THE AFRICAN PLANTS INITIATIVE (API) IN SOUTH AFRICA

Introduction

Given the ongoing and often destructive impact of humans on the natural environment, the need for sound and robust taxonomies has become critically important (see for example Godfray & Knapp, 2004). The difficulty with naming organisms is especially acute in African countries, where resources and facilities for taxonomic research are limited (Klopper & al., 2002), and biodiversity is usually relatively high. South Africa, for example, incorporates the world's richest temperate flora with 19,581 indigenous plant species from 2267 genera and 349 families of vascular plants (Germishuizen & al., 2006; Steenkamp & Smith, 2006). Approximately 65% of the country's vascular plant species are endemic (Raimondo & al., 2009), with many occurring in its three regions and 15 centres of plant endemism (Van Wyk & Smith, 2001).

Expertise as well as preserved and living material of the biodiversity of developing nations—typically former colonies of imperialist nations—are often located in developed countries and not available in the country of origin (Figueiredo & Smith, 2010). The CBD recognises this impediment and in Article 17 calls on signatory parties to exchange and repatriate information to facilitate research (Global Taxonomy Initiative, 2001). To overcome the obstacle of having to physically ship valuable—and essentially irreplaceable—pressed plant specimens between herbaria around the world, the African Plants Initiative (API) was conceived. The notion was to scan type specimens and make electronic images of them available online. This approach efficiently enables both virtual repatriation of information, and access by researchers of other herbaria to the most important accessioned material, thus removing some of the constraints to taxonomic work. It has been six years since the inception of the API, and this paper reports on its achievements in South Africa, one of the founding countries of the thrust.

Background

The API was initiated in 2004 with the South African National Biodiversity Institute (SANBI) and the Royal Botanic Gardens, Kew, as founding members, following successful grant negotiations with the Andrew W. Mellon Foundation. The API was initially coordinated by ALUKA, which is one of the main programs run by Ithaka. Ithaka is a non-profit organisation which aims to fast-track the productive and efficient uses of information technology for the global scholar community. ALUKA, in turn, is an international, collaborative initiative producing an online digital library of scholarly resources from and about Africa as part of an aim to connect resources and scholars from around the world. They provide powerful tools for knowledge exchange and production. More recently, JSTOR, which is also part of Ithaka, has taken over the management of the plant component of ALUKA with a view to creating a global botanical resource.

The API started with the aim of digitising herbarium type specimens of African plants and linking them to a range of related images and data, including photographs, drawings, botanical art, field notes, published Flora accounts, and other reference works, and making them available through the internet. Type specimens are essential in classifying and naming plants, which action in turn fundamentally underpins all other species-level biological research, including conservation science. Appropriately, the foundational importance of systematics in achieving all the Targets of the Global Strategy for Plant Conservation (GSPC) has been recognised (UNEP, 2002); this role of taxonomy has been articulated eloquently in two recent papers (Paton & al., 2008; Paton, 2009).

In South Africa, the initiative grew to include other projects: these include medicinal plants of southern Africa, synopsis of the Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring islands, grasses (Poaceae) of southern Africa, aloes (*Aloe* L.; Aspodelaceae) of the world, and the documentation of taxon protologues of the mesembs (Aizoaceae).

Project management and workshops

The Initiative was managed by a Senior Advisory Group made up of representatives from SANBI, the Royal Botanic Gardens, Kew, Missouri Botanical Garden, the University of Ethiopia, Addis Ababa, and the Mellon Foundation. Individual project coordinators at each participating centre managed the day-to-day running of the various projects and implemented decisions taken by the Steering Committee. A technical advisory group (TAG) was formed to deal with technical issues pertaining to data management and standards. Four API workshops were held at the Kirstenbosch Research Centre in Cape Town, South Africa, between 2004 and 2008. The first three workshops discussed progress, difficulties and future actions while the workshop in November 2008 finalised the structuring of a small grants programme for future work by African members and the identification of current gaps where such funds may be best applied.

South African API partners

The type scanning initiative in South Africa was run through SANBI, the Bolus Herbarium at the University of Cape Town

(BOL), the Selmar Schönland Herbarium at Rhodes University and the Albany Museum (GRA), and the Herbarium of the University of KwaZulu-Natal, Pietermaritzburg (NU). Within SANBI, the scanning of types was undertaken at the Compton Herbarium at Kirstenbosch (NBG), the National Herbarium in Pretoria (PRE), and the KwaZulu-Natal Herbarium in Durban (NH). Type specimens held by the H.G.W.J. Schweickerdt Herbarium at the University of Pretoria (PRU) were scanned at PRE, while those held by the SA Museum Herbarium (SAM) were scanned at the Compton Herbarium (NBG), which holds and curates them.

The medicinal plants of southern Africa, grasses of southern Africa and aloes of the world projects were run from the National Herbarium (PRE) while the mesembs database and the synopsis of the Lycopodiophyta and Pteridophyta were executed from the Compton Herbarium.

Staff and capacity building

During the course of the API project, 34 contract workers were employed for assistance with the above-mentioned endeavours. A number of these employees have since taken up permanent positions within SANBI and elsewhere in the biodiversity sector. Two staff members, one each from the National and Compton Herbaria, received training in scanning, databasing, and quality control of type specimen data and other images at the Royal Botanic Gardens, Kew, and they in turn conducted in-house training in South Africa.

Projects

Type specimen scanning. — Type specimen scanning was initiated in 2004 and completed in 2009. During the scanning process type specimens were extracted from the herbarium cabinets and the label data entered or updated in the Pretoria, National Herbarium (PRE), Computerised Information System (PRECIS). A barcode label was generated and attached to each specimen, along with a scale bar and colour chart. Each sheet was then scanned as a 600 dpi TIFF image, and images later linked to the relevant metadata. A total of 27 contract staff members was involved in scanning of type specimens at the six herbaria across South Africa; these workers scanned a total of 58,788 images of specimens, slides and artworks. A breakdown of image types for each repository is given in Table 1.

Synopsis of Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring islands. — This project started in September 2004 and concluded in June 2008, and it aimed to provide a synopsis, including relevant synonyms, of the lycophytes and ferns occurring in Africa, the western Indian Ocean region, and the eastern Atlantic Ocean region. The only publication dealing with these plant groups in Africa and the Madagascan region as a whole was Kuhn's *Filices Africanae*, published in 1868, in which approximately 500 species were recorded. The project brought together scattered old and recent literature into a single searchable database in an effort to provide a uniform nomenclatural platform for the pteridophyte Flora of the defined region. About 1440 species (including infraspecific taxa) with more than 6500 names are now listed in the synopsis. The data is to be made available as a web-based database by JSTOR, and has been published in hard copy format by SANBI as volume 23 of the *Strelitzia* series (Roux, 2009).

Documenting taxon protologues of the mesembs (Aizoaceae). — The mesembs are one of the largest families of plants in southern Africa, with nearly 2000 species in over 120 genera; altogether about 8% of the regional vascular flora. As original taxonomic literature, such as protologues of these species, is often published in old or obscure journals and books, it is frequently difficult for researchers to access. The mesemb protologue project was started in November 2007 and concluded in October 2008. Its aim was to obtain and make available as an online database as many mesemb taxon protologues as possible to assist all students of this plant group and prevent duplication of search effort by successive researchers. Taxon protologues were scanned and stored as PDF files and will be made available (along with associated metadata) to JSTOR as an online resource with links to the relevant type specimen images already held by JSTOR. A BRAHMS (Botanical Research and Herbarium Management Software) database was developed for storing and indexing species names based on an initial list of names obtained from the International Plant Name Index (IPNI). Each scanned protologue is also linked to the relevant name in the database. The project managed to digitise 448 of about 1000 potential references, which amounts to 7420 pages of scanned text.

Grasses of southern Africa. — Twenty years ago, Gibbs Russell & al. (1990) published a comprehensive treatment of the grasses of southern Africa. It included descriptions of 198 genera and about 965 taxa. The aim of the API grasses project was to revise the information in the book and update the text and distribution maps, as well as increase the number of illustrations. All this information, supplemented by photos, will then be made available to users on the JSTOR website.

The project was initiated in June 2005 and is nearing completion. Three hundred and six new illustrations were completed with 129 being of whole plants and the remainder of spikelet parts. Scans of 418 illustrations and 372 distribution maps were prepared. The text for 747 taxa was revised and updated.

Aloes of the World Project (AWP). — The genus *Aloe* is a prominent component of many African landscapes. The genus comprises ±600 taxa to which over 1200 names have been applied. Members of the genus can be found in Africa and Arabia, and on Socotra, Madagascar and the Mascarene Islands. The majority of aloes (±400) occur in Africa, with only ±40 in Arabia (two of which occur also in Somalia) and three on Socotra, while Madagascar

Table 1. Specimens and images scanned by the various herbaria in South Africa as part of the API Type Scanning Initiative. Data current in June 2010.

Repository	Type specimens	Other specimens	Slides (images)	Artwork (images)
PRE	12,000	7,700	3,766	2,200
BOL	8,899	0	0	0
NBG & SAM	7,985	0	4,185	3,018
GRA	3,300	0	0	0
NU	600	3,395	0	0
NH & PRU	927	0	813	0
Total	33,711	11,095	8,764	5,218

is presently known to harbour around 140 *Aloe* species. In the AWP the members of genus *Lomathophyllum* Willd. (all of which are distinctly berry-fruited) were included as a section of *Aloe*. *Lomathophyllum* comprises ±20 taxa, of which 14 are restricted to Madagascar, one species is found on Aldabra, three on Mauritius, two on Réunion (of which one also occurs on Mauritius), one from Rodrigues, and another from Pemba.

The AWP has sought to bring together all the relevant information and available images on this predominantly African genus, and to make this information available through JSTOR. The project is a collaboration between SANBI and the National Herbarium at the University of Ethiopia in Addis Ababa. In November of 2007—the year of initiation of the AWP—a group of about 40 international experts on the genus *Aloe* met in South Africa for a workshop to seek consensus on achievable key objectives for the AWP. This was the first event of its kind where *Aloe* alone was approached on this scale. Delegates agreed on an interim compromise whereby only essential elements are to be hosted on the JSTOR (African Plants Initiative) website pending an upgrade of the information in line with ongoing developments at JSTOR (Smith & al., 2008a,b).

The *Aloe* database currently holds 1250 plant names with 600 of those being current. To date 1176 literature references, 322 species descriptions, 1139 derivations of taxon names, 305 flowering times, 137 chromosome numbers, and 517 habitat information fields have been entered. The database also contains 1519 common names and information on 798 type specimens. Fifty distribution maps have been created. A LucID key was created containing a list of illustrated characters, and the 27 *Aloe* species occurring in Angola were used as a sample to test the electronic key. Encoding of the key is ongoing.

Recently, further funding for the expansion of this project has been approved. Accordingly, it is expected that the project will be finalised in 2011.

Medicinal plants of southern Africa. — The southern African region has an extremely rich and diverse flora. The region is also home to several cultural groups, all of whom utilise the flora for traditional medicines. The information on the medicinal plants of the region is scattered throughout various texts, many of which are out of print and difficult to source. A comprehensive database consolidating the major texts is thus a valuable resource for anyone interested in the ethnomedicine of the region.

The Medicinal Plants Project (MPP) aimed to expand the annotated checklist of medicinal and magical plants of southern Africa (Arnold & al., 2002), which was published by the then National Botanical Institute of South Africa. While this text listed medicinal plants known from the region and provided limited floristic information, no actual traditional usage information was provided, rather just references to the literature in which it was cited. The MPP has accordingly aimed to populate a database with extensive additional information and images to be hosted on the JSTOR website. For each record in the database the following information was captured: the ailment treated, the species and plant part used, the country of use and the specific user group, whether the plant is used in a medical or magical sense, and whether it is used for the treatment of humans or livestock. 51,373 medicinal records for 3461 taxa were entered into the database, 1318 slide images were scanned, and 1603 distribution maps produced. A database containing 10,013 common names of taxa was compiled and included information such as the language/usergroup and the region where used. A Microsoft Access database was created into which information from the literature used to compile Arnold & al. (2002) was entered. The initial intention was to include all the original references, but some were excluded from the database because they were unavailable, or of a language in which none of the staff was proficient. Data were extracted from a total of 15 major reference works.

The project was managed from the National Herbarium's Data Section in Pretoria, starting in May 2005 and concluding in October 2007. During this period seven contract staff members assisted with the project.

The API goes online

The first release of the African Plants Initiative content area on the ALUKA website took place on 1 February 2007. Apart from the digitised type specimens, ALUKA also brought together additional materials including photographs, line drawings, water colour illustrations, oil paintings, and extensive plant-related literature. Together, these materials provide information ranging from the morphology and uses of plant species to the history of plant exploration and discovery in Africa, thus providing a holistic portal to plant research in South Africa, and beyond. Much of this content has since been transferred to JSTOR where it can be accessed at http://plants.jstor.org. JSTOR currently houses 292,252 scans of plant specimens collected in Africa and 11,821 photographs of African plants.

The future

More recently the API made available a series of small grants to other African countries. Fourteen projects representing eleven countries have been funded. Projects range from further digitisation of specimens of, for instance, rare, endangered, endemic and invasive plants, to types held in smaller African herbaria, and to the compilation of regional checklists to aid in determining levels of species diversity and endemism.

A further call for support for projects run by SANBI was also granted, resulting in nine smaller initiatives running from 2009 to 2011. These projects will produce electronic identification keys, checklists, and other electronic resources for selected plant groups. Further plant specimen digitisation initiatives will also shortly be undertaken; these target specimens of, for example, economically important and endemic plants.

Conclusion

The API has resulted in assisting the fulfilment of some of the obligations of countries signatory to the CBD, namely repatriation of, and enabling access to, information worldwide. Computerization of natural history collections is also an objective of the Global Biodiversity Information Facility (GBIF) (www.gbif.org) to which many countries are party.

By making data available through these comprehensive, easily accessible databases, users will be able to rapidly compile biodiversity catalogues, study biogeographical patterns, and assist in both long-term conservation planning and adaptive conservation management (Smith & Smith, 2004). Importantly—and ultimately to underpin sustainable development for human wellbeing—the work of African taxonomists has been shored up by the API. Taxonomists

will be able to access plant specimen images, so allowing them to continue the important, fundamental work of correctly assigning names to plants, strengthening the foundation on which all biodiversity and conservation science is built.

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Literature cited

Arnold, T.H., Prentice, C.A., Hawker, L.C., Snyman, E.E., Tomalin, M., Crouch, N.R. & Pottas-Bircher, C. 2002. Medicinal and magical plants of southern Africa: An annotated checklist. *Strelitzia* 13: 1–203.

Figueiredo, E. & Smith, G.F. 2010. The colonial legacy in African plant taxonomy. *S. African J. Sci*. 106(3/4): 5–7.

Germishuizen, G., Meyer, N.L., Steenkamp, Y. & Keith, M. (eds.). 2006. *A checklist of South African plants*. Southern African Botanical Diversity Network Report 41. Pretoria: SABONET.

Gibbs Russell, G.E., Watson, L., Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M. & Dallwitz, M.J. 1990. Grasses of southern Africa. *Mem. Bot. Surv. South Africa* 58: 1–437.

Global Taxonomy Initiative. 2001. Progress Report on the Global Taxonomy Initiative. www.biodiv.org/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-04-en.doc.

Godfray, H.C.J. & Knapp, S. 2004. Introduction. Taxonomy for the 21st century. *Philos. Trans., Ser. B* 359: 559–569.

Klopper, R.R., Smith, G.F. & Van Rooy, J. 2002. The biodiversity of Africa. Pp. 60–86 in: Baijnath, H. & Singh, Y. (eds.), *Rebirth of science in Africa: A shared vision for life and environmental sciences*. Hatfield: Umdaus Press.

Paton, A. 2009. Baseline informatics and the plant conservation baseline. *Trends Pl. Sci.* 14: 629–637.

Paton, A.J., Brummitt, N., Govaerts, R., Harman, K., Hinchcliffe, S., Allkin, B. & Nic Lughadha, E. 2008. Towards Target 1 of the Global Strategy for Plant conservation: A working list of all known plant species—progress and prospects. *Taxon* 57: 1–10.

Raimondo, D., von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, P.A. (eds.). 2009. Red List of South African plants. *Strelitzia* 25: 1–668.

Roux, J.P. 2009. Synopsis of the Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring islands. *Strelitzia* 23: 1–296.

Smith, G.F., Walters, M., Crouch, N.R. & Klopper, R.R. 2008a. Aloes of the world: A comprehensive collaboration to consolidate knowledge on the genus *Aloe* L. *Aloe* 45: 19–20.

Smith, G.F., Walters, M., Klopper, R.R. & Crouch, N.R. 2008b. Aloes of the world: African Plants Initiative. An international web-based collaboration to promote scholarly research on *Aloe* L. *Bradleya* 26: 121–128.

Smith, T.J. & Smith, G.F. 2004. Selecting important plant areas in southern Africa. *S. African J. Sci.* 100: 434–435.

Steenkamp, Y. & Smith, G.F. 2006. Introduction to A checklist of South African plants. Pp. iv–ix in: Germishuizen, G., Meyer, N.L., Steenkamp, Y. & Keith, M. (eds.), *A checklist of South African plants*. Southern African Botanical Diversity Network Report 41. Pretoria: SABONET.

UNEP. 2002. Global Strategy for Plant Conservation. COP Decision VI/9. CBD Secretariat. http://www.biodiv.org/decisions/default.aspx?m=COP-06&id=7183&lg=0 (accessed 29 June 2010).

Van Wyk, A.E. & Smith, G.F. 2001. *Regions of floristic endemism in southern Africa: A review with emphasis on succulents*. Hatfield: Umdaus Press.

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