

Priorities for biosystematic studies of the southern African flora

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Molecular information is now providing powerful new ways of exploring biodiversity, particularly at the species level and below. The importance of biosystematic studies is discussed, and a number of previously published criteria¹ are used explicitly to list several southern African plant families which are considered to deserve a high priority in research programmes. Our botanical diversity is a unique asset which has the potential to make a substantial contribution towards improving our economic position in the 'global village'. Biosystematics can play an important role to ensure that we grasp the commercial opportunities provided by our genetically diverse flora.

Plant diversity in southern Africa has traditionally been explored and documented by alpha-taxonomists, who have gone a long way towards providing an inventory of our flora at the species level.² Evolutionary relationships within some taxa have been studied in recent years, but there are only a few cases³⁻⁸ where the evolution and ecology of single species have been studied at the population level. The term 'biosystematics' is generally understood to refer to the testing of hypotheses on species delimitations and hybridization,⁹ using populations as the units of study^{10,11} or the investigation of micro-evolution, chromosomes and genetic systems.¹²

Modern technology provides us with sophisticated new experimental and molecular tools¹³ to explore evolution at the population level. In addition to enzyme electrophoresis, the polymerase chain reaction (PCR)¹⁴ and DNA sequencing¹⁵ are now widely available. The most popular nucleotide sequences come from the chloroplast gene *rbcL* but these have been used mainly for comparisons at higher taxonomic levels, such as the seed plants,¹⁶ monocotyledons,¹⁷ Asteraceae¹⁸ and Apiaceae.¹⁹ Other sequence data, such as those in the nuclear ribosomal DNA internal transcribed spacer (ITS) have also been successfully employed in phylogenetic studies.²⁰ The first South African work using the *rbcL* gene was on the subfamily Arundoideae of the Poaceae.²¹ For studying genetic variation within and between populations, the DNA-based fingerprinting method known as RAPD²² (for random amplified polymorphic DNA) has now become routine.²³ In South Africa, RAPD has been applied to *Saccharum* (sugarcane)²⁴ and *Prunus africana* (Hook. f.) Kalkman populations.²⁵ Several research programmes, aimed mainly at the fingerprinting of commercial clones, are in progress at various universities and institutes. Molecular information (from micromolecules and macromolecules) has thus become technically easy to generate and provides wonderful new opportunities to test our old assumptions that were based on morphological patterns. In this paper, the concept of biosystematics is broadened to include molecular systematics at all taxonomic levels, namely, populations, species, genera and families.

Criteria for recognizing priorities

At a recent workshop¹ entitled 'Priorities in Systematic Research and Training', held at the Linnaean Society in London, six criteria for recognizing high priorities were identified. Since biodiversity is a global concern, these criteria do not apply only

to northern hemisphere conditions but are directly applicable also to southern Africa: 1) scientific excellence; 2) relevance (clearly identified user communities); 3) enhancing scientific coverage (e.g. poorly known families such as the Mesembryanthemaceae); 4) scale of relevance (global, regional or local); 5) urgency (threatened habitats, commercial opportunities); and 6) feasibility (time and resources). Selected examples from the southern African flora are used below to illustrate the application of these criteria. Southern African plant families considered to be of high priority for biosystematic studies are also referred to.

1) *Scientific excellence.* What is needed in southern Africa is excellent science, regardless of its being 'basic' (i.e. mainly of theoretical interest) or 'applied' (i.e. of direct practical value). See Box 1. Biosystematics can make important contributions to both, but there is a danger of merely generating a wealth of cytological and genetic information without contributing much to systematic theory.²⁶ The three levels of activity shown in Box 1 are all equally important since they are interdependent. Neglect of any one of these activities will adversely affect the other two. The continued importance of alphataxonomy can be judged from the fact that 15% to 20% of our flora is not yet described at the species level. (This estimate comes from our own work in the families Apiaceae and Fabaceae, where I have calculated the total number of new species described by our research group over the last 10 years, expressed as a percentage of the total number of species. The results were 15% for the Fabaceae and 20% for Apiaceae.) At the biosystematic and applied levels, the degree of infraspecific variation becomes more important, but this part of our biodiversity is often overlooked and is definitely underestimated. Southern Africa is not only rich in species diversity, but also exceptionally rich in genetic diversity within species, as can be seen from the large numbers of geographical variants that are found in many of our plants, e.g. *Aspalathus linearis* (Burm. f.) Dahlg.^{27,28} Other examples include the pan-African *Lotononis platycarpa* (Viv.) Pic.-Serm.²⁹ and *Acacia karroo* Hayne.³⁰ Studies on the biology of species should therefore not be restricted to single populations, because each population may contain only a portion of the total morphological,³ chemical³¹ or electrophoretic³² variation within the species.

2) *Relevance.* There are three important considerations: *Economic value.* It is often overlooked that systematic botany had its roots in medicine (after all, Linnaeus was a medical doctor) and that the use of plants has always been an important

Box 1.		
Levels of systematic research. The biosystematic (molecular) approach can make important contributions at all three levels of activity.		
Activity	Aim	Products
Alphataxonomy	Inventory of the flora	National and regional Floras
Biosystematics	In-depth knowledge	Monographs and revisions
Applied research	Solving problems	New and better crops

Box 2.			
Three basic steps in the commercialization of plants.			
Steps	Selection criteria	Product quality	Examples from the southern African flora
1. Harvesting from wild populations	Choice based on tradition	High variability, variable quality	<i>Aloe ferox</i> , <i>Cyclopia</i> spp., <i>Agathosma</i> spp., <i>Sclerocarya birrea</i> (A. Rich.) Hochst.
2. Domestication and cultivation	Choice based on practical criteria	Moderate variability, improved quality	<i>Aspalathus linearis</i> , several horticultural crops, e.g. Proteaceae.
3. Crop improvement	Choice based on economic criteria	Low variability, high quality	Several horticultural crops, e.g. <i>Gerbera</i> ; no food plants or medicinal plants

motivation behind inventories (such as the colonial Floras). The commercial potential of our flora is only partially explored (mainly for horticultural use), and it is impossible even to imagine the long-term economic value of our plant genetic resources. It is precisely at this level that biosystematic studies become relevant.

The commercialization of plants involves three basic steps, as shown in Box 2. Very few southern African plants have been developed as commercial crops and most of the resource is still harvested in the wild. Numerous medicinal plants fall into this category, including *Aloe ferox* Mill. (the source of Cape aloes, our most important indigenous medicinal product), *Harpagophytum procumbens* (Burch.) DC. ex Meissn., *Agathosma betulina* (Berg.) Pillans and *A. crenulata* (L.) Pillans. A few indigenous plants have passed the second step and have been domesticated, such as *Aspalathus linearis* (the source of Rooibos tea, our most important indigenous food product in commercial value). Crop improvement and breeding work has been done on a few horticultural crops, but there are no indigenous food plants or medicinal plants that have reached this level of development. Biosystematic studies are highly relevant in new crop development. The wise and innovative use of the unique genetic resources provided by the southern African flora is one of the areas in which southern Africa may reach new frontiers in science and technology.³³ An important step in the right direction was the establishment of an Indigenous Plant Use Forum, coordinated by the Foundation for Research Development. A national network was established, and the Network Directory³⁴ is a useful document because it provides easy access to most of the role players in indigenous plant use research.

Conservation of biodiversity. Biodiversity is usually measured in terms of the number of species, genera and families per unit area.³⁵ This emphasis on species diversity undoubtedly leads to an underestimate of the total biodiversity of the southern African flora, as much of the diversity is found at the level of varieties and geographical races. The regional variation in commercially important plants is rarely considered in conservation management despite the fact that local wild populations are important sources of new genes for future breeding work. The role of biosystematics is to document biodiversity at the population level, so that rational decisions can be made about the *in situ* conservation of our genetic resources.

Evolutionary patterns. The study of the underlying principles of evolution in the southern African flora is mainly a cultural activity. We are morally obliged to explore the diversity and to seek an understanding of the historical forces that have resulted in the remarkable divergence of the flora. A deeper understanding, as reflected in modern phylogenetic classification systems, is also of practical importance because of the high predictive value.

Related plants have similar characteristics and we can thus predict where superior genotypes are likely to be found. The development of new crops and new products then becomes a rational process rather than a random search.

3) *Enhancing scientific coverage.* Taxonomic knowledge of our flora is very unevenly distributed amongst the families and genera. The large family Mesembryanthemaceae is subendemic to southern Africa, with many of its members locally dominant in the dry interior, yet it remains poorly known.³⁶ This criterion has been an important consideration in the choice of families in Box 3.

4) *Scale of relevance* (global, regional or local). Studies of families with a cosmopolitan distribution are important to provide a global perspective. The African Apiaceae, for example, includes many unusual character combinations and detailed studies on relationships within this family and the closely related Araliaceae.¹⁹ Families with a pan-African distribution, such as the Asclepiadaceae and Asphodelaceae, have regional relevance, and may provide new insight into the historical biogeography of the continent. Families endemic to southern Africa have been listed as locally relevant in Box 3. These families form an important part of our unique botanical heritage and provide opportu-

Box 3.		
Priorities for biosystematic and chemosystematic studies of the southern African flora, arranged according to their scale of relevance. All genera with commercial value (or potential value) should be added to this list.		
Global priorities	Regional priorities	Local priorities
Asteraceae	Amaryllidaceae	Achariaceae
Apiaceae	Asclepiadaceae	Bruniaceae
Ericaceae	Asphodelaceae	Greyiaceae
Fabaceae	Geraniaceae	Geissolomataceae
Poaceae	Hyacinthaceae	Grubbiaceae
Proteaceae	Iridaceae	Penaeaceae
Welwitschiaceae	Meliantaceae	Retziaceae
Zamiaceae	Mesembryanthemaceae	Roridulaceae
	Oxalidaceae	Stangeriaceae
	Polygalaceae	Stilbaceae
	Restionaceae	
	Rutaceae	
	Scrophulariaceae (incl. Selaginaceae)	

nities for exciting new scientific discoveries. For logistic reasons, these families can best be studied by local botanists.

5) *Urgency* (threatened habitats, commercial opportunities). A large part of our floristic wealth is under threat from human impact, mainly due to habitat destruction resulting from urban encroachment, agriculture, commercial forestry and industrial development. At the same time, the floristic wealth forms the basis for the development of new crops and new products. In sophisticated global markets, our genetic resources provide an underestimated competitive advantage which will gradually be lost if there is no local innovation.

6) *Feasibility* (time and resources). Biosystematic studies are generally expensive in monetary terms, and should therefore be focused on projects with a high relevance in terms of the criteria listed above. Commercially important plant groups may provide equally suitable models for studying basic processes than an obscure group with no obvious relevance.

Conclusions

There should be a balance between the traditional herbarium-based methods (alphataxonomy) and modern approaches (biosystematics, molecular taxonomy) if we are to succeed in documenting our biodiversity within a reasonable period. It is equally important to strike a balance between highly theoretical research and problem-driven research, but systematics will undoubtedly benefit from a more critical selection of projects. According to the six criteria discussed above, a number of clear priorities can be identified. Plant families considered to have a high priority in terms of biosystematic studies are listed in Box 3 according to their scale of geographical relevance. Information from micro-molecules and macromolecules will continue to play an important role at all levels of systematics research, but it is becoming increasingly obvious that molecular data should be used to supplement other information and not to replace it.

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