Engel. 2017. A new species of <i>Mermiglossa</i> from Kenya, with comments on the arrangement of Old World Panurginae (Hymenoptera: Andrenidae). <i>Journal of Melittology</i> 75: 1–11
2017	<i>Pachyanthidium (Trichanthidium) anoplos</i>	Eardley, C.D. and T. Griswold. 2017. Taxonomic revision of the Afrotropical species of <i>Pachyanthidium</i> Friese (Hymenoptera: Megachilidae: Anthidiini). <i>Zootaxa</i> 4237: 401–453
2018	<i>Anthidiellum (Chloranthidiellum) pamae</i>	Eardley, C.D. 2018. Taxonomic revision of the sub-Saharan <i>Anthidiellum</i> Cockerell (Apoidea: Megachilidae: Anthidiini). <i>Zootaxa</i> 4402: 201–250
2018	<i>Anthidiellum (Pycnanthidium) somaliense</i>	Eardley 2018
2018	<i>Cyphanthidium gessorum</i>	Eardley, C.D. and T. Griswold. 2018. Taxonomic revision of <i>Cyphanthidium</i> Pasteels (Hymenoptera: Apoidea: Megachilidae: Megachilinae: Anthidiini), an endemic Afrotropical bee genus. <i>Zootaxa</i> 4450(1): 26–40
2018	<i>Cyphanthidium whiteheadi</i>	Eardley and Griswold 2018
2018	<i>Trachusa namibiensis</i>	Kasperek, M. 2018. A new species of <i>Trachusa</i> Panzer, 1804 (Megachilidae: Anthidiini) from southern Africa, with notes on the subgeneric classification and a key to the Afrotropical species. <i>Zootaxa</i> 4399: 329–340

Appendix 2

The species of Afrotropical bees synonymised or removed from synonymy since 2010. References are listed below the table.

Year	Senior synonym	Junior synonym, citation
2011	<i>Afroheriades (Archeriades) dolichocephalus</i>	<i>Archeriades hennigi</i> , 1
2011	<i>Afroheriades (Archeriades) dolichocephalus</i>	<i>Heriades reicherti</i> , 1
2011	<i>Capicola capicola</i>	<i>Capicola aurescens</i> , 2
2011	<i>Capicola capicola</i>	<i>Capicola braunsiana</i> , 2
2011	<i>Capicola capicola</i>	<i>Hesperapis obscura</i> , 2
2011	<i>Capicola capicola</i>	<i>Hesperapis turneri</i> , 2
2011	<i>Hoplitis (Anthocopa) namaquaensis</i>	<i>Hoplitis (Anthocopa) ausica</i> , 2
2011	<i>Wainia (Wainiella) sakanienensis</i>	<i>Wainia (Wainiella) albobarbata</i> , 2
2011	<i>Wainia (Wainiella) sakanienensis</i>	<i>Wainia (Wainiella) otaviensis</i> , 2
2011	<i>Wainia (Wainiella) sakanienensis</i>	<i>Wainia (Wainiella) perpolitus</i> , 2
2012	<i>Andrena africana</i>	<i>Notomelitta tropicalis</i> , 3
2012	<i>Megachile (Callomegachile) demeter</i>	<i>Megachile (Callomegachile) excavata</i> , 4
2012	<i>Megachile (Callomegachile) kamerunensis</i>	<i>Megachile (Callomegachile) kamerunensis totafusca</i> , 4
2012	<i>Megachile (Callomegachile) kamerunensis</i>	<i>Megachile (Callomegachile) totafusca</i> , 4
2012	<i>Megachile (Callomegachile) rufipennis</i>	<i>Megachile (Callomegachile) chrysorrhoea</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) aridissima</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) coelorhina</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) pallipennis</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) pernicioso</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) phenacosoma</i> , 4
2012	<i>Megachile (Callomegachile) rufiventris</i>	<i>Megachile (Callomegachile) rukuruensis</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Chalicodoma insolita</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Megachile (Chalicodoma) biexcisa</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Megachile (Chalicodoma) fulvosetosa</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Megachile (Chalicodoma) insolita</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Megachile (Chalicodoma) johannis</i> , 4
2012	<i>Megachile (Chalicodoma) karoensis</i>	<i>Megachile (Chalicodoma) musculus</i> , 4
2012	<i>Megachile (Chalicodoma) murina</i>	<i>Chalicodoma (Chalicodoma) aurulenta</i> , 4
2012	<i>Megachile (Chalicodoma) murina</i>	<i>Chalicodoma (Chalicodoma) bipunctulata</i> , 4
2012	<i>Megachile (Chalicodoma) murina</i>	<i>Megachile (Chalicodoma) acanthura</i> , 4
2012	<i>Megachile (Chalicodoma) murina</i>	<i>Megachile (Chalicodoma) reicherti</i> , 4
2012	<i>Megachile (Chalicodoma) niveofasciata</i>	<i>Chalicodoma (Chalicodoma) lineofasciata</i> , 4
2012	<i>Megachile (Chalicodoma) niveofasciata</i>	<i>Chalicodoma cinctiventris</i> , 4
2012	<i>Megachile (Chalicodoma) niveofasciata</i>	<i>Megachile (Chalicodoma) albopilosa</i> , 4
2012	<i>Megachile (Chalicodoma) niveofasciata</i>	<i>Megachile (Chalicodoma) mesopyrrha</i> , 4
2012	<i>Megachile (Creightonella) angulata</i>	<i>Megachile (Creightonella) heptadonta</i> , 5
2012	<i>Megachile (Creightonella) angulata</i>	<i>Megachile (Creightonella) hoplitis</i> , 5
2012	<i>Megachile (Creightonella) angulata</i>	<i>Megachile (Creightonella) kivuicola</i> , 5
2012	<i>Megachile (Creightonella) cognata</i>	<i>Megachile (Creightonella) congruens natalensis</i> , 5
2012	<i>Megachile (Creightonella) dorsata</i>	<i>Megachile (Creightonella) ikuthaensis</i> , 5
2012	<i>Megachile (Gronoceras) bombiformis</i>	<i>Megachile (Gronoceras) bombiformis yapiensis</i> , 4
2012	<i>Megachile (Gronoceras) bombiformis</i>	<i>Megachile (Gronoceras) yapiensis</i> , 4
2012	<i>Megachile (Gronoceras) cincta</i>	<i>Megachile (Gronoceras) cincta nigrocincta</i> , 4
2012	<i>Megachile (Gronoceras) cincta</i>	<i>Megachile (Gronoceras) cincta tricolor</i> , 4
2012	<i>Megachile (Gronoceras) cincta</i>	<i>Megachile (Gronoceras) combusta</i> , 4
2012	<i>Megachile (Gronoceras) cincta</i>	<i>Megachile (Gronoceras) nigrocincta</i> , 4

Year	Senior synonym	Junior synonym, citation
2012	<i>Megachile (Gronoceras) cincta</i>	<i>Megachile (Gronoceras) tricolor</i> , 4
2012	<i>Megachile (Gronoceras) felina</i>	<i>Gronoceras cerberus optima</i> , 4
2012	<i>Megachile (Pseudomegachile) cradockensis</i>	<i>Megachile (Pseudomegachile) empeyi</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) crocutella</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) decemsignata</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) diversiventris</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) jumodi</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) mucoreiventris</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) nubilosa</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) pachingeri</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) rhodotrichura</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) solitaria</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) torridus</i> , 4
2012	<i>Megachile (Pseudomegachile) fervida</i>	<i>Megachile (Pseudomegachile) torula</i> , 4
2012	<i>Megachile (Pseudomegachile) mossambica</i>	<i>Megachile (Pseudomegachile) armatipes</i> , 4
2012	<i>Megachile (Pseudomegachile) mossambica</i>	<i>Megachile (Pseudomegachile) cyanura</i> , 4
2012	<i>Megachile (Pseudomegachile) mossambica</i>	<i>Megachile (Pseudomegachile) laminata</i> , 4
2012	<i>Megachile (Pseudomegachile) mossambica</i>	<i>Megachile (Pseudomegachile) obscuribasis</i> , 4
2012	<i>Megachile (Pseudomegachile) mossambica</i>	<i>Megachile (Pseudomegachile) ritchiei</i> , 4
2012	<i>Megachile (Pseudomegachile) nasicornis</i>	<i>Megachile (Pseudomegachile) bullata</i> , 4
2012	<i>Megachile (Pseudomegachile) schultheissi</i>	<i>Megachile (Pseudomegachile) congruens</i> , 4
2012	<i>Megachile (Pseudomegachile) schultheissi</i>	<i>Megachile (Pseudomegachile) congruens flaviventris</i> , 4
2012	<i>Megachile (Pseudomegachile) schultheissi</i>	<i>Megachile (Pseudomegachile) flexa</i> , 4
2012	<i>Megachile (Pseudomegachile) schultheissi</i>	<i>Megachile (Pseudomegachile) marginipennis</i> , 4
2013	<i>Hypotrigona squamuligera</i>	<i>Hypotrigona penna</i> , 6
2013	<i>Megachile (Amegachile) fimbriata</i>	<i>Megachile (Amegachile) vulpecula</i> , 7
2013	<i>Megachile (Amegachile) nasalis</i>	<i>Megachile (Amegachile) ventrifasciata</i> , 7
2013	<i>Megachile (Amegachile) nasalis</i>	<i>Megachile (Amegachile) volkmanni</i> , 7
2013	<i>Megachile (Eutricharaea) barbata</i>	<i>Megachile (Eutricharaea) coelostoma</i> , 7
2013	<i>Megachile (Eutricharaea) barbata</i>	<i>Megachile (Eutricharaea) discretula</i> , 7
2013	<i>Megachile (Eutricharaea) barbata</i>	<i>Megachile (Eutricharaea) nasutula</i> , 7
2013	<i>Megachile (Eutricharaea) barbata</i>	<i>Megachile (Eutricharaea) nitidicauda</i> , 7
2013	<i>Megachile (Eutricharaea) basalis</i>	<i>Megachile (Eutricharaea) latimetatarsis</i> , 7
2013	<i>Megachile (Eutricharaea) basalis</i>	<i>Megachile (Eutricharaea) rozenii</i> , 7
2013	<i>Megachile (Eutricharaea) basalis</i>	<i>Megachile (Eutricharaea) waterbergensis</i> , 7
2013	<i>Megachile (Eutricharaea) bucephala</i>	<i>Megachile (Eutricharaea) semifulva</i> , 7
2013	<i>Megachile (Eutricharaea) cyanescens</i>	<i>Megachile (Eutricharaea) okanjandica</i> , 7
2013	<i>Megachile (Eutricharaea) cyanescens</i>	<i>Megachile (Eutricharaea) vittatula</i> , 7
2013	<i>Megachile (Eutricharaea) eurymera</i>	<i>Megachile (Eutricharaea) rhodoleucura</i> , 7
2013	<i>Megachile (Eutricharaea) eurymera</i>	<i>Megachile (Eutricharaea) tarsignata</i> , 7
2013	<i>Megachile (Eutricharaea) familiaris</i>	<i>Megachile (Eutricharaea) luteola</i> , 7
2013	<i>Megachile (Eutricharaea) familiaris</i>	<i>Megachile (Eutricharaea) stellensis</i> , 7
2013	<i>Megachile (Eutricharaea) muansae</i>	<i>Megachile (Eutricharaea) leucospilura</i> , 7
2013	<i>Megachile (Eutricharaea) salsburyana</i>	<i>Megachile (Eutricharaea) seclusa</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) acalognatha</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) concinna</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) marusa</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) microxanthops</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) robertiana</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) semivenusta</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) umbiloensis</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Eutricharaea) venustella</i> , 7
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Paracella) gratiosa</i> , 7

Year	Senior synonym	Junior synonym, citation
2013	<i>Megachile (Eutricharaea) venusta</i>	<i>Megachile (Paracella) sarna</i> , 7
2013	<i>Megachile (Eutricharaea) wahlbergi</i>	<i>Megachile (Eutricharaea) pondonis</i> , 7
2013	<i>Megachile (Heriadopsis) whiteana</i>	<i>Megachile (Heriadopsis) tantilla</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) albofilosa</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) candidicauda</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) candidigena</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) flavibasis</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) heterotricha</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) meesi</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) neli</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) rubeola</i> , 7
2013	<i>Megachile (Paracella) chrysopogon</i>	<i>Megachile (Paracella) spinarum</i> , 7
2013	<i>Megachile (Paracella) curtula</i>	<i>Megachile (Paracella) paritocola</i> , 7
2013	<i>Megachile (Paracella) curtula</i>	<i>Megachile (Paracella) bicingulata</i> , 7
2013	<i>Megachile (Paracella) curtula</i>	<i>Megachile (Paracella) granulicauda</i> , 7
2013	<i>Megachile (Paracella) edwardsi</i>	<i>Megachile (Paracella) spatulicornis</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) clarescens</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) laticeps</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) obesa</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) ovatomaculata</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) rudihirta</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) stellarum</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile (Paracella) thomasseti</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile clarescens</i> , 7
2013	<i>Megachile (Paracella) malangensis</i>	<i>Megachile thomasseti clarescens</i> , 7
2013	<i>Megachile (Paracella) pilosella</i>	<i>Megachile (Paracella) boswendica</i> , 7
2013	<i>Megachile (Paracella) pilosella</i>	<i>Megachile (Paracella) rubrociliata</i> , 7
2013	<i>Megachile (Paracella) pilosella</i>	<i>Megachile (Paracella) rufisetosa</i> , 7
2013	<i>Megachile (Paracella) semierma</i>	<i>Megachile (Paracella) lydenburgiana</i> , 7
2013	<i>Megachile (Paracella) semierma</i>	<i>Megachile (Paracella) pretoriaensis</i> , 7
2013	<i>Megachile (Paracella) semierma</i>	<i>Megachile (Paracella) pycnocephala</i> , 7
2013	<i>Megachile (Paracella) ungulata</i>	<i>Megachile (Paracella) apiformis</i> , 7
2013	<i>Megachile (Paracella) ungulata</i>	<i>Megachile (Paracella) rufibasis</i> , 7
2013	<i>Megachile (Paracella) ungulata</i>	<i>Megachile (Paracella) umtaliensis</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) asarna</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) capiticola</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) chromatica</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) chrysognatha</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) ekuivella</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) flammicauda</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) gratiosella</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) haematognatha</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) heteroscopa</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) krebiana</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) mackieae</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) masaiella</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) melanura</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) natalica</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) rhodesica</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) rufosuffusa</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) rufulina</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) semiflava</i> , 7
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) subcordata</i> , 7

Year	Senior synonym	Junior synonym, citation
2013	<i>Megachile cordata</i>	<i>Megachile (Paracella) tardula</i> , 7
2013	<i>Thrinchostoma (Diagonozus) lettowvorbecki</i>	<i>Thrinchostoma (Diagonozus) guineense</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) emini</i>	<i>Thrinchostoma (Thrinchostoma) telekii</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) emini</i>	<i>Thrinchostoma undulatum</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) petersi</i>	<i>Thrinchostoma (Thrinchostoma) wissmanni</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) petersi</i>	<i>Thrinchostoma rubrocinctum</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) torridum</i>	<i>Thrinchostoma (Eothrinchostoma) wellmanni</i> , 8
2013	<i>Thrinchostoma (Eothrinchostoma) torridum</i>	<i>Thrinchostoma malelanum</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Halictus (Thrinchostoma) bibundicus</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Thrinchostoma (Thrinchostoma) bequaerti</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Thrinchostoma (Thrinchostoma) bequaerti ochropus</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Thrinchostoma lualiensis</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Thrinchostoma tessmanni</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) productum</i>	<i>Thrinchostoma vachali</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) sjoestedti</i>	<i>Thrinchostoma (Thrinchostoma) mwangai</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) sjoestedti</i>	<i>Thrinchostoma (Thrinchostoma) sjoestedti rufescens</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) sjoestedti</i>	<i>Thrinchostoma (Thrinchostoma) ugandae</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) sjoestedti</i>	<i>Thrinchostoma millari</i> , 8
2013	<i>Thrinchostoma (Thrinchostoma) sjoestedti</i>	<i>Thrinchostoma umtaliense</i> , 8
2014	<i>Lipotriches (Armatriches) kondeana</i>	<i>Nomia angulifera apicata</i> , 9
2014	<i>Lipotriches (Cubitriches) colona</i>	<i>Nomia melanosticta</i> , 9
2014	<i>Lipotriches (Cubitriches) colona</i>	<i>Nomia viridarii</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Andrena matha</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia basatorum</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia burorum</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia dalyana</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia dominarum</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia ferripennis</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia matha breviceps</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia phenacopoda</i> , 9
2014	<i>Lipotriches (Cubitriches) cubitalis</i>	<i>Nomia rugicollis</i> , 9
2014	<i>Lipotriches (Lipotriches) oberthurella</i>	<i>Nomia atopozona</i> , 9
2014	<i>Lipotriches (Patellotriches) tetraloniformis</i>	<i>Nomia fortis</i> , 9
2014	<i>Lipotriches (Rhopalomelissa) brachysoma</i>	<i>Nomia ligata</i> , 9
2014	<i>Lipotriches (Rhopalomelissa) cinerascens</i>	<i>Nomia brunnipes</i> , 9
2014	<i>Lipotriches (Rhopalomelissa) cinerascens</i>	<i>Rhopalomelissa brunnipes</i> , 9
2014	<i>Lipotriches (Rhopalomelissa) clavata</i>	<i>Nomia andrei</i> , 9
2014	<i>Lipotriches (Stellotriches) arnoldi</i>	<i>Nomia opacibasis</i> , 9
2014	<i>Lipotriches (Stellotriches) arnoldi</i>	<i>Nomia opacibasis sublucens</i> , 9
2014	<i>Lipotriches colona</i>	<i>Rhopalomelissa melanosticta</i> , 9
2014	<i>Lipotriches colona</i>	<i>Rhopalomelissa viridarii</i> , 9
2014	<i>Lipotriches fulvipes</i>	<i>Rhopalomelissa alivalensis</i> , 9
2014	<i>Lipotriches fulvipes</i>	<i>Rhopalomelissa gastrodonta</i> , 9
2014	<i>Lipotriches fulvipes</i>	<i>Nomia alivalensis</i> , 9
2014	<i>Hylaeus (Deranchylaeus) curvicarinatus</i>	<i>Prosopis flaviscutum</i> , 14
2014	<i>Hylaeus (Deranchylaeus) curvicarinatus</i>	<i>Hylaeus graaffi</i> , 14
2014	<i>Hylaeus (Deranchylaeus) dregei</i>	<i>Hylaeus (Deranchylaeus) microstictus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) gabonicus</i>	<i>Hylaeus (Deranchylaeus) bequaertianus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) krebsonianus</i>	<i>Hylaeus (Deranchylaeus) immarginatus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) krebsonianus</i>	<i>Hylaeus (Deranchylaeus) abjunctus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) lightfooti</i>	<i>Hylaeus (Deranchylaeus) absonulus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) lightfooti</i>	<i>Hylaeus (Deranchylaeus) reditus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) lineaticeps</i>	<i>Hylaeus (Deranchylaeus) subreditus</i> , 14

Year	Senior synonym	Junior synonym, citation
2014	<i>Hylaeus (Deranchylaeus) perater</i>	<i>Hylaeus (Deranchylaeus) extensicornis</i> , 14
2014	<i>Hylaeus (Deranchylaeus) promontorii</i>	<i>Hylaeus (Deranchylaeus) rhodognathus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) atriceps</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) major</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) dominae</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) punctiferus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) sanctus</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus (Deranchylaeus) sublucens</i> , 14
2014	<i>Hylaeus (Deranchylaeus) robertianus</i>	<i>Hylaeus multifarius</i> , 14
2014	<i>Hylaeus (Deranchylaeus) rugipunctus</i>	<i>Hylaeus (Deranchylaeus) simulans</i> , 14
2014	<i>Hylaeus (Deranchylaeus)</i>	<i>Prosopis tenuis</i> , 14
2014	<i>Hylaeus (Deranchylaeus) tenuis</i>	<i>Hylaeus (Deranchylaeus) simplior</i> , 14
2014	<i>Hylaeus (Deranchylaeus) tenuis</i>	<i>Hylaeus (Deranchylaeus) perdensis</i> , 14
2014	<i>Hylaeus (Deranchylaeus) xanthostoma</i>	<i>Hylaeus (Deranchylaeus) kasindensis</i> , 14
2015	Removed from synonymy	<i>Plesianthidium (Spinanthidium) calvini</i> , 10
2015	Removed from synonymy. Records in Eardley and Urban (2010) were documented before <i>P. volkmanni</i> and <i>P. rufocaudatum</i> were recognized as separate. They are therefore unreliable.	<i>Plesianthidium (Spinanthidiellum) rufocaudatum</i> , 10
2016	Removed from synonymy	<i>Serapista friesei</i> , 11
2016	Removed from synonymy	<i>Serapista pernigra</i> , 11
2017	<i>Pachyanthidium (Pachyanthidium) paulinieri</i>	<i>Pachyanthidium (Pachyanthidium) cordatum salamense</i> , 12
2018	<i>Anthidium minutulum flavescens</i>	<i>Anthidiellum (Chloranthidiellum) eritrinum</i> , 13
2018	<i>Anthidiellum (Chloranthidiellum) flavescens nigrescens</i>	<i>Anthidiellum (Chloranthidiellum) eritrinum</i> , 13
2018	<i>Anthidiellum (Pycnanthidiellum) transversale</i>	<i>Anthidiellum (Chloranthidiellum) eritrinum</i> , 13
2018	<i>Anthidiellum bessei</i>	<i>Anthidiellum (Chloranthidiellum) eritrinum</i> , 13
2018	<i>Anthidium auriscopatum</i>	<i>Anthidiellum (Pycnanthidium) absonulum</i> , 13
2018	<i>Dianthidium melanocephalum</i>	<i>Anthidiellum (Pycnanthidium) apicatum</i> , 13
2018	<i>Dianthidium spilotum</i>	<i>Anthidiellum (Pycnanthidium) apicatum</i> , 13

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Appendix 3

New country records of species (i.e. not in the CAB) represented by specimen records downloaded from the GBIF Data Portal.

Country	Species
Angola	<i>Amegilla albocaudata</i> , <i>Amegilla langi</i> , <i>Amegilla nubica</i> , <i>Amegilla obscuriceps</i> , <i>Amegilla spilostoma</i> , <i>Amegilla velutina</i> , <i>Anthidiellum polyochrum</i> , <i>Anthophora rufolanata</i> , <i>Braunsapis albipennis</i> , <i>Braunsapis otavica</i> , <i>Ceratina labrosa</i> , <i>Melitturga capensis</i> , <i>Serapista denticulata</i> , <i>Tetralonia cinctula</i> , <i>Tetralonia penicillata</i> , <i>Thyreus calceatus</i>
Benin	<i>Sphecodes hagensi</i>
Botswana	<i>Afranthidium braunsi</i> , <i>Allodapula variegata</i> , <i>Anthophora armata</i> , <i>Braunsapis fuscineris</i> , <i>Ceratina lunata</i> , <i>Ceratina nasalis</i> , <i>Ceratina nyassensis</i> , <i>Coelioxys analis</i> , <i>Coelioxys natalensis</i> , <i>Coelioxys rufispina</i> , <i>Compso Melissa zaxantha</i> , <i>Liotrigona bottegoi</i> , <i>Lipotriches vulpina</i> , <i>Meliponula beccarii</i> , <i>Meliponula bocandei</i> , <i>Meliponula ferruginea</i> , <i>Pseudapis anthidioides</i>
Burkina Faso	<i>Amegilla atrocincta</i> , <i>Amegilla calens</i> , <i>Xylocopa watmoughi</i>

Country	Species
Burundi	<i>Afranthidium abdominale</i> , <i>Amegilla acraensis</i> , <i>Amegilla calens</i> , <i>Amegilla nigratarsis</i> , <i>Pseudoanthidium truncatum</i> , <i>Serapista denticulata</i> , <i>Xylocopa caffra</i> , <i>Xylocopa olivacea</i>
Cameroon	<i>Lipotriches orientalis</i> , <i>Pseudapis alicae</i> , <i>Seladonia africana</i> , <i>Seladonia foana</i> , <i>Seladonia jucunda</i> , <i>Tetralonia fraterna</i>
Central African Republic	<i>Amegilla acraensis</i> , <i>Amegilla atrocincta</i> , <i>Hypotrigona gribodoi</i> , <i>Meliponula bocandei</i>
Chad	<i>Amegilla nubica</i> , <i>Xylocopa inconstans</i>
Democratic Republic of Congo	<i>Cyphanthidium sheppardi</i> , <i>Tetralonia mesotes</i>
Eritrea	<i>Amegilla eritrina</i> , <i>Anthophora vestita</i>
Ethiopia	<i>Anthophora vestita</i>
Gabon	<i>Allodape mea</i> , <i>Amegilla circulata</i> , <i>Amegilla kaimosica</i> , <i>Braunsapis calidula</i> , <i>Ceratina malindiae</i> , <i>Ceratina nasalis</i> , <i>Ceratina nyassensis</i> , <i>Ceratina pacis</i> , <i>Ceratina tanganyicensis</i> , <i>Ceratina viridis</i> , <i>Ceylalicthus muiri</i> , <i>Hypotrigona araujoi</i> , <i>Liotrigona bottegoi</i> , <i>Megachile discolor</i> , <i>Megachile ianthoptera</i>
Ghana	<i>Amegilla atrocincta</i> , <i>Amegilla calens</i> , <i>Amegilla kaimosica</i> , <i>Amegilla vivida</i> , <i>Ceratina lineola</i> , <i>Ceratina nasalis</i> , <i>Meliponula beccarii</i> , <i>Nomia rufitarsis</i> , <i>Tetralonia nigropilosa</i> , <i>Xylocopa albiceps</i> , <i>Xylocopa olivacea</i>
Ivory Coast	<i>Amegilla nila</i> , <i>Ctenoplectra bequaerti</i> , <i>Xylocopa caffra</i>
Kenya	<i>Amegilla atrocincta</i> , <i>Amegilla bechuanensis</i> , <i>Amegilla caelestina</i> , <i>Amegilla cymatilis</i> , <i>Amegilla grandiceps</i> , <i>Amegilla kuleni</i> , <i>Amegilla penicula</i> , <i>Amegilla rapida</i> , <i>Amegilla vivida</i> , <i>Ammobates auster</i> , <i>Anthophora xanthostoma</i> , <i>Braunsapis langenburgensis</i> , <i>Braunsapis lyrata</i> , <i>Braunsapis nautica</i> , <i>Braunsapis neavei</i> , <i>Cellariella somalica</i> , <i>Ceratina nasalis</i> , <i>Ceratina nyassensis</i> , <i>Ceratina speculifrons</i> , <i>Ctenoplectra polita</i> , <i>Haetosmia ethiopiensis</i> , <i>Hylaeus fumatus</i> , <i>Hypotrigona araujoi</i> , <i>Hypotrigona ruspolii</i> , <i>Lipotriches hirsutula</i> , <i>Lipotriches leucomelanura</i> , <i>Lipotriches neglecta</i> , <i>Lipotriches patellifera</i> , <i>Megachile ianthoptera</i> , <i>Meliponula ferruginea</i> , <i>Nomia vassei</i> , <i>Pachymelus festivus</i> , <i>Pasites appletoni</i> , <i>Pasites jenseni</i> , <i>Pseudapis anthidioides</i> , <i>Pseudapis patellata</i> , <i>Seladonia africana</i> , <i>Tetralonia nigropilosa</i> , <i>Tetraloniella abessinica</i> , <i>Tetraloniella abrochia</i> , <i>Tetraloniella apicalis</i> , <i>Tetraloniella ataxia</i> , <i>Tetraloniella aurantiflava</i> , <i>Tetraloniella elsei</i> , <i>Tetraloniella katanangensis</i> , <i>Tetraloniella ottiliensis</i> , <i>Thyreus bouysouvi</i> , <i>Thyreus interruptus</i> , <i>Xylocopa lugubris</i>
Lesotho	<i>Afromelecta fulvohirta</i> , <i>Amegilla spilostoma</i> , <i>Colletes malleatus</i> , <i>Epeolus natalensis</i> , <i>Megachile cordata</i> , <i>Megachile curtula</i> , <i>Megachile venusta</i> , <i>Pseudoanthidium tertium</i>
Liberia	<i>Amegilla acraensis</i> , <i>Amegilla albocaudata</i> , <i>Amegilla nubica</i> , <i>Meliponula beccarii</i>
Malawi	<i>Amegilla albocaudata</i> , <i>Amegilla aspergina</i> , <i>Amegilla caelestina</i> , <i>Amegilla calens</i> , <i>Amegilla capensis</i> , <i>Amegilla cymatilis</i> , <i>Amegilla kaimosica</i> , <i>Amegilla mimadvena</i> , <i>Amegilla nila</i> , <i>Amegilla nubica</i> , <i>Amegilla penicula</i> , <i>Anthophora tetradonta</i> , <i>Braunsapis langenburgensis</i> , <i>Braunsapis simplicipes</i> , <i>Ceratina nasalis</i> , <i>Euasps erythros</i> , <i>Hypotrigona araujoi</i> , <i>Hypotrigona gribodoi</i> , <i>Hypotrigona ruspolii</i> , <i>Lipotriches tridentata</i> , <i>Megachile rufiventris</i> , <i>Meliponula ferruginea</i> , <i>Patellapis minima</i> , <i>Seladonia foana</i> , <i>Seladonia jucunda</i> , <i>Tetraloniella abessinica</i> , <i>Tetraloniella ogilviae</i> , <i>Thyreus axillaris</i> , <i>Xylocopa flavicollis</i> , <i>Xylocopa lugubris</i> , <i>Xylocopa mixta</i>
Mauritius	<i>Thyreus calceatus</i>
Mozambique	<i>Amegilla caelestina</i> , <i>Anthophora armata</i> , <i>Ceratina opaca</i> , <i>Hypotrigona araujoi</i> , <i>Hypotrigona gribodoi</i> , <i>Hypotrigona ruspolii</i> , <i>Megachile alternans</i> , <i>Megachile bituberculata</i> , <i>Meliponula beccarii</i> , <i>Meliponula ferruginea</i> , <i>Thrinchostoma kandti</i>
Namibia	<i>Afranthidium biangulatum</i> , <i>Afranthidium hamaticauda</i> , <i>Afranthidium haplogastrum</i> , <i>Afranthidium repetitum</i> , <i>Amegilla calens</i> , <i>Amegilla nigratarsis</i> , <i>Anthidium bechuanalandicum</i> , <i>Anthophora xanthostoma</i> , <i>Braunsapis fuscinervis</i> , <i>Braunsapis vitrea</i> , <i>Capicola rhodostoma</i> , <i>Capicola rufiventris</i> , <i>Ceratina armata</i> , <i>Ceratina nasalis</i> , <i>Coelioxys caeruleipennis</i> , <i>Colletes zuluensis</i> , <i>Euylaeus mirifrons</i> , <i>Heriades wellmani</i> , <i>Hylaeus braunsi</i> , <i>Hypotrigona gribodoi</i> , <i>Lipotriches patellifera</i> , <i>Lipotriches vulpina</i> , <i>Megachile atopognatha</i> , <i>Megachile atripes</i> , <i>Megachile frontalis</i> , <i>Megachile malangensis</i> , <i>Megachile maxillosa</i> , <i>Megachile meadewaldoi</i> , <i>Megachile semierma</i> , <i>Megachile unguolata</i> , <i>Melitturga barbarae</i> , <i>Melitturga capensis</i> , <i>Melitturga penrithorum</i> , <i>Pachymelus peringueyi</i> , <i>Patellapis chubbi</i> , <i>Pseudapis flavicarpa</i> , <i>Pseudoheriades moricei</i>
Nigeria	<i>Afranthidium abdominale</i> , <i>Euasps erythros</i> , <i>Hypotrigona araujoi</i> , <i>Meliponula cameroonensis</i> , <i>Pseudapis alicae</i> , <i>Tetralonia fraterna</i> , <i>Tetralonia obscuriceps</i>
Senegal	<i>Afranthidium abdominale</i> , <i>Amegilla acraensis</i> , <i>Thyreus pretextus</i>
Seychelles	<i>Ceratina electron</i>
Somalia	<i>Haetosmia ethiopiensis</i>