

Research plan for plant taxonomy 2020–2030

J.E. Victor



Garden Route





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The South African National Biodiversity Institute (SANBI) was established on 1 September 2004 through the signing into force of the National Environmental Management: Biodiversity Act (NEMBA) No. 10 of 2004 by President Thabo Mbeki. The Act expands the mandate of the former National Botanical Institute to include responsibilities relating to the full diversity of South Africa's fauna and flora, and builds on the internationally respected programmes in conservation, research, education and visitor services developed by the National Botanical Institute and its predecessors over the past century.

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Mystacidium



Introduction

Taxonomic research includes the science of taxonomy and classification, and involves discovering, naming, describing and classifying biological organisms. The term taxonomy is used in this document in a broad sense and, therefore, includes systematics and phylogeny. In light of South Africa's fast-growing population, increased habitat altering projects, as well as climate change impacts, all of which present changes needing to be managed, the key framework knowledge of species and their relationships provided by taxonomy and systematics is vital. At the South African National Biodiversity Institute (SANBI), the Foundational Biodiversity Science (FBS) division is positioned at the base layer of SANBI's research value chain, providing foundational taxonomic information for all fields of biodiversity research. The particular part of SANBI's mandate with which the FBS division is concerned are the responsibilities to:

- coordinate and promote the taxonomy of South Africa's biodiversity;
- collect, generate, process, coordinate and disseminate information about biodiversity; and
- undertake and promote research on indigenous biodiversity.

Taxonomic research at SANBI has been directed by *A biosystematics research strategy for the algae, animals, bacteria and archaea, fungi and plants of South Africa 2013–2018* (Victor et al. 2013), with plant taxonomic research directed by the *Strategy for plant taxonomic research in South Africa 2015–2020* (Victor et al. 2015a). This strategy also gives guidance to plant taxonomists, nationally or internationally, who are interested in what the priorities are for research on South African plants. SANBI taxonomists worked as a team to achieve four strategic objectives as follows:

1. Produce an open access, online checklist and Flora of South African plants by 2020.
2. Revise priority plant genera that are in need of revision.
3. Resolve taxonomic problems in single or small groups of taxa to improve the South African National Plant Checklist.
4. Improve the herbarium collections as a research resource.

These objectives were developed into four research programmes, which coordinated the activities of plant taxonomists at SANBI.

In 2018 the development of the SANBI Research Strategy was initiated, and with that, the update of the research strategy for plant taxonomic research commenced with a view to publishing the update in 2020 upon expiration of the previous version. Workshops were conducted for plant taxonomists at SANBI to give

input into the new research plan. The draft plan was circulated for further input and the final version developed.

Taxonomic research involves the discovery, description and naming of taxa, and the investigation of plant characteristics that leads to understanding evolutionary relationships between them. This information is published in a variety of ways on different platforms. The main sources of taxonomic information for plants are geographical Floras, which are usually published as stand-alone books; and taxonomic treatises, which are published as books (families and sometimes large genera) or in journals (usually genus or subgenus-level revisions). Taxonomic information is, therefore, interspersed throughout a variety of books, journals and web pages. Whereas the purpose of geographical Floras is to provide an account of the plants existing in a particular region for identification purposes and consolidating what is already known, the treatments of families and genera are aimed at describing new taxa, as well as improving, correcting and clarifying the taxonomy and descriptions of existing taxa.



Ms Tandlwe Nkonki –
plant taxonomist.

Main outputs of plant taxonomy

Output 1: Checklists

The South African National Plant Checklist is compiled, updated and disseminated by SANBI, as part of the mandate to 'coordinate plant taxonomy in South Africa'. All plant taxa, with the exception of algae, that are known to occur in South Africa are catalogued, with input from external specialists. The SANBI Checklist Coordinator has commenced with the addition of algae to complete the plant checklist. The South African National Plant Checklist is maintained in a taxonomically up-to-date state and available on the SANBI website (posa.sanbi.org) and an updated version published annually. This forms the backbone of an online Flora, which consolidates all available published descriptive information on South African plants.



Output 2: e-Flora

The e-Flora programme was initiated with the implementation of the plant taxonomic research strategy (Victor et al. 2015a). All staff members were involved and strict deadlines adhered to, and external contributions were received. The e-Flora of South Africa is now



online as part of the World Flora Online, with the South African version to be launched independently by SANBI.

Output 3: taxonomic publications

Plant taxonomists have a long history of producing important taxonomic products to assist the general public with information related to taxonomy. Field guides, checklists and identification guides are produced to enable taxonomic information to be accessible by end-users. Some examples of important products published by SANBI plant taxonomists are the checklists of South African plants, e.g. Germishuizen et al. (2006), *Seedplants of southern Africa: families and genera* (Leistner 2000), *Herbarium Essentials* (Victor et al. 2004), and *Guide to the plant families of southern Africa* (Koekemoer et al. 2015). A series of regional Floras have been published by plant taxonomists at SANBI with the aim of providing coverage of the whole country, and the last treatises are still in progress. Floras for the northern provinces (comprising Gauteng, Limpopo, Mpumalanga and North-West), Western Cape, Eastern Cape and Free State, and parts of the Northern Cape have been completed (Retief & Herman 1997; Manning & Goldblatt 2013; Snijman 2013; Retief & Meyer 2017; Bredenkamp 2019). A Flora of KwaZulu-Natal and one for the remaining parts of the Northern Cape are currently in preparation, and once published, these geographical treatises will cover the flora of the entire country.

The initial list of priority plant genera for revision (Victor et al. 2015a) comprised 159 genera. Implementation of the Strategy (Victor et al. 2013) led to targeted research on these groups, with more than half of the priority genera now either revised or undergoing taxonomic investigation. Most of the remaining genera





Conophytum

from the original priority list belong to the family Aizoaceae. In addition, a list of taxonomically problematic species for research focus was provided and more than 30% of these problems have been solved during the time frame of the initial Strategy.

Output 4: primary datasets

The database of plant specimen information is a critically important product provided by SANBI, with information disseminated online. The Botanical Database of Southern Africa (BODATSA) documents the information from over 1.2 million preserved plant specimen labels in SANBI herbaria. Although SANBI herbaria have quality control procedures in place, errors in the database expose SANBI to criticism. Plant taxonomists (both scientists and support staff) all play an important role in curation and control of quality of specimen label information, so that it is of sufficient standard to be used by end-users.

Datasets collated by SANBI are used in many products, including Red List assessments, Environmental Impact Assessments (EIAs), as well to advice on responsible development for Strategic Infrastructure Projects (SIPs). The Red List of South African plants (Raimondo et al. 2009) was based on SANBI's plant database, as well as information provided by taxonomists and conservationists countrywide.

Resources available for plant taxonomy at SANBI

Libraries and literature

Taxonomic research is dependent on availability of good literature resources. SANBI has two main libraries, the Mary Gunn Library in Pretoria, and the Harry Molteno Library in Kirstenbosch, Cape Town. In addition, library users have access to interlibrary loans. Taxonomic literature is dispersed amongst the books, journals and other publications, but is accessible through online internet resources such as the Biodiversity Heritage Library internet resource.

Human capacity for plant taxonomy

A review of capacity for plant taxonomic research in South Africa (Victor et al. 2015c) concluded that there is a severe shortage of capacity available in South Africa to manage the country's diverse flora in terms of taxonomy and provision of foundational information. The following was evident from this review:

- vast areas of the country remain undercollected;



Dr Ashton Welcome
- plant taxonomist.

- many plant taxa are underrepresented in herbarium collections (about 3 800 taxa represented by fewer than five specimens in SANBI herbaria); and
- certain families have abnormally high levels of taxonomic problems (Victor & Smith 2011).

A solution to providing future capacity for taxonomic research in SANBI is for scientists to mentor interested and talented support staff employed in technical positions in herbaria, as well as interns and students that have an interest in and aptitude for taxonomic research (Victor et al. 2015c). Addressing future capacity shortage in taxonomic research, identification and curation of collections is a challenge, and the need to focus on self-help guides such as identification guides, e-Flora, keys, and textbook type resources (for example Victor et al. 2004; Koekemoer et al. 2015) has been identified.

Material available for taxonomic research

With contribution from R.H. Archer

The collection of plant specimens and associated data in herbaria is the most vital resource for taxonomic research. Although there are 72 herbaria in South Africa, collectively housing more than 3.2 million plant specimens, the representation of specimens geographically is unequally distributed. There are parts of the interior of the country that are represented by fewer than 10 specimens per quarter degree grid square in the collections of the SANBI herbaria (representing roughly 25 × 25 km, or 625 km²), and vast areas represented by fewer than 50 specimens per quarter degree grid square. For more than 10 quarter degree grid squares, SANBI herbaria do not have any specimens at all. This can only partly be attributed to lower levels of diversity in some areas; mostly it is due to a lack of collecting in difficult to access areas.

Plant species represented by very low numbers of specimens in herbaria are characteristically rare taxa and often distributed in inaccessible or hard to access localities. Ideally, the full geographical distribution range and morphological variation of taxa should be represented in collections. The SANBI collecting programme targets collection of specimens to increase representation of undercollected areas and taxa. Taxonomists plan collecting trips when undertaking registered research projects to target collection of specimens that are undercollected. Collection targeted to geographically undercollected areas (e.g. the Biogaps Project, in collaboration with SANBI's Biodiversity Research, Assessment and Monitoring Division [BRAM]) can be done by experienced technicians or scientists.

In addition to specimen collections, a xylarium collection is housed at PRE, under the care of a dedicated xylarium curator. This collection originates from the South African Forestry Research Institute Wood Collection, which was held by the South African Forestry Research Institute in Durban until 2018, and curated by Ms Stephanie T. Dyer. The collection of approximately 5 000 specimens was donated to

the National Herbarium, Pretoria (PRE) in 2018. The information in this collection is currently being entered into a database, with the intention of making it available on a Botanical Research and Herbarium Management System (BRAHMS) online database in future.

The ideal is to actively continue with accession of new wood samples at PRE. It may be argued that there is little to be added on the southern African wood knowledge (e.g. Dyer et al. 2016). However, new species of South African trees, even well-known timber species such as a new pink ivory, are still being or will be described. Very little is known about most smaller tree species, woody shrubs, lianes and their potential uses by local people. National Herbarium staff should be encouraged and equipped to collect wood samples of potential new species if the opportunity exists. Exchanges with other wood collections and xylaria worldwide would be beneficial and will increase the usefulness of this small collection.

With the retirement of Ms Dyer, and consequently a cessation of her personal wood identification business in Hilton, KwaZulu-Natal, there is a need for SANBI to continue playing this role for the public. The approximately 1 500 microscope slides in three cabinets will then be transferred to PRE. There are currently about 40 requests for identification per year, commanding fees of R500 per sample. South African Customs are among the main clients. The identification service should be maintained, but this requires an assistant to help with preparation of wood samples and the ability to interpret the various types of cells and score the various characters in the extensive INSIDEWOOD database.

SANBI taxonomic information database

The checklist, e-Flora and database of plant specimen information are critically important products provided by SANBI, with information disseminated online. The BODATSA database documents the information from over 1.2 million preserved plant specimen labels in SANBI herbaria. Although SANBI herbaria have quality control procedures in place, errors in the database abound, exposing SANBI to criticism. Scientists play an important role in curation and quality control of specimen label information, so that it is of sufficient standard to be used by end-users.

Programmes of activity for taxonomy for the next ten years

The vision of plant taxonomists at SANBI is to *lead the discovery and expansion of knowledge of southern African plant diversity*. The objectives are to curate high quality and representative collections of herbarium specimens and associated data; to undertake research to produce taxonomic treatments and identification guides; and to make this information accessible through publications and online, so that all citizens can access information on South Africa's diverse flora. Taxonomists are responsible for keeping the South African National Plant Checklist updated; compiling and updating the e-Flora of South Africa; through taxonomic research, producing updated taxonomic treatments and identification guides/tools for South African plants; undertaking systematic research to support taxonomic treatments and enhance understanding; collecting to ensure adequate representation and curatorial care of the specimen collection and correcting and updating the specimen database.

Strategic objective 1:

*document the South African flora and
maintain this checklist in an up-to-
date state, accessible to the public*

With contribution from R.R. Klopper

The aim of this strategic objective is to provide a complete and regularly updated checklist of plants in South Africa, including classification, synonyms and local names that are accessible to end-users through the internet accessible portal. The South African National Plant Checklist is available on the SANBI website (posa.sanbi.org). The current omission to this checklist is the Chlorophyta and other algae, which are currently being added, and which will be addressed as a priority for completion in the future.

The checklist is maintained in an up-to-date state by the Checklist Coordinator and Deputy Checklist Coordinator (senior level scientists), with the help of an assistant (technician), who together ensure that all the latest published nomenclatural changes are incorporated into the checklist. The South African National Plant Checklist Committee was established to make decisions on deviations from following latest published taxonomic changes, in a transparent and fair manner. The

policy that governs the South African National Plant Checklist is available online at <https://www.sanbi.org/documents/south-african-national-plant-checklist-policy/> and at <http://opus.sanbi.org/handle/20.500.12143/6880> (together with other checklist-related documentation). This policy ensures consistency and credibility in making decisions relating to the checklist.

SANBI follows the Angiosperm Phylogeny Group II system (APG II) classification and selected later updates for family level classification. This has been discussed by SANBI taxonomists on various occasions (most recently, on 18 June 2018) and agreed upon by the majority, and has also been accepted by the South African National Plant Checklist Committee.

There are some species level problems in the checklist. Research projects dealing with taxonomic problems of a species and its nearest relatives, or a species complex, have the advantage of being of a manageable size suitable for completion by interns or students enrolled in Honours courses (priority species for research can be found by clicking on the relevant link on the following page: <https://www.sanbi.org/biodiversity/foundations/biosystematics-collections/biosystematics-strategies/>).

Strategic objective 2: *develop and maintain South Africa's e-Flora*

The aim of this programme is to coordinate and disseminate existing taxonomic descriptive information for all plants. SANBI is committed to contributing to Target 1 of the Global Strategy for Plant Conservation (GSPC). Following the approach published by Victor et al. (2014), SANBI staff are completing South Africa's Flora for the electronic World Flora Online. There are two posts dedicated to this project: the e-Flora Coordinator (senior level scientist) and the e-Flora Support Officer (technician); in addition, all scientists and support staff, as well as external contributors, have contributed to the project. This enormous investment will provide an invaluable resource to South African citizens, as well as end-users from around the world. For the 2020–2025 period, the e-Flora database will be continually updated and improved, with SANBI scientists and the e-Flora team curating the database as an integral part of their duties.

At a strategic workshop in Pretoria on 18 June 2018 for all SANBI biosystematics researchers, there was consensus amongst the scientists regarding the need to stay involved in the e-Flora and update it, as well as add more information to improve its use and value. The vision for the e-Flora is to be a highly informative resource for taxonomic and associated information that staff actively contribute to and take ownership of, and that end-users value.

For the next ten years, SANBI taxonomists will contribute to the e-Flora by adding family and genus descriptions, updating descriptions with improved ones as new taxonomic treatments are published, developing keys (see strategic objective 4),

adding more images with verified names, linking DNA vouchers (cited only) to species entries, and linking distribution data. Since this database will be an invaluable tool to end-users, it has had a large investment into it already. Each scientist invests a portion of their time towards the e-Flora, either updating or improving quality, or adding other information; each is responsible for keeping their allocated families updated.

Strategic objective 3: *conduct taxonomic research and produce publications*

The aim of this strategic objective is to revise plant genera that are in need of revision, to fill in gaps in knowledge of South Africa's flora. Taxonomic research should also be aligned with needs of major initiatives to ensure that taxonomy delivers useful knowledge. Research sub-programmes are as follows:

1. Complete conspectuses (Karoo Flora, KwaZulu-Natal Flora).
2. Revise priority plant genera that are in need of revision.
3. Resolve taxonomic problems in single taxa or small taxon groups to improve the South African National Plant Checklist (see strategic objective 1).

To provide an objective list of genera prioritised for revision for sub-programme 2, indicators for identifying taxa most in need of revision were used as criteria (Victor et al. 2015b). The indicators were as follows:

- the date of the publication of the last revision (with older treatments, especially prior to 1970, being more likely to be out of date);

- proportion of unidentified specimens of genera in SANBI herbaria (unidentified specimens indicating difficulty in identification or taxonomic problems);
- proportion of taxa classified as Data Deficient due to taxonomic problems (DDT) (Victor 2006);
- economic importance (such as food plants, medicinal or horticultural value, timber or alien species); and
- proportion of taxa occurring in South Africa.

From these analyses, a list of plant genera categorised according to their priority for revision was developed and circulated widely amongst biosystematics researchers in South Africa and abroad. The list was further refined and updated in 2020, based on input of specialists' expert knowledge. Analyses were conducted on angiosperms, gymnosperms and pteridophytes according to the methodology described in Victor et al. (2015b). Sufficient data are lacking to do similar analyses for bryophytes and chlorophytes, and these are discussed below. The list is updated annually and accessible on the SANBI website at: <http://www.sanbi.org/sites/default/files/documents/documents/priority-plant-genera-revision.pdf>.

The strategy for algal taxonomy (Bolton & Victor 2013) informs phycologists of the priorities for taxonomic research on Chlorophyta and other algae in South Africa.

A photograph of Mr Lufuno Makwarela, a man with a beard wearing a light-colored jacket over a blue shirt, sitting at a desk in an office. He is looking down at a document on the desk, which appears to be a specimen sheet with a plant drawing. On the desk, there is a laptop, a printer, and other office equipment. A blue vertical text box is overlaid on the left side of the image.

Mr Lufuno Makwarela preparing type specimens for scanning.



Orphanium



SANBI has not had the capacity for research on these groups, nor has taken responsibility for algal collections, and this is being addressed through the National Science Collections Facility (nscf.co.za).

The lower plant families, hornworts, liverworts and bryophytes, have the following research needs: one hornwort (Anthoceroophyta) and 31 leafy liverwort (Marchantiophyta) families have not been treated since the 1960s and are in urgent need of taxonomic revision. Although most moss (Bryophyta) families in the fourth and last fascicle of the Flora of Southern Africa have been/are under revision, the families Amblystegiaceae (8 genera, 11 species) and Brachytheciaceae (11 genera, 22 species) have not been allocated yet and are urgently in need of taxonomic revision (last revised in 1926). Large areas of southern Africa remain underexplored and 41% of half degree grid squares in southern Africa still do not contain any Bryophyte records (Van Rooy & Phephu 2016). Recent collecting in these areas, especially the Cape Region, resulted in the discovery of many new records and new taxa, including new monotypic genera (Zander & Hedderson 2009, 2011). The Bryophytes of the region still need to be assessed, following IUCN (2001) methodology, for the Red List of South African plants. However, many Bryophyte taxa remain Data Deficient, which makes this task challenging.

Most lichen groups in southern Africa are poorly known and in urgent need of taxonomic revision (Fryday 2015). Fortunately, the recently published checklist of lichenised, lichenicolous and allied fungi reported from South Africa (Fryday 2015) provides a sound basis and ideal opportunity for research on the taxonomy, ecology and conservation of South African lichens. The National Herbarium has a collection of lichens that provides an excellent opportunity for research initiatives in this field.

Strategic objective 4: *create identification guides*

At a workshop on 18 June 2018 at SANBI, the taxonomists of SANBI identified the creation of keys as being the most important priority for future research. The shortage of capacity was recognised, and the future prognosis of filling posts with experienced and able researchers was acknowledged to be dismal. The solution was proposed that interactive keys with explanatory details would be a vital way to enable end-users to identify South African flora in future. Popular families or groups need to be prioritised initially, mainly focussing on large groups that plant collectors and enthusiasts struggle to identify, such as Fabaceae, Poaceae and Asteraceae. Keys to taxa of major concern for conservation (e.g. *Encephalartos*), sustainable use and management of invasive and pest species, and disease vectors, should be prioritised.

Strategic objective 5: *conduct research to enhance understanding of relationships between taxa*

The aim of this strategic objective is to use phylogenetic understanding of groups to lead to improved taxonomic treatments and revisions. The two main resources used by taxonomists in phylogenetic research are:

- molecular studies; and
- micromorphology (scanning electron microscopy, or SEM; and high power digital microscopy).

Conducting taxonomic research in such a way that insight is provided into other fields, especially focusing on determining evolutionary relationships and specialisations, remains of paramount importance. Studies on function/process (as



Aptostimum



opposed to structure/pattern) informs taxonomic work, and provides high-profile research outputs for attracting funding.

A molecular laboratory exists at the Kirstenbosch Research Centre, and a new one is being established at the National Herbarium in 2021. Both the Compton and National herbaria are equipped with microscopes, including digital microscopes. The National Herbarium is also equipped with a Scanning Electron Microscope.

Strategic objective 6: *develop and improve quality of primary datasets*

Herbaria capture, house, maintain and disseminate electronic data of specimen label information. The aim of this programme is to ensure that data captured in the electronic database accurately mirrors data provided on the specimen labels to improve the quality of foundational data provided by herbaria.

It is recommended that the following standards for curation are adhered to:

- Quality standards and quality control procedures are in place for populating plant specimen databases and checking for errors.
- The two main sources of errors in herbarium databases: (1) names (identification), and (2) localities (georeferenced as well as lower resolution such as quarter degree grid). Correction and verification of electronically captured label information is a standard task done by all scientists (10–20%

of time) and support staff. This is done either by systematically working through specimens, checking identifications and localities against the database and correcting them, or generating taxon distribution maps and identifying points that appear to be out of place.

- Errors in identifications, locality and georeferencing are corrected by scientists or technical support officers who are experienced at identifying the taxa concerned and have knowledge of the geography of the area concerned.

Monitoring of progress is an essential component of improving data quality in herbaria. Changes and updates that have been made to the database at SANBI are summarised and displayed on a SANBI website page at intervals to illustrate to end-users how progress is being made to clean-up data.

Strategic objective 7: *improve comprehensiveness of information provided by herbaria*

The aim of this programme is to undertake exploration to discover and catalogue South Africa's flora. This involves three sub-programmes:

1. Sample and store biological material for DNA barcoding.
2. Improve the herbarium collections as a research resource by prioritising collecting activities towards plant taxa that are underrepresented in herbarium collections.
3. Conduct collecting projects to document flora of poorly known areas that are underrepresented by specimens in herbaria and are potentially under threat from development.

DNA barcoding aims to build up a library that can be used as a reference for future identification of plant species. DNA material can be stored in a biobank housed at SANBI. Collection of DNA material should be targeted towards economically important but difficult to identify groups, especially where expertise for identification is lacking. The genera *Encephalartos* and *Eucalyptus* are examples of important groups that should be prioritised for barcoding. It is critical that specimen voucher identifications are verified by specialists and lodged at herbaria.

Strategic prioritisation for expanding the collections through a systematic and efficient approach will expand the knowledge base of plant diversity. Collecting from undercollected areas and focussing on plant taxa that are underrepresented in herbaria provides vital foundational information for research purposes as well as for end-users.

Eulophia



The ideal number of plant specimens representing each taxon will differ between herbaria and between taxa. As a general guideline for SANBI herbaria, if fewer than five specimens exist for one taxon, then it is considered to be underrepresented and should be prioritised for collecting.

Because of the large areas that are undercollected, it is recommended that quarter degree grid squares with fewer than 10 specimens (especially those with none) are targeted as first priority, but especially in areas that are earmarked for future development.

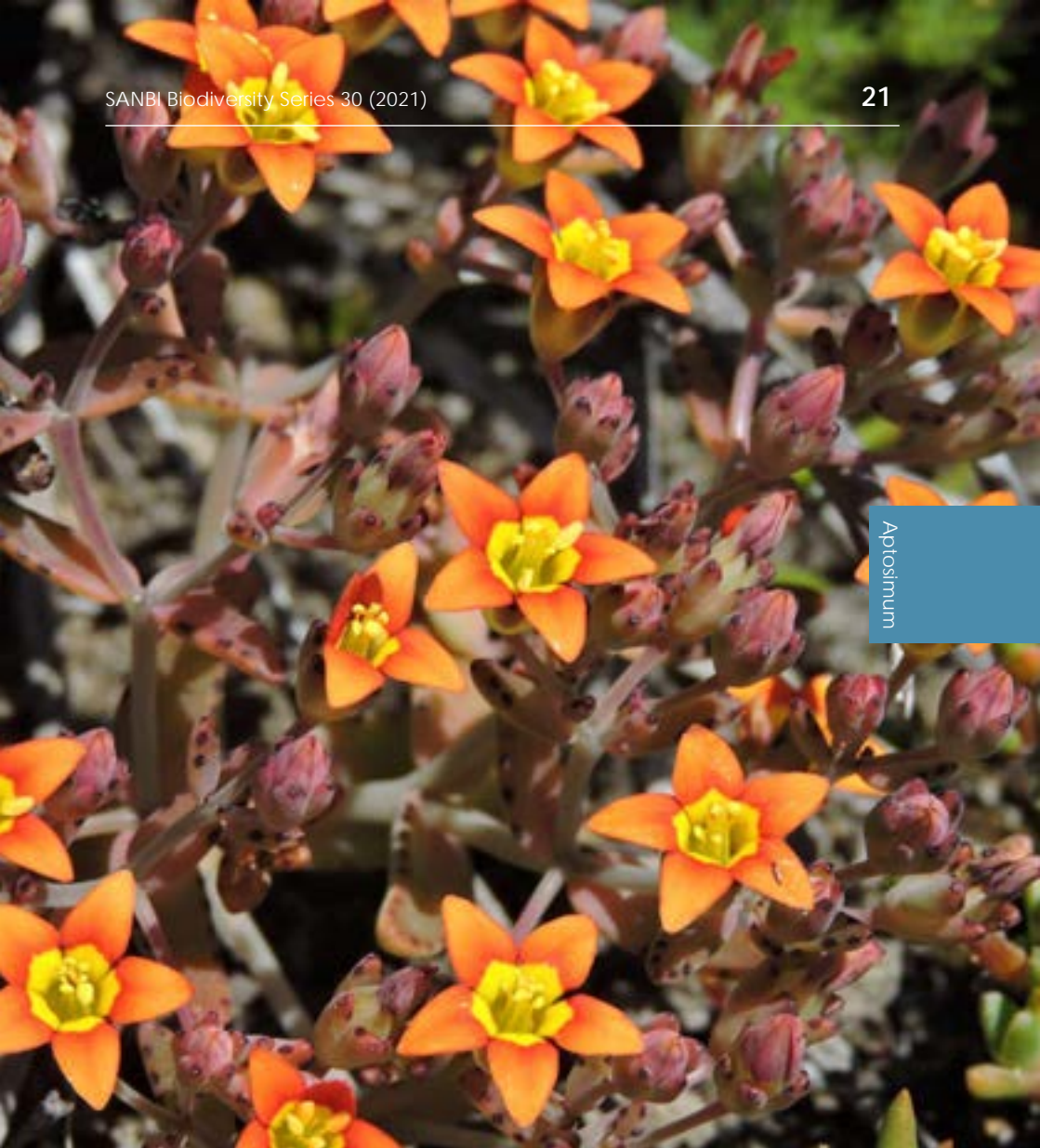
Discussion and conclusions

There are seven strategic objectives for plant taxonomy. Existing capacity at SANBI is utilised towards addressing the priorities of this plan for plant taxonomy. Capacity needs to be developed in certain areas, especially in lower plants, of which components (especially lichens and Chlorophyta) have been neglected.

To achieve a natural and predictive classification system, morphological data are integrated with results from other sources such as molecular, anatomical, cytological, physiological and palynological studies. Phylogenetic studies are essential to circumscribe the group of interest, identify nearest relatives, and identify patterns of character evolution. Understanding taxonomic and evolutionary relationships contributes towards understanding other characteristics of an organism, such as the causal factors for rarity, which improves our ability to conserve and manage biodiversity. However, phylogenetic work should not be the end product of a molecular study, but rather, projects should be designed in such a way that molecular results will assist with revisionary work.

The diminishing number of taxonomists in South Africa necessitates a focus on producing keys and popular publications to enhance the accessibility of taxonomic information. Field guides with images to aid identification, electronic keys (e.g. Lucid) and easy access to scientific literature through the e-Flora portal, are ways in which SANBI achieves dissemination to the broader public and other stakeholders. An area for future development is in applications for mobile cellular phones and tablets, although the expense of this is currently a limitation.

The SANBI website hosts a list of taxonomic priorities for research and expertise of botanists, both professional and amateur, from herbaria and universities countrywide, as well as priority genera for research. It is hoped that this research plan will act as a resource to stimulate interest in taxonomic research, and will serve to coordinate taxonomic research on South Africa's plants.



Aptostimum

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