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Sub-Saharan Botanical Collections: Taxonomic research and impediments

Sebsebe Demissew, Henk Beentje, Martin Cheek and Ib Friis

Abstract

Many historical specimens from sub-Saharan Africa are only found in European herbaria, but a higher number of newer specimens than widely assumed are kept in African herbaria, with a concentration in eastern and southern parts of the continent. Many of these herbaria were initiated in connection with independence of former European colonies in Africa, fewer were built on well-established herbaria from the colonial period. There are many gaps in collecting coverage, not least with regard to areas of high plant diversity; this is often caused by poor access or political instability. High species diversity exists in both humid and arid parts of Africa. Lack of collections from and knowledge about areas of high species diversity makes it difficult to prioritise conservation efforts. Gaps in taxonomic knowledge exist in certain large families, such as Rubiaceae, or in large genera, such as *Cyphostemma* (Vitaceae), *Euphorbia* (Euphorbiaceae), *Ipomoea* (Convolvulaceae), *Polystachya* (Orchidaceae), and *Barleria* (Acanthaceae). Newly collected specimens are now mainly kept in African herbaria, but lack of training and resources in tropical African herbaria are important challenges to prevent African botanists from continuing a somewhat declining European activity, partly caused by the downgrading in priority given to herbaria in European universities and research institutions. Encouraging examples of progress are the many regional African floras that have now been finished or nearly finished in collaboration between African and European herbaria, and the increasing digitization of herbaria and the general development of relevant services on the Internet, which provides new possibilities for botanical studies in Africa.

Key Words: biodiversity hotspots, conservation, field work, herbaria, historical collections, tropical Africa, South Africa

Sebsebe Demissew, The National Herbarium, Department of Plant Biology and Biodiversity, Addis Ababa University, P.O. Box 3434; Gullele Botanic Garden, P.O Box 153/1029, Addis Ababa, Ethiopia. E-mail: sebseb.demissew@gmail.com

Henk Beentje, Royal Botanic Gardens, Kew, TW9 3AE, England, UK. E-mail: h.beentje@kew.org

Martin Cheek, Royal Botanic Gardens, Kew, TW9 3AE, England, UK. E-mail: m.cheek@kew.org

Ib Friis, Natural History Museum of Denmark, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark. E-mail: ibf@snm.ku.dk

At the 4th congress of Association pour l'Étude Taxonomique de la Flore d'Afrique Tropicale (AETFAT) held at Lisbon and Coimbra, Portugal in September 1960, early sub-Saharan collections were intensely discussed during the session *Histoire de l'Exploration botanique de l'Afrique au Sud du Sahara* and the proceedings include a series of overviews that cover most of the region (Aubreville 1962 [W Africa]; Cufodontis 1962 [NE Tropical Africa]; Exell 1962a,b [islands in the Gulf of Guniea]; Fernandes & Fernandes 1962 [Mozambique]; Gillett 1962 [E Africa]; Hepper 1962 [W Africa]; Keay 1962 [W Africa]; Mendonça 1962a,b [Angola, Mozambique]; Siméon & Tourney 1962 [Congo]; Wild 1962 [Zimbabwe, Malawi]; White 1962 [Zambia]). Later historical reviews include Beentje and Smith (2001) and Beentje (2015) for Tropical East Africa, Friis (2007, 2011) and Sebsebe Demissew (2011, 2014) for Ethiopia and Thulin (2006) for Somalia.

Historical Collections

The oldest sub-Saharan plant collections date back to the 1670-1690s, with early collectors such as Patric Adair (Johanna Island = Anjouan), Edward Bartar (Ghana), Charles Coombs (Calabar in Nigeria), and John Kirckwood (Angola and Cabinda: Cabo Verde in Cape Verde Islands and Calabar in Nigeria), but most of the early collections come from the Cape of Good Hope in South Africa and were collected by Adair, William Dampier, John Fox, Paul Hermann, George Lewis, Frederick Ruysch, George Stonestreet

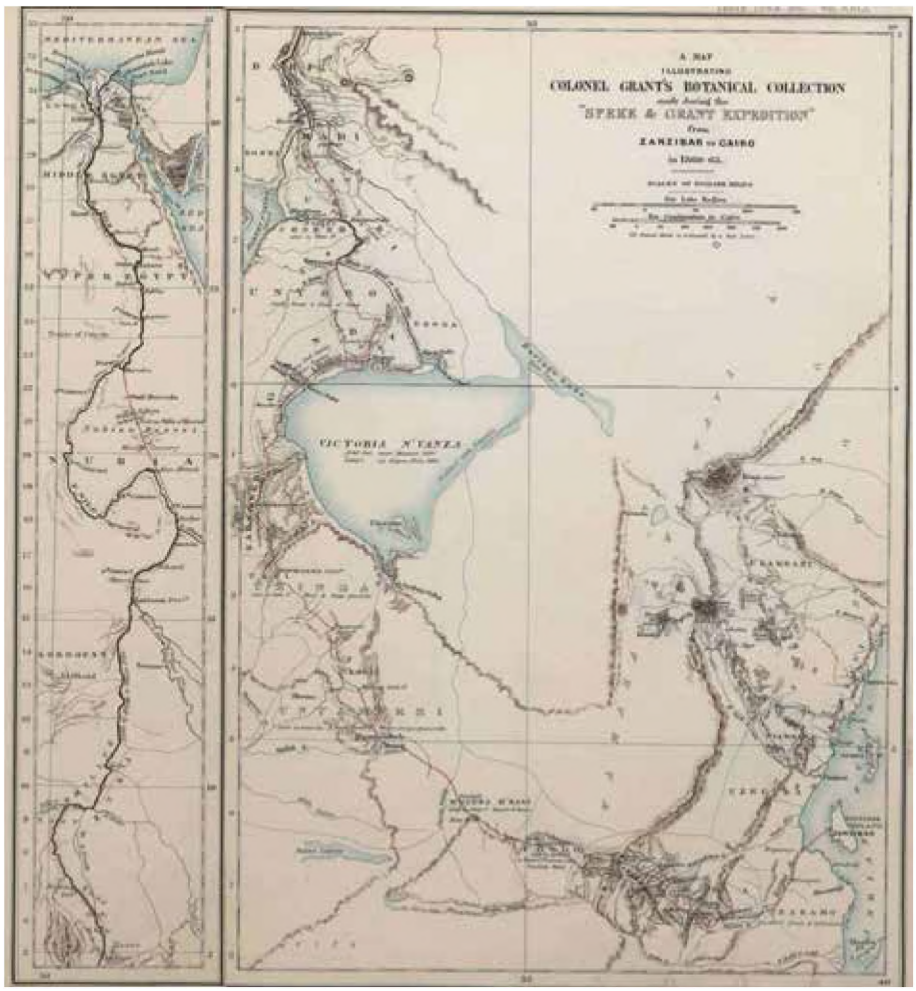

Fig. 1. The route of the travels of J.H. Speke and J.A. Grant from Zanzibar through Tanzania and Uganda in 1860-1863. Map published with Grant and Oliver (1872).

Fig. 2. Friedrich Martin Josef Welwitsch (1806–1872). Lithograph with facsimile signature, 19th century. In the collections of the Royal Botanic Gardens, Kew (published with permission).

(Exell 1962a). Most of the early collections were made along the coast. Apart from travels in Ethiopia and South Africa and attempts to cross the Sahara from the North (see for example Onana *et al.* 2017) the first long inland journey that involved collecting of plants was that in 1860–1863 of J.H. Speke and J.A. Grant from Zanzibar along the Nile to Cairo (Fig. 1).

In the 18th and 19th centuries most collections of plants in sub-Saharan Africa were done by naturalists funded by European countries, institutions, or by individuals with the intention to explore territories unknown to Europeans. All collections of these travellers were deposited in institutions in Europe (Table 1). There were no academic institutions dealing with botany, or indeed any herbarium collections, in sub-Saharan Africa before 1870.

Fig. 3. The only known portrait of Georg Heinrich Wilhelm Schimper (1804–1878; lived in Ethiopia from 1837 to his death). Detail from a series of group portraits of Emperor Tewodoros' European hostages, with their wives and children, taken after their release in 1868 by Sergeant John Harrold, a member of the British army. Schimper wears a turban-like headgear and is dressed in an Ethiopian silk cloak with embroidered edge. The people portrayed in the British photographs of the hostages have been identified by Gräber (1999a, 1999b). From Friis (2007).

Three 19th century collectors deserve special mentioning because of their particularly large output of collections made during long residences or extended travelling in Tropical Africa: Schimper, Welwitch and Schweinfurth. Not only did they make many collections in tropical Africa, their collections included

Table 1. Examples of historical collections of tropical African plants made before the 20th century and the herbaria where these specimens are deposited. Based on information from *Index Herbariorum* (Thiers continuously updated) and the index of collectors in *Index Herbariorum, Part II* (Lanjouw & Stafleu 1954, 1957; Chaudhri *et al.* 1972; Vegter 1976, 1983, 1986, 1988), updated with http://plants.jstor.org/. Schweinfurth's data have been supplemented from Wickens (1972). Most of the material brought out of Ethiopia by Bruce were drawings and seeds and bulbs; the few extant herbarium specimens were prepared from plants cultivated in various gardens in Europe (Hulton *et al.* 1991). Speke and Grant, Hildebrandt and Schweinfurth collected during travels in East and in North-East Africa; Hildebrandt's field trip to Madagascar in 1879-1891 is not included.

Region	Collector	Year	No. of collections	Countries	Herbaria where the collectors' specimens are deposited
North-East Africa	James Bruce	1769-1771	Low	Ethiopia	LINN, P
	G.H.W. Schimper	1837-1863	2600+	Ethiopia, Eritrea	B (main), BM (main), P (main), PC (main), A, AWH (currently BR), BERN, BHU (currently B), BP, BR, BREM, C, CAL, CAS, CGE, CN, CORD, DBN, DPU (currently NY), DR, E, E-GL, ETH, F, FI, FT, G, G-BOIS, GE, GH, GOET, GRO, H, HAL, HBG, HOH, JE, K, KIEL, KR, L, LE, LG, LV, LY, LZ, M, MANCH, MO, MPU, MW, NA, NCY, NEU, NH, NMW, NY, OXF, PAL, PR, PRC, REG, RO, S, SAM, STR, STU, TCD, TO, TUB, U, UPS, US, VT, W, WAG, WB, WRSL, WU, Z, ZT
	G. Schweinfurth	1867-1897	4000	Egypt, Sudan, Ethiopia, Eritrea	B (main, partly lost), AAR (currently HUJ), BAS, BM, BO, BP, BPI, BR, C, CAIM, CORD, DBN, E, FI, FT, G, GE, GOET, GZU, H, HBG, HUJ, K, KIEL, L, LE, LY, M, MO, MPU, MW, NH, NMW, NY, OXF, P, PC, PH, PR, S, SAM, US, W, WIR, WRSL, WU, Z
East and North-East Africa	J.M. Hildebrandt	1872-1877	1650	Ethiopia, Somalia, Kenya, Tanzania	B [main set, partly lost], BM, BR, CORD, GOET, K [important set], KIEL, L, LY, MO, P, PC, W
	J.H. Speke & J.A. Grant	1860-1863	?650	Tanzania, Uganda	K

Region	Collector	Year	No. of collections	Countries	Herbaria where the collectors' specimens are deposited
West Africa	A.M.F.J. Palisot de Beauvois	1786-1788	hundreds	Benin, Nigeria	FI-WEBB, G, GH, P [main set], P-JU
	J. Heudelot	1835-1837	1000	Senegal	A, B, BM, BR, CN, DS, FI, G, K, NY, OXF, P [main set], P-JU, PC, W
	G. Mann	1859-1863	3000	Sierra Leone, Nigeria, Cameroon, Bioko, Sao Tomé	A, B, BM, E, G, GH, H, K [main set], L, LE, P, S, U, W
Southern Africa	F.M.J. Welwitsch	1853-1861	3000+	Angola (mainly), Namibia	B, BM [second of two main sets], BOL, BR, C, COI, G, H, K, LE, LISU [first of two main sets], M, MO, MPU, NU, P, TUR, W
	J. Kirk	1861-1886	2800+	Mozambique, Malawi, Zanzibar	B, CAL, E, F, FHO, GH, K [main set], LE, MO, OXF, W

more duplicates than the other early collectors, and their collections are represented at more European and North American herbaria than any of the other 19th century collectors (Table 1), thus bringing many plant specimens into herbaria and spreading the knowledge of African plants. Schimper's and Welwitsch's collections include significantly more type specimens of African plant species than all other collectors in tropical Africa, both earlier and later (Gillett 1972; Albuquerque *et al.* 2009). Also a high proportion of Schweinfurth's collections are types. Friedrich Welwitsch (1806-1872; Fig. 2) carried out expeditions in Angola for over seven years (1853-1860). Two almost equivalent sets of his collections are housed at the Natural History Museum, London, UK (BM) and at the University of Lisbon (LISU), but his duplicates are widespread (Vegter 1988; Albuquerque *et al.* 2009). Georg Heinrich Wilhelm Schimper (1804-1878; Fig. 3) lived in Ethiopia for more than 40 years, from 1837 to his death (Gräber 1999a,b; Gestrich & McEwan 2015; McEwan 2015). Over the 40 years of his collecting activity, his first set were placed at different herbaria, mainly P and B, where most of it was lost in World War II, but numerous of his duplicates are widely deposited in European and North American herbaria and now partly also in ETH, Addis Ababa (Friis 2007). Georg August Schweinfurth (1836-1925) went to Egypt in 1863, from where he travelled along the Red Sea coast of Africa and through northern Sudan in 1863-1865, including a stay in the border region between Sudan and Ethiopia. Having returned to Europe in 1866, he explored in 1869-1871 the western parts of South Sudan and the north-eastern parts of todays' Democratic Republic of Congo. From 1874 to 1888 he was based in Cairo and travelled widely in Egypt and to Socotra, and, after his return to Germany, he explored Eritrea in 1891 and 1894 (Wickens 1972).

Later in the 20th century, after European countries had established colonies in Africa, there was an interest to continue the exploration of botanical resources by documenting them in the form of floras and to establish colonial or national herbaria in Africa (Table 2; Fig. 4). The regional survey in Table 2 shows a high

Table 2. Richness of collections in sub-Saharan Africa, based on regionally accumulated number of collections in herbaria in sub-Saharan Africa. Data from *Index Herbariorum* (Thiers continuously updated).

Region	Countries	Number of herbaria	Collections in national herbaria	Associated major herbaria in Europe or USA
Horn of Africa	Djibouti, Eritrea, Ethiopia, Somalia and the Sudan	6	160,000	P, FT, K
Eastern Africa	Burundi, Kenya, Malawi, Mozambique, Rwanda, South Sudan, Tanzania, Uganda and Zambia and Zimbabwe	23	2,396,000	BR, LISC, K, MO
Central Africa	Angola, Cameroun, Central Africa, Chad, Republic of the Congo, Democratic Republic of Congo, Equatorial Guinee, Gabon, São Tomé and Príncipe	23	685,000	BR, COI, LISC, P
Western Africa	Benin, Burkina Faso, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo	24	626,000	P, K
Southern Africa	Botswana, Lesotho, Namibia, South Africa, Swaziland	48	3,153,000	
Total		124	7,020,000	

concentration of herbaria in South Africa and a high concentration of large herbaria with many collections in eastern and southern Africa. Figure 4 shows the foundation of many new herbaria after World War II and around the end of the colonial era in the 1960s.

African Collections in Africa and Europe

Index Herbariorum (Thiers continuously updated) has recorded 172 herbaria and a total of 7,171,888 collections in sub-Saharan Africa (Table 3). These herbaria are found in 38 out of 49 countries. The establishment of these herbaria, which started in 1864 in South Africa, has continued up to today (Figs. 4), but the size and distribution of these herbaria are extremely variable (Figs. 5, 6). The largest number of specimens are found in herbaria in South Africa (PRE in Pretoria with 1.2 million and NBG Compton Herbarium with just over ½ million) and tropical East Africa (EA in Nairobi with 1 million and SRGH in Harare >½ million; Fig. 6) . The herbaria in sub-Saharan Africa have a total of more than 7 million specimens (Table 3). Only Eritrea, South Sudan, Chad, Gambia and Guinea Bissau have no herbaria recorded in the *Index Herbariorum*.

In comparison, the herbarium of the Royal Botanic Gardens, Kew (K), is assumed to have about 2.5 million collections from sub-Saharan Africa out of their total holding of about 7 million. The herbarium of the Museum national d'histoire naturelle at Paris (P) seems to hold slightly more than 700,000 collections from tropical Africa (and slightly more than half a million from Madagascar), to judge from the database https://science.mnhn.fr/institution/mnhn/col-

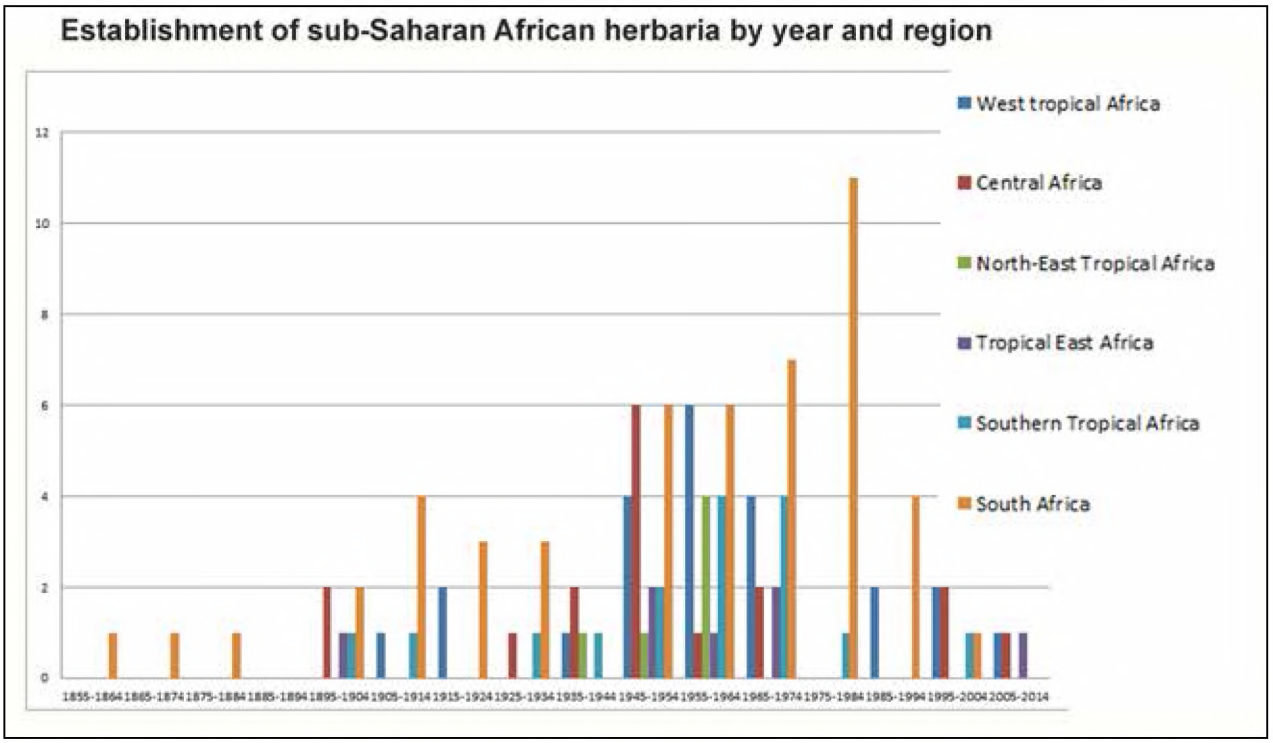

Fig. 4. Number of herbaria established in sub-Saharan Africa by year and region. Based on information from Thiers (continuously updated).

lection/p/item/list?secteur=AFM. Thus, the number of herbarium specimens held in sub-Saharan Africa institutions is significant and, as it would seem, at least as many herbarium collections must be held in herbaria in sub-Saharan Africa as in temperate institutions, which is contrary to the commonly held belief that vastly more African herbarium specimens are deposited in northern institutions than in Africa.

Gaps in Collecting Coverage

The gaps in plant-collecting in sub-Saharan Africa have many causes. During pre-colonial times it was difficult to make collections in most parts of tropical Africa (Fig. 7A). Plant collectors suffered from diseases such as malaria and were hampered by poor infrastructure; Luigi Balugani, the Italian illustrator who accompanied James Bruce, died of dysentery or malaria in Gondar in Ethiopia in 1771 (Hulton *et al.* 1991), the two French botanical collectors sent on a collecting trip to Ethiopia in 1838 newer returned from their journey, and Richard Quartin-Dillon died in 1840 in northern Ethiopia from an unknown disease. Some

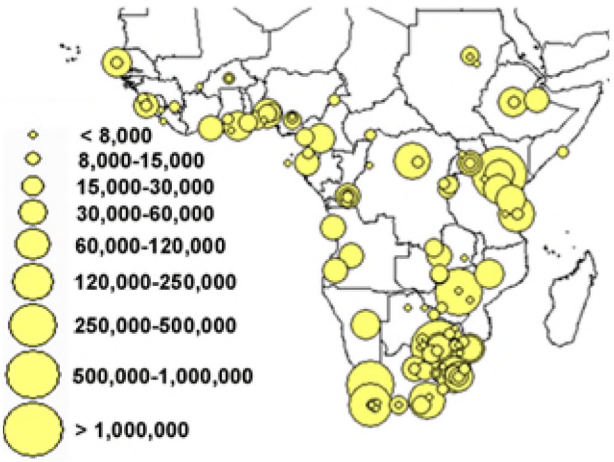

Fig. 5: Size and distribution of herbaria in sub-Saharan Africa. Based on information from Thiers (continuously updated).

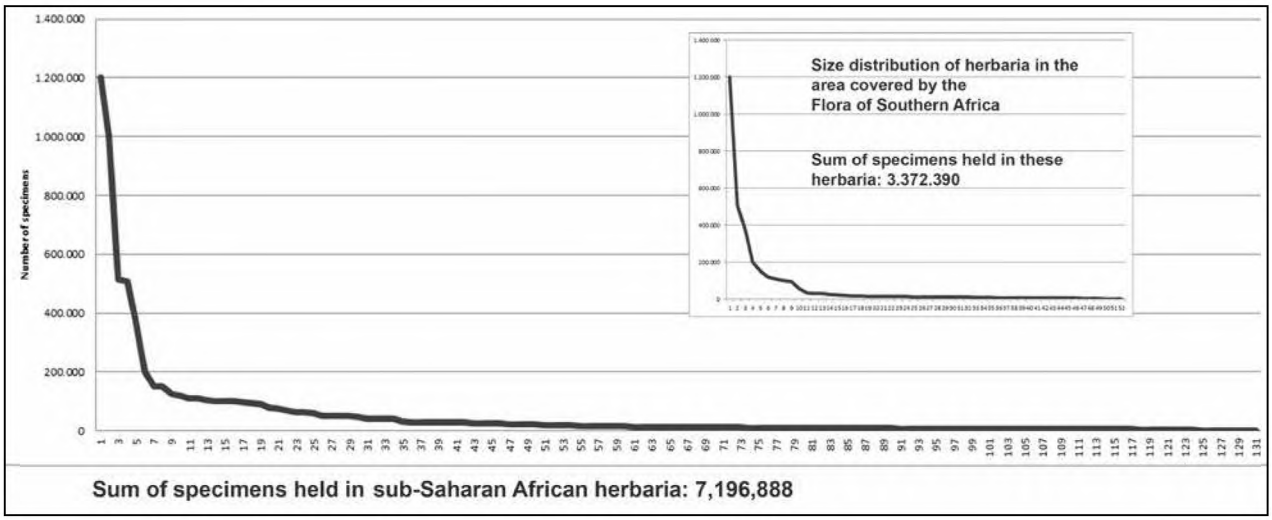

Fig. 6. Size-distribution of herbaria in sub-Saharan Africa and southern Africa. Few herbaria have many specimens, many herbaria have few specimens. Based on information from Thiers (continuously updated).

Table 3. Richness of collections by country in sub-Saharan Africa, based on estimated number of higher plant species, area in km², estimated number of species per 1000 km², number of herbaria, number of collections, collections per 1000 km² and collections per estimated number of species. Data on estimated number of species from Beentje and Smith (2001), with modifications from the checklist of Sudan and South Sudan (Darbyshire *et al.* 2015), other data from *Index Herbariorum* (Thiers continuously updated). Countries for which no herbarium has been recorded in the *Index Herbariorum* are marked with a zero.

Country	Estimated number of species	Area (in 1000 km²)	Estimated number of species/ 1000 km²	Number of herbaria	Number of collections	Collections per 1000 km²	Collections per estimated number of species
South Africa	23,400	1223	19.1	55	3,218,590	2631.7	137.5
Congo (Kinshasa)	10,000	2345	4.3	12	302,894	129.2	30.3
Tanzania	10,000	940	10.6	6	292,300	311.0	29.2
Cameroon	8300	475	17.5	5	137,000	288.4	16.5
Gabon	7200	267	27.0	1	40,000	149.8	5.6
Ethiopia and Eritrea	6600	1184	5.6	4	137,000	115.7	20.8
Kenya	6500	583	11.1	3	1,100,000	1886.8	169.2
Congo (Brazzaville)	6000	267	22.5	1	40,300	150.9	6.7

Country	Estimated number of species	Area (in 1000 km²)	Estimated number of species/ 1000 km²	Number of herbaria	Number of collections	Collections per 1000 km²	Collections per estimated number of species
Mozambique	5700	783	7.3	5	125,350	160.1	22.0
Zimbabwe	5500	389	14.1	5	540,636	1389.8	98.3
Uganda	5400	243	22.2	4	84,767	348.8	15.7
Angola	5200	1247	4.2	4	90,000	72.2	17.3
Zambia	5000	746	6.7	8	86,000	115.3	17.2
Nigeria	4700	924	5.1	8	194,500	210.5	41.4
Côte d'Ivoire	3700	322	11.5	3	40,000	124.2	10.8
Ghana	3700	238	15.5	5	102,052	428.8	27.6
Central African Republic	3600	617	5.8	2	10,000	16.2	2.8
Equatorial Guinea	3300	28	117.9	1	8000	285.7	2.4
Namibia	3200	824	3.9	1	94,000	114.1	29.4
South Sudan	3100	620	5.0	0	0	0	?
Guinea	3000	246	12.2	7	19,800	80.5	6.6
Somalia	3000	638	4.7	1	10,000	15.7	3.3
Burundi	2500	28	89.3	1	20,000	714.3	8.0
Togo	2500	57	43.9	1	21,000	368.4	8.4
Rwanda	2300	26	88.5	1	16,702	642.4	7.3
Benin	2200	116	19.0	1	18,000	155.2	8.2
Liberia	2200	111	19.8	1	7000	63.1	3.2
Senegal	2100	197	10.7	2	122,000	619.3	58.1
Sudan	2100	1886	1.1	3	40,500	21.5	19.3
Swaziland	2100	17	123.5	1	7200	423.5	3.4
Botswana	2000	30	66.7	5	31,000	1033.3	15.5
Sierra Leone	2000	72	27.8	4	64,857	900.8	32.4
Chad	1800	1284	1.4	0	0	0	0
Malawi	1800	119	15.1	1	100,000	840.3	55.6
Mali	1700	1204	1.4	1	6400	5.3	3.8

Country	Estimated number of species	Area (in 1000 km²)	Estimated number of species/ 1000 km²	Number of herbaria	Number of collections	Collections per 1000 km²	Collections per estimated number of species
Lesotho	1600	30	53.3	3	21,600	720	13.5
Niger	1200	1189	1.0	1	0	0	0
Burkina Faso	1100	280	3.9	3	20,940	74.8	19.0
Gambia	1000	10	100.0	0	0	0	0
Guinea Bissau	1000	36	27.8	0	0	0	0
Saõ Thomé e Principe	900	1	900.0	1	1500	1500	1.7
Djibouti	600	22	27.3	1	0	0	0
		21864000 km²		172 herbaria	7,171,888 collections	Average for total area and total number of collections: 328 collection per 1000 km²	Average for all countries 6.4 collections per estimated species

were even killed by wild animals; Antoine Petit was seized and drowned by a crocodile when crossing the Blue Nile in 1843 (Stearn 1982) and the Italian collector and big-game hunter Emanuele Ruspoli was trampled to death by an angry, wounded elephant near Burgi in Sidamo, southern Ethiopia, in 1893 (Settesoldi *et al.* 2005).

Even after the colonial period, many problems have persisted in spite of vast improvements in the infra-structure. Gaps in collecting activities persist, as seen in Fig. 7C, because collectors follow the main roads or because access to remote areas remains difficult and dangerous due to political instability. Current areas of instability include those where armed political conflicts are on-going, as widely reported in the international news-media, for example in South Sudan, Eastern Congo and northern Mali. Religious fundamentalism is also seriously destabilizing large areas, such as the activities of Al-Shabab in Somalia, which is making large areas of the neighbouring territories in the Ogaden in Ethiopia and North-Eastern Kenya inaccessible. The activities of Boko Haram impede access to parts of northern Nigeria, and the Lord's Resistance Army has seriously hampered studies in northern Uganda and north-eastern Congo. And also today diseases may make field work difficult or impossible, for example the outbreaks of ebola in Guinean Republic, Liberia and Sierra Leone in 2014–2016.

Conversely, there are areas that are well-collected, and such areas often figure on high-diversity lists, and therefore, they are studied again and again, and their inclusion becomes a self-fulfilling prophesy. But studying lesser-known areas can pay off. For example, Mt Kupe, Mwanenguba and the Bakossi Mountains in Cameroun were virtually unknown (with 123 plant species known from the area in 1993) until a team from Yaoundé and Kew explored them in 1995-2004 and found 2440 plant species, of which 82 were nar-

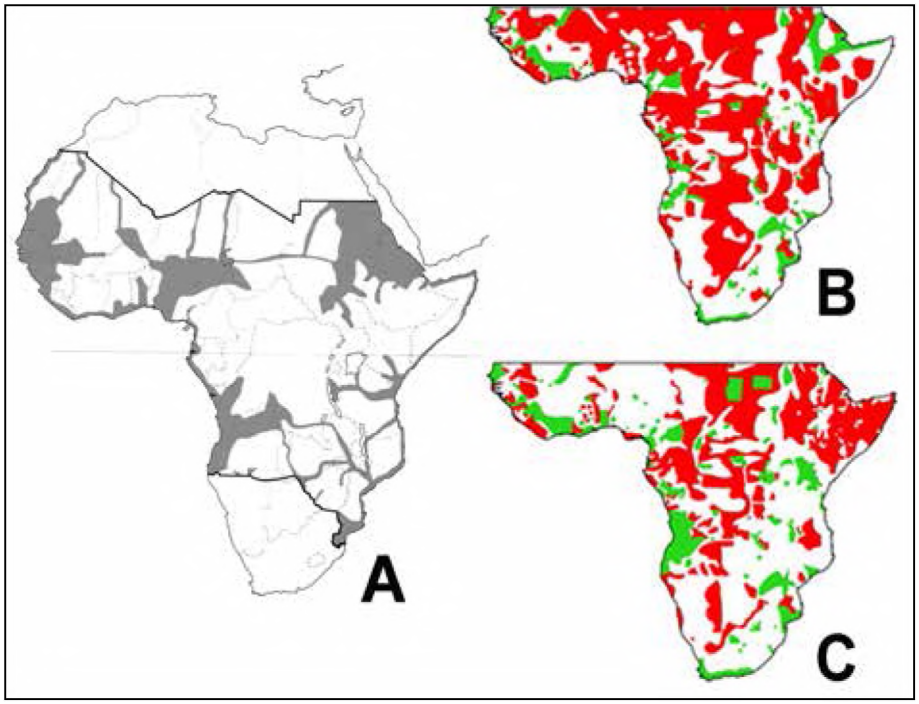

Fig. 7. The degree of floristic exploration of Africa from ca. 1860 to ca. 1980. (A). Parts of tropical Africa visited by European travellers by 1860 (grey); by this time the entire Cape Region is indicated as visited. (B). Degree of floristic exploration at ca. 1965. (C). Degree of floristic exploration at ca. 1980. Poorly known areas are indicated with red, moderately well-known areas with white, and well known with green. (A) From map on p. 16 in Vol. 1 of Lebrun and Stork (1991–1997), redrawn from Plate 10 in Supan (1888). (B) Redrawn from Léonard (1965). (C) Redrawn from Hepper (1979).

row endemics, and 232 were threatened taxa (Cheek *et al.* 2004). These data catapult this area into one of the most important and richest plant diversity spots in tropical Africa, which emphasizes the importance of studying under-explored areas. A similar case is the Makueni area of less than 200 km^2 of wooded grassland in Kenya, which was virtually botanically unknown until an inventory organized by the National Museums of Kenya showed that it housed 847 species, including 758 vascular plants, 20 bryophytes, and 69 lichenized fungi (Malombe *et al.* 2015).

It is difficult to state much with certainty about what plants are not known or represented in herbaria, but some attempts have been made in Table 3. First we have tried to look at the number of collections per 1000 km^2, for which the average is 328. Some countries seem to have a reasonably good coverage of collections per 1000 km^2, with 3–9 times the average. This relates in particular to South Africa (2632 collections per 1000 km^2), Kenya (1887 collections per 1000 km^2), Zimbabwe (1390 collections per 1000 km^2) and Botswana (1033 collections per 1000 km^2). These figures do indeed indicate well stocked herbaria, but it should be noted that South Africa, Zimbabwe and Kenya have old herbaria which have acted as central institutions for what is now several separate countries; the EA herbarium in Nairobi, for example, was for long time a central herbarium for Kenya, Uganda and Tanzania, and received also collection from other neighbouring countries. But the fact that more than 25 countries are below the average would seem to suggest serious gaps.

Also the number of collections per estimated number of species for the countries may indicate serious gaps in collecting in many sub-Saharan African countries. Gabon, a species-rich country that covers biodiversity hotspots (Fig. 8A) has only 5.6 collections per estimated species, which is below the average of 6.4.

Gaps in Collecting Activity and Knowledge about Areas of High Diversity

As it seems to be the case with Gabon, many of the high-diversity areas in sub-Saharan Africa, popularly known as biodiversity hotspots, are under-studied and collections from these areas poorly represented in

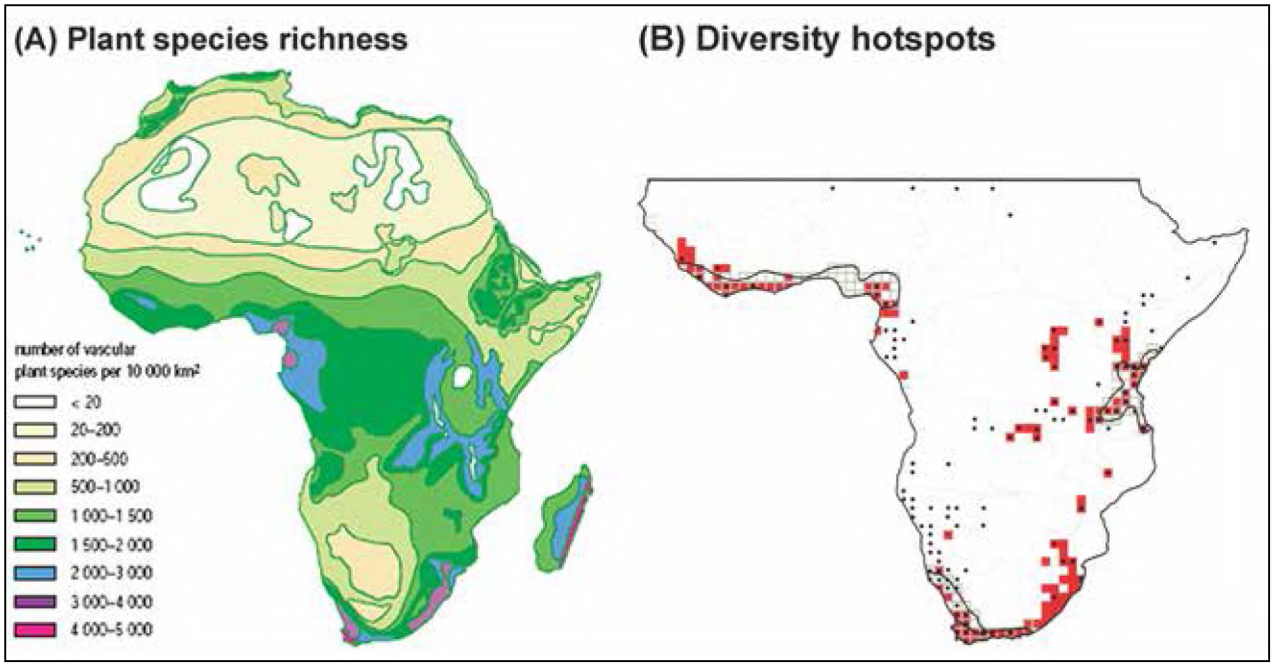

Fig. 8. Diversity of the African flora, biodiversity hotspots and need for conservation and in some cases more collecting activity and exploration (compare with Fig. 6 and 8). (A) Map showing estimated number of vascular plant species per 10,000 km² in sub-Saharan Africa. (B) Sub-Saharan areas estimated to be of high conservation value. The diversity hotspot areas defined by Myers *et al.* (2000) are indicated by solid black lines. Open cells surrounded by grey lines are one-degree squares covered by the hotspots of Myers *et al.,* while the redefined hotspots by Küper *et al.* (2004) are indicated with red cells. The map also shows (black dots) the 125 cells of the 'near-minimum-cost'-set where the most species can be protected at lowest cost. (A) Part of map of estimated plant diversity of the world by Mutke and Barthlott (2005). (B) From Küper *et al.* (2004).

herbaria, African as well as European. This makes it difficult to prioritise these areas with high diversity even though they may be threatened. The original and well-known Myers-Mittermeier hotspots (Myers *et al.* 2000) were painted with a very broad brush, and the resulting picture was geared towards public relations for the conservation of areas characterized by the presence of particularly spectacular species, often outstanding species of animals, so-called 'flagship-species.' We are not denying the need for conservation in many of these areas, but such hotspots as 'Horn of Africa' or 'Madagascar' are defined too broadly to be informative. Some of the high-diversity areas within these 'hotspots' are pretty small and discrete, such as the Nogaal Valley in Somalia, the Uluguru and Udzungwa Mountains in Tanzania, or the Bakossi Mountains in Cameroon.

Areas with more than 3000 species per 10,000 km² are quite small. The map only shows the diversity on a continental scale, but even these relatively small areas can sometimes, on a finer scale, be broken up into smaller centres of high diversity, for example the Monts de Cristal in Gabon, which was not included in the map of Myers *et al.* (2000). Because of their small size these areas are particularly important to focus upon for conservation purposes. In 2004 one of us contributed to the redefinition of the African hotspots on a much finer scale and more linked to hard facts than Myers' areas (Küper *et al.* 2004) (Fig. 8B). The map also shows where to protect the most species at lowest cost; that often (but not always) means least human impact, so these are not hotspots, which are defined by having lost at least 70% of their primary vegetation (Myers *et al.* 2000).

When areas with high diversity and high conservation value are under-collected, then these areas represent high-priority gaps that need addressing. Some such areas may be 'invisible' both on distribution and diversity maps and in herbaria because of under-collecting, as proven by the Bakossi Mountains in Cameroon and the Makueni wooded grasslands in Kenya. This points to the need for more fieldwork in as many suspected or potential hot-spots as possible. The study of undiscovered hot-spots may also provide taxonomically interesting new species, such as *Ancistrocladus tanzaniensis* Cheek & Frimodt-Møller, *Diospyros uzungwaensis* Frimodt-Møller & Ndang., *Lijndenia udzungwarum* R.D. Stone & Q. Luke, *Asplenium udzungwense* Beentje, *Coleotrype udzungwaensis* Faden & Layton, *Pauridiantha udzungwaensis* Ntore & Dessein, all described, with many others, within the last fifteen years from humid habitats in the Udzungwa Mountains in Tanzania. The Udzungwa Mountains was a poorly known, but in fact a floristically and faunistically very rich part of the Eastern Arc Mountains, which only became well known after the 1990s (Lovett 1993, 1998).

Equally high and hitherto unnoticed diversity might be seen in dry habitats, for example the 137 new species described from Somalia since ca. 1990 (Thulin 2006). Recent examples of undiscovered floristic richness in dry habitats in the Horn of Africa are a range of striking new species in Acanthaceae, Apocynaceae, Euphorbiaceae, Leguminosae and Solanaceae from the Ogaden in eastern Ethiopia and adjacent parts of Somalia (Thulin *et al.* 2008; Thulin 2008, 2009a,b,c; Thulin & Vollesen 2015), to which has recently been added two extraordinarily tall, woody and large-flowered species of *Commicarpus* from an arid high-diversity part of south-eastern Ethiopia (Friis *et al.* 2016) This also points to the need to study potential hot-spots in order to fill taxonomic gaps.

Gaps in Taxonomic Knowledge

While gaps in collecting activity in high diversity areas mean that the herbaria are not representative, the gaps in taxonomic knowledge mean that collections in herbaria are not updated and properly utilised. Gaps in taxonomic knowledge are twofold: gaps in the broader understanding of taxonomy at the level of genera and species, and gaps in the production of floras and lacking flora-coverage (Sebsebe Demissew 2011, 2014; Beentje 2015). Taxon-knowledge gaps in sub-Saharan Africa itself are especially vexing in the larger families: Poaceae, Fabaceae, and Asteraceae. But larger genera also need their own specialists; although not belonging in the previously mentioned mega-diverse families several large genera are understudied in Africa, such as: *Cyphostemma* (Vitaceae), *Euphorbia* (Euphorbiaceae), *Ipomoea* (Convolvulaceae), *Polystachya* (Orchidaceae), *Barleria* (Acanthaceae), and *Pavetta* (Rubiaceae).

Although there are now reasonably good estimates of the size of the floras of nearly all African countries, the actual coverage with published floras for the continent is still full of gaps (Table 4). The total area of sub-Saharan Africa is 24.2 million km^2 of which 36% are covered by complete floras (Sebsebe Demissew 2011, 2014; Beentje 2015). Another 34% have incomplete floras, ranging from only very partially complete to almost finished. The *Flowering Plants of the Sudan* (Andrews 1950–1956), now covering both Sudan and South Sudan and encompassing a sizeable part of sub-Saharan Africa north of the Equator, is based on few collections and does not have much in the way of identification keys, but has been supplemented with check-lists (Friis & Vollesen 1998, 2005; Darbyshire *et al.* 2014). Finally, some countries do not have scientific floras at all: Chad, Central African Republic, Equatorial Guinea and Congo-Brazzaville, and Gambia, Guinea Bissau, Chad and South Sudan do not seem yet to have established a national herbarium, indeed any herbarium in their countries. For a few areas of high plant diversity field guides have been published, or guides dealing with selected taxa; mostly, these overlap with published floras.

All of this shows the continued need for fieldwork and the subsequent storage and treatment of the collected material in herbaria. Our printed floras are based on existing specimens in herbaria, but work in the field may both add new records and new species

Table 4. Coverage of published floras in sub-Saharan Africa. Data updated from a presentation by H. Beentje at the conclusion of the *Flora of Tropical East Africa* project in 2012. The *Flora of Tropical East Africa* is the largest modern tropical flora ever completed. The species in the *Flora of Southern Africa* area are covered by much other information. The recent checklist of Sudan and South Sudan (Darbyshire *et al.* 2015) includes 3969 species.

	Completion %	(approx.) # species
Flora of West Tropical Africa (in 2nd ed.)	100	7072
Flora of Tropical East Africa	100	12,104
Flora of Somalia	100	3165
Flora of Ethiopia and Eritrea	100	7,000
Flora Zambesiaca	90	10,000
Flore de l'Afrique Centrale	60	10,000
Flore du Cameroun	40	9,000
Flore du Gabon	40	7,000
Flore de Madagascar	35	12,000
Flora of Southern Africa	13	23,400

(Friis 2014); and, moreover, add information useful in making conservation assessments, such as population sizes and threat levels.

Gaps in Resources and Taxonomic Impediment

The taxonomic impediment, which is caused by shortage of herbarium material and taxonomic information, of floristic coverage, and of taxonomic practitioners, is often the main reason for big gaps. Quite frequently the reasons for gaps are financial – fieldwork the establishment and maintenance of herbaria and the employment of herbarium scientists and curatorial staff comes pretty low on most governments' and institutions' priority lists. As a result there is a world-wide shortage of vital taxonomic information to manage/conserve/use our biodiversity. The importance of the taxonomic impediment was recognized by the Convention on Biological Diversity (CBD), signed at the 1992 Rio Earth Summit, but the initiatives taken have not yet solved the problem. The number of practicing taxonomists has been shrinking for several decades, and many taxonomists are now quite advanced in years or practicing in their retirement (Ingrouville 1989; Buyck 1999; Drew 2011).

An important reason for the underfunding of taxonomy is that the discipline is looked upon as old-fashioned, stagnant and not producing economically important results. Far too often it is taken for granted that plants are easy to name, which in very many cases they are not. Increasing funding can only come out of more general awareness of how vital a function taxonomists fulfil. More appreciation of what we do is needed, and it has to be made clear that taxonomists provide vital baseline data utilised by a host of other researchers, from scientists involved in DNA-barcoding and -phylogeny to biochemists,

pharmacologists, conservationists, ecologists, ethnographers and even forensic scientists in the service of the police, at times.

There is also an access problem: much of the information provided by taxonomists is locked up in herbaria only accessible to scientists, in obscure publications, or in peoples' heads. The production of floras is one way to synthesize such data. But to improve and streamline the accessibility of our scientific results we need more training, more staff, and this equates to more money. It is vital that a new generation can take over, using modern methods in communication to (maybe) speed up the completion of floras and the popularization of the importance of wild plants. In the meantime, we can work on making our data more easily accessible, in more user-friendly formats as e-floras, overview databases and field guides.

Positive Development

Taxonomists are slowly closing some of the gaps mentioned above. We are still collecting, at least in certain parts of Africa, naming the collections and incorporating them in herbaria, we are tackling large genera and problem groups, through collaboration and through using both classical and modern methods. We are making our data more accessible by publishing on the web as well as in hardcopy, by making databases available, by sharing and by teaching.

Collections, revisions and monographs are what powers taxonomic progress. They build on fieldwork, herbarium studies and accumulated expertise, and solve problems of taxonomic interrelationships; they provide the floras with the hard-core science on which to build floras, field guides, ecological studies, etc. Floras synthesize all existing knowledge and make it accessible in a unified format. Formats of printed floras themselves may vary quite a bit, but they should ideally all provide solid contributions to our understanding of the African plant world, an understanding on which future generations can build. And some flora projects are also excellent capacity-building taxonomic projects, based on close collaboration between taxonomists in the South and in the North: a shining example is the *Flora of Ethiopia and Eritrea* (Hedberg 2011; Sebsebe Demissew 2011, 2014). Once a flora for a country or a region has been completed, it may give rise to spinoff products like field guides, which are both more restricted in scope than the original flora and more user-friendly. There is also the important category of overview websites that build on floras and monographs. One can mention the International Plant Names Index (IPNI), a database of plant names and associated basic bibliographic information (www.ipni.org), TROPICOS, with information on 4.3 million specimens, many of which are from Africa, and bibliographic data (www.tropicos.org); the Biodiversity Heritage Library (BHL), through which much taxonomic literature is made available on-line (www.biodiversityheritagelibrary.com), JSTOR, with on-line access to historical journals (www.jstor.org) and the Global Plants Initiative (GPI), Global Plants on JSTOR, with scanned high-resolution images of more than two million type specimens (plants.jstor.org).

A number of partially linked and unique resources for plant taxonomists and other interested users deal specially with the plants of sub/Saharan Africa: (1) a number of volumes in two series, entitled *Énumeration des plantes à fleurs d\Afrique tropicale* and *Tropical African Flowering Plants* by Lebrun and Stork (1991-1997; 2003-2015). The two series list all the species of vascular plants occurring in tropical Africa, the later series with ecological information and generalized distribution maps. (2) The extremely accessible and useful African Plant Database (http://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php) in which one can search for any African plant name (199,873 in total in May, 2017) and find bibliographical data, synonymy, notes on ecology and distribution, a generalized map, and links to other sites such as (Global Plants on JSTOR). (3) Photo guides with images of many species, such as http://www.africanplants.senckenberg.de/root/index.php. All these aid both herbarium curation and taxonomic research in sub/Saharan Africa.

Conclusions

We have seen that plant collections in sub-Saharan Africa are more and more kept in Africa itself, and the collections are spread widely over the continent. These plant collections do not cover all areas equally, and collecting gaps remain in high diversity hotspots, as seen from a comparison of Table 3 with Fig. 9. The hotspots should be investigated before it is too late, but it is important to remember that not all high diversity areas have been localised or can be predicted.

The taxonomic impediment is strong in Africa, mainly due to underfunding. This causes a shortage of trained taxonomists and curators. We need to address this, as a community, by making it clear that we fulfil a vital role, on which many other disciplines rely. In the post-colonial time and until the present, collaboration between taxonomists in the South and in the North has been very productive (Beentje 2015; Hedberg 2011; Sebsebe Demissew 2011, 2014; Onana 2017), resulting in national or regional floras of high standards. The number of taxonomists in the North who can take part in future collaborative efforts is declining, adding to the taxonomic impediment in the South. African taxonomists cannot change this development in Europe and North America, but one can hope that increasing South-South collaboration, and the increasing ability of African botanists to attract their own funding, might alleviate some of this impediment in the future.

As shown in this paper, many of the areas of high plant diversity in tropical Africa remain under-collected and under-studied. Where such areas are rich in species and coincide with threats to the habitats, they should become priority areas for collecting and study, in order to give a strong basis for coming conservation proposals.

There is a current need in many countries in sub-Saharan Africa to complete their national botanical inventories for conservation purposes, for sustainable use of their plant resources, and to fulfil their obligations to the Aichi Biodiversity Targets (https://www.cbd.int/sp/targets/) by 2020. This will require more alpha level taxonomic research to in under-explored areas in sub-Saharan Africa, despite the progress made in specimen collections, flora documentation, and in the fields of molecular systematics.

While large gaps remain in flora coverage, we urgently need more specialists in large families, both for the curation of herbaria and for the many practical uses of taxonomic treatments. There is good progress in making our work more accessible, and therefore in collaboration between colleagues, both inside the discipline and with colleagues in other fields. Much remains to be done, both with the plant collections of Africa and with their utilisation, and continuing threats to the biodiversity all over the continent make this urgent – but there is hope for the future, too, with much already accomplished.

References

Albuquerque, S., Brummitt, R.K. & Figueiredo, E. (2009). Typification of names based on the Angolan collections of Friedrich Welwitsch. *Taxon* 58: 641-646.

Andrews, F.W. (1950-1956). *Flowering Plants of the Anglo-Egyptian Sudan.* Vol. 1-3. (Vol. 3 entitled Flowering Plants of the Sudan). Buncle, Arbroath, Scotland.

Aubreville, A. (1962). L'exploration botanique de l'Afrique Occidentale française. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 51-54.

Beentje, H. (2015). Science comes from collaboration and communication: The Flora of Tropical East Africa as an example. *Webbia* 70(1): 171-179.

Beentje, H. & Smith, S. (2001). FTEA and after. *Systematics and Geography of Plants* 71: 265-290.

Buyck, B. (1999). Taxonomists are an endangered species in Europe. *Nature* 401: 321 |doi:10.1038/43762

Chaudhri, M.N., Vegter, I.H. & Wal, C.M. de (1972). Index Herbariorum. Part 2(3), I-L. *Regnum vegetabile* 86.

Cheek, M., Pollard, B.J., Darbyshire, I., Onana, J.-M. & Wild, C. (2004). *The Plants of Kupe, Mwanenguba and the Bakossi Mts, Cameroon. A Conservation Checklist.* Royal Botanic Gardens, Kew.

Cufodontis, G. (1962). A preliminary contribution to the knowledge of the botanical exploration of northeastern tropical Africa. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 233-250.

Darbyshire, I., Kordofani, M., Farag, I., Candiga, R. &

Pickering, H. (2014). *The Plants of Sudan and South Sudan. An Annotated Checklist*. Royal Botanic Gardens, Kew.

Drew, L. (2011). Are we losing the science of taxonomy? As need grows, numbers and training are failing to keep up. *BioScience* 61(12): 942-946. https://doi.org/10.1525/bio.2011.61.12.4

Exell, A.W. (1962a). Pre-Linnaean collections in the Sloane Herbarium from Africa south of the Sahara. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT*. Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 47-54.

Exell, A.W. (1962b). Botanical collecting on the islands of the Gulf of Guinea. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT*. Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 95-102.

Fernandes, A. & Fernandes, R. (1962). Les voyages de Manoel Galvao da Sylva au Mozambique. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT*. Junta de Investigações Científicas do Ultramar, Lisboa. , Pp.153-160.

Friis, I. (2007). The scientific study of the flora of Ethiopia and Eritrea up to the beginning of the Ethiopian Flora Project (1980). *In*: I. Hedberg, I. Friis & E. Persson (eds.), *Flora of Ethiopia and Eritrea*, Vol. 8, General Part and Index to Vols. 1–7. The National Herbarium, Addis Ababa, and Department of Systematic Botany, Uppsala. Pp. 1-25.

Friis, I. (2011). Botanical collecting activity in the area of the Flora of Ethiopia and Eritrea during the 'motor period'. *In*: I, Hedberg & E. Persson (eds.), The Ethiopian Flora Project 1980-2009. *Acta Universitatis Upsaliensis, Symbolae Botanicae Upsalienses* 35(2): 45-68.

Friis, I. (2014). Changes of flora-information over time: Examples from Ethiopia and Eritrea and the Nordic Countries. *Ethiopian Journal of Biological Sciences* 13 (Suppl.): 47-67.

Friis, I., Gilbert, M.G. Weber, O. & Sebsebe Demissew. (2016). Two distinctive new species of *Commicarpus* (Nyctaginaceae) from gypsum outcrops in eastern Ethiopia. *Kew Bulletin* 71 (Paper 34): 1–19.

Friis, I. & Vollesen, K. (1998). Flora of the Sudan-Uganda border area east of the Nile, I. Catalogue of vascular plants, 1st part. *Biologiske Skrifter* 51(1): 1-389.

Friis, I. & Vollesen, K. (2005). Flora of the Sudan-Uganda border area east of the Nile : II. Catalogue of vascular plants, 2nd part, vegetation and phytogeography. *Biologiske Skrifter* 51(2): 391–855.

Gestrich, A. & McEwan, D. (eds.) (2015). *Georg Wilhelm Schimper in Abyssinia. Observations on Tigre* - Online Edition at German Historical Institute London (http://www.ghil.ac.uk/Schimper (Addressed in April, 2015).

Gillett, J.B. (1962). The history of the botanical exploration of the area of The Flora of Tropical East Africa (Uganda, Kenya, Tanganyika and Zanzibar). *In:* A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT*. Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 205-230.

Gillett, J.B. (1972). Schimper's botanical collecting localities in Ethiopia. *Kew Bulletin* 27: 115-128.

Grant, J.A. & Oliver, D. (1872). The Botany of the Speke and Grant Expedition, an Enumeration of the Plants collected during the Journey of the late Captain J. H. Speke and Captain (now Lieut.-Col.) J. A. Grant from Zanzibar to Egypt. The Determinations and Descriptions by Professor Oliver and others connected with the Herbarium, Royal Gardens, Kew; with an Introductory Preface, Alphabetical Notes of Native Names, and Notes by Colonel Grant. Part 1. *Transactions of the Linnaean Society of London* 29: 1-69, Tab. 1-37 and 1 Map.

Gräber, G. (1999a). Die befreiten Geiseln Kaiser Tewodoros II. Aus dem Photoalbum der Royal Engeneers 1867–1868. *AETHIOPICA International Journal of Ethiopian Studies* 2: 159-182.

Gräber, G. (1999b). Georg Wilhelm Schimpers abyssinische Zeit (1837–1878). Zum 120. Todesjahr (October 1998) des Mannheimer Äthiopiensforscher und Ehrenmitgleid des Verein für Naturkunde Mannheim. *Jahresbericht Verein für Naturkunde Mannheim E.V.*, neue Folge, 6: 47-68.

Hedberg, I. (2011). The Ethiopian Flora Project - the Uppsala perspective. *In*: I, Hedberg & E. Persson (eds.), The Ethiopian Flora Project 1980-2009. *Acta Universitatis Upsaliensis, Symbolae Botanicae Upsalienses* 35(2): 19–25.

Hepper, F.N. (1962). Botanical collectors in West Africa, except French territories, since 1860. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT*. Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 69-76.

Hepper. F.N. (1979). Second edition of the map showing the extent of floristic exploration in Africa south of the Sahara, published by AETFAT. *In*: J. Kunkel, *Taxonomic Aspects of African Economic Botany, Proceedings of the IX Plenary Meeting of AETFAT*. Las Palmas de Gran Canaria. Pp. 157-162, with loose map.

Hulton, P., Hepper, F.N. & Friis, I. (1991). *Luigi Balugani's Drawings of African Plants from the Collection made by James Bruce of Kinnaird on his Travels to Discover the Source of the Nile*. Yale Center for British Art, New Haven, and Balkema, Rotterdam.

Ingrouville, M. (1989). The decline and fall of British taxonomy. *New Scentist* 1646: 64.

Keay, R.W.J. (1962). Botanical collectors in West Africa prior to 1860. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. , Pp. 55-68.

Küper, W., Sommer, J.H., Lovett, J.C., Beentje, H.J., Rompaey, R.S.A.R. van, Chatelain, C., Sosef, M.S.M. & Barthlott, W. (2004). Africa's hotspots of biodiversity redefined. *Annals Missouri Botanical Garden* 91, 4: 525-535.

Lanjouw, J. & Stafleu, F.A. (1954). Index Herbariorum. Part 2(1), A-D. *Regnum vegetabile* 2.

Lanjouw, J. & Stafleu, F.A. (1957). Index Herbariorum. Part 2(2), E-H. *Regnum vegetabile* 9.

Lebrun, J.-P. & Stork, A. (1991-1997). *Enumeration des Plantes* à fleurs *d'Afrique Tropicale*. Vol. 1, Généralités et Annonaceae à Pandaceae; Vol. 2, Chrysobalanaceae à Apiaceae; Vol. 3, Monocotylédones: Limnocharitaceae à Poaceae; Vol. 4, Clethraceae à Lamiaceae. Conservatoire et Jardin Botanique Ville de Genève.

Lebrun, J.-P. & Stork, A. (2003-2015). *Tropical African Flowering Plants: Ecology and Distribution*. Vol. 1, Annonaceae-Balanitaceae; Vol. 2: Euphorbiaceae-Dichapetalaceae; Vol. 3: Mimosaceae-Fabaceae (incl. Derris); Vol. 4: Fabaceae (Desmodium-Zornia); Vol. 5: Buxaceae-Simaroubaceae; Vol 6, Burseraceae-Apiaceae, Addendum to Volumes 1-5 (Families A-C); Volume 7: Monocotyledons, 1 (Limnocharitaceae-Agavaceae); Vol. 8, Monocotyledons 2 (Anthericaceae-Palmae), Vol. 9, Orchidaceae Part 1 (Genera A-G). [All the volumes that have appeared so far]. Conservatoire et Jardin Botanique Ville de Genève.

Léonard, J. '1965'. (1968). Carte du degree d'exploration floristique de l'Afrique au sud du Sahara, editee par l'A.E.T.F.A.T. (Association pour l'étude taxonomique de la flore de l'Afrique tropicale). Texte explicatif [avec une carte non-inséré]. / Map of the extent of floristic exploration in Africa south of the Sahara, published by A.E.T.F.A.T. (Association pour l'étude taxonomique de la flore de l'Afrique tropicale). [Explanatory text and map]. *Webbia* 19: 907-914, with loose map.

Lovett, J.C. (1993). Eastern Arc moist forest flora. *In*: J.C. Lovett & S.K. Wasser (eds.), *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge. Pp. 33-55.

Lovett, J.C. (1998). Importance of the Eastern Arc Mountains for vascular plants. *Journal of East African Natural History* 87: 59 74.

Malombe, I., Newton, L. & Kirika, P. (2015). *Botanical Inventory of Relic Wooded Grasslands in Wote Division, Makueni County*. National Museums of Kenya, Nairobi.

McEwan, D. (2015). *Georg Wilhelm Schimper: Botanist and Explorer, Geologist and Mapmaker in Northern Ethiopia 1837 to 1878*. (http://www.ityopis.org/Issues-Extra_files/ityopis-extra-mcewan.pdf - (Addressed April 2015).

Mendonça, A.F.A. (1962a). Botanical collectors in Angola. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 111-122.

Mendonça, A.F.A. (1962b). Botanical collectors in Mozambique. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 145-152

Mutke, J. & Barthlott, W. (2005). Patterns of vascular plant diversity at continental to global scales. *Biologiske Skrifter* 55: 521-531.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

Onana, J.-M., Mafanny, J.M. & Mekembom, Y.N. (2017). The North-South Synergy: The National Herbarium and Limbe Botanical Garden experience. *Scientia Danica, B (Biologica)* 6: 117-139.

Sebsebe Demissew (2011). The Ethiopian Flora Project – the Addis Ababa perspective. *Symbolae botanicae Upsalienses* 35(2): 27-43.

Sebsebe Demissew (2014). Overview of the Flora of Ethiopia and Eritrea: The long road to a completion. *Ethiopian Journal of Biological Sciences* 13 (Supp.): 1-27.

Settesoldi, L., Tardelli, M. & Raffaelli, M. (2005). *Esploratori Italiani nell' Africa Orientale fra il 1870 ed il 1930. Missioni Schientifichi con Raccolte Botaniche, Rilievi Geografici ed Etnografici.* Pubblicazione n. 104, Centro Studi Erbario Tropicale, Firenze, Italy.

Siméon, G. & Tourney, R. (1962). Les collections rassemblées de 1870 a 1908 pa'r les missions scientifiques allemandes et par Th. Kassner dans le territoire de 1a Republique du Congo (ex Congo Belge). *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 231-232.

Stearn, W.T. (1982). Preface. *In*: Anonymous (ed.), *Facsimile edition of A. Richard, Tentamen Florae Abyssinicae,* Vol. 1-2. Institute of Systematic Botany, Uppsala University, Uppsala.

Supan, A. (1888). Ein Jahrhundert der Afrikaforschung. Zum hundertjährigen Gedenktag der Gründung der African Association. 9. Juni 1788. *Petermanns Mittheilun-*

gen aus Justus Perthes' Geographischer Anstalt 34: 161-188, with Table 10-11.

Thiers, B. [Continuously updated]. *Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff.* New York Botanical Garden's Virtual Herbarium. (http://sweetgum.nybg.org/ih/ (Accessed in April, 2015).

Thulin, M. (2006). Preface. *In*: M. Thulin (ed.), *Flora of Somalia.* Vol. 3. Royal Botanic Gardens, Kew. Pp. 1–2.

Thulin, M. (2008). *Acacia fumosa* sp. nov. (Fabaceae) from Eastern Ethiopia. *Nordic Journal of Botany* 25: 272-274.

Thulin, M. (2009a). New species of *Euphorbia* (Euphorbiaceae) from eastern Ethiopia. *Kew Bulletin* 64: 469-476.

Thulin, M. (2009b). New species of *Coccinia* and *Momordica* (Cucurbitaceae) from North-Eastern tropical Africa. *Kew Bulletin* 64: 485-489.

Thulin, M. (2009c). *Solanum pronum* (Solanaceae), a new species from north-eastern tropical Africa. *Kew Bulletin* 64: 491-493.

Thulin, M., Goyder, D. & Liede-Schumann, S. (2008). *Cibirhiza spiculata* (Apocynaceae), a remarkable new species from eastern Ethiopia. *Kew Bulletin* 63: 617-624.

Thulin, M. & Vollesen, K. (2015). *Blepharis gypsophila* (Acanthaceae), a new species from Ethiopia. *Kew Bulletin* 70 (Paper 26): 1 - 3.

Vegter, I.H. (1976). Index Herbariorum. Part 2(4), M. *Regnum vegetabile* 93.

Vegter, I.H. (1976). Index Herbariorum. Part 2(5), N-R. *Regnum vegetabile* 109.

Vegter, I.H. (1986). Index Herbariorum. Part 2(6), S. *Regnum vegetabile* 114.

Vegter, I.H. (1988). Index Herbariorum. Part 2(7), T-Z. *Regnum vegetabile* 117.

White, F. (1962). A history of plant collecting in Northern Rhodesia. *In*: A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 175-204.

Wickens, G.E. (1972). Dr. G. Schweinfurth's journeys in the Sudan. *Kew Bulletin* 27(1): 129-146.

Wild, H. (1962). Biographical notes on botanical collectors in the Federation of Rhodesia and Nyasaland. *In:* A. Fernandes (ed.), *Comptes Rendus de la IV Réunion Pléniere de l'AETFAT.* Junta de Investigações Científicas do Ultramar, Lisboa. Pp. 161-174.