Priority-driven Barcoding of Life for Southern Africa, and beyond

Report of a Southern Africa Regional DNA Barcode Meeting
South African National Biodiversity Institute, Cape Town, South Africa

Gideon F. Smith[1], David Schindel[2], Richard Smith[3], & Scott Miller[4]

Introduction

On 7 and 8 April 2006 the South African Biodiversity Institute (SANBI) hosted the first outreach meeting on DNA barcoding in developing regions, jointly organized by the Consortium for the Barcode of Life (CBOL), SANBI, BioNET-SAFRINET and BioNET-INTERNATIONAL (hereafter BioNET; see meeting announcement, Appendix 1). This was the first of at least four regional meetings CBOL plans to hold in 2006-7. The goals of the southern African meeting were to:

- Clarify concepts and applications of barcoding;
- Raise awareness of the uses of DNA barcoding for biodiversity research and species identification among researchers and potential end-user organizations;
- Raise awareness of the pitfalls of barcoding, focusing on the responsible application of the technique;
- Explore the potential applications of DNA barcoding to environmental, agricultural, health and other challenges facing countries in southern Africa; and
- Clarify funding opportunities to participate in barcoding thrusts.

The meeting took place at the Centre for Biodiversity Conservation in the Kirstenbosch National Botanical Garden and was attended by 67 participants from 11 southern African countries (Botswana, Lesotho, Madagascar, Malawi, Mauritius, Moçambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe), four other African countries (Ethiopia, Ghana, Kenya, Nigeria) and two other regions (south and southeast Asia) for which future regional meetings are being planned. These participants were selected from the region's academic research community, government agencies (especially those responsible for quarantine, plant health and pest management), and interested NGOs and foundations. Ten CBOL officials (from Brazil, Canada, Denmark, France, Kenya, UK, and USA) attended as presenters, moderators and rapporteurs.

Acknowledgments

The SANBI barcode meeting was made possible through funding from the Swiss Agency for Development Cooperation (SDC), the JRS Biodiversity Foundation, CBOL, the Global Biodiversity Information Facility (GBIF), the South African Department of Science and Technology, and the Alfred P. Sloan Foundation. Significant in-kind support was provided by BioNET's Secretariat and BioNET-SAFRINET, SANBI, and CBOL.

Background

In 2004 CBOL was established as an alliance of biodiversity research institutions including museums and herbaria, private sector companies, NGO's and government departments. The aim of CBOL is to explore and promote the development of DNA barcoding as a global standard for species identification. Using DNA barcoding, the taxonomic community could develop a comprehensive sequence database of all described species, preferably associated with voucher specimens against which sequences of sampled individuals can be compared. This reference database and its associated voucher specimens would enable non-taxonomists to identify organisms using the standard techniques of molecular biology. DNA barcoding is therefore widely advocated as (1) a tool for basic research in biodiversity, (2) a way to catalogue and index

[1] Office of the Chief Director: Research & Scientific Services, South African National Biodiversity Institute, Private Bag X101, Pretoria, 0001 South Africa / John Acocks Professor of Botany, H.G.J.W. Schweickerdt Herbarium, Department of Botany, University of Pretoria, Pretoria, 0002 South Africa
[2] Consortium for the Barcode of Life, National Museum of Natural History, 10th and Constitution Ave. NW, CE119, MRC 105, P.O. Box 37012, Washington, DC 20013-7012
[3] BioNET INTERNATIONAL, Global Network for Taxonomy Technical Secretariat, Bakeham Lane, Egham, Surrey TW20 9TY UK
[4] Office of the Under Secretary for Science, Smithsonian Institution, 1000 Jefferson Drive, SW, Suite 230, MRC 009, P.O. Box 37012, Washington, DC 20013-7012

known biodiversity, (3) a way to accelerate the pace of discovering and cataloguing new species, and (4) a system for identifying organisms for applied purposes. For most animal groups, the mitochondrial gene region cytochrome c oxidase I ("COI") is proving highly effective as a barcode. The optimal barcode regions for plants and fungi are still being identified.

Barcoding has managed to attain significant momentum in recent years. Among other things, groups of biologists are considering how this initiative can be harnessed for purposes that will advance taxonomy and systematics - in effect, discussing how to integrate these large-scale sequence data sets with the more traditional taxonomic data sets to create comprehensive assessments of biodiversity. This seems a responsible approach to utilising barcoding for taxonomic, and other, purposes. The aim is to use all characters and data available, including but by no means limited to DNA sequences, to delimit, discover, and identify the building blocks of the biological world.

In addition to evoking enthusiasm among many taxonomists and ecologists, barcoding has met with concerns and objections. Many taxonomists have warned against using a short gene sequence as the sole basis on which new species are described. Others have noted that the barcode region alone is insufficient basis on which to reconstruct phylogenetic relationships. CBOL officials described these criticisms and the limitations of the barcoding approach. They stressed that the principal use of barcoding should be as a species-level diagnostic for well-known species – one that can be applied rapidly and cost-effectively by non-taxonomists.

The momentum associated with barcoding has the potential to raise the visibility and impact of taxonomy in the scientific community and among the general public. This would highlight the need to train taxonomists and parataxonomists, establish and maintain reference collections and support taxonomic research and natural history institutions in southern Africa, and beyond.

Meeting Structure and Content[5]

The two day meeting began with a half-day devoted to introductory presentations on DNA barcoding, barcode data standards, and the application of barcoding to taxonomic research and applied socioeconomic problems such as agricultural pests, invasive species, and disease vectors (see meeting agenda, Appendix 2). Two half-days were then devoted to discussions in break-out groups. In the first discussion session, participants compiled lists of potential barcoding projects that are the highest priority for southern Africa as a whole and for individual countries. These projects could serve:

- academic research goals, such as expanding our understanding of poorly known taxonomic groups, habitats, and/or geographic regions; or
- societal needs, such as environmental protection, public health, control of agricultural pests, and protection of threatened and endangered species.

The second break-out discussion was devoted to an assessment of the region's current capacity to do DNA barcoding, and the training and capacity-building that would be needed to enable barcoding in the region. "Capacity" was interpreted broadly to include:

- Molecular biology laboratory facilities;
- Lab instrumentation for DNA extraction, PCR amplification, and gene sequencing;
- Trained researchers and technicians;
- Taxonomic experts;
- Reference collections of and for voucher specimens;
- Databases and computer networks for bioinformatics data management;
- Internet connections for access to taxonomic data resources (e.g., literature, GenBank);
- Training programs for taxonomists and collection managers;
- Regional networks of cooperating researchers and collections;
- Regulations and permits allowing collection of material, and;
- Agreements permitting international transfer of specimens and DNA.

[5] See meeting agenda, Appendix 2. Presentations linked to the agenda are available at http://www.barcoding.si.edu/SANBIagenda.htm

The final half-day of the meeting was spent in open discussion, during which the break-out groups shared their findings.

Meeting Results

Participants engaged in a lively and free exchange of opinions on the validity and utility of the barcode approach. Out of this discussion, a groundswell of support emerged at the Kirstenbosch meeting. Delegates found common ground in supporting the use of DNA barcodes for basic and applied research, and as a solution for many applied societal problems. There was strong support for the goal of democratising taxonomic information for the masses of end-users.

Priorities for Barcoding Projects in southern Africa. Following their discussions in break-out groups, the meeting participants shared their findings and developed the following list of high-priority barcoding projects. In compiling this list, participants looked for barcoding projects with the following characteristics:

- address an immediate need (either for researchers or society in southern Africa);
- focus on species of commercial value, endangered species, and endemic species;
- have potential users and supporters;
- are ready to be implemented by identified leaders in the region;
- have an adequate supply of reference collections and taxonomic experts in the region; and
- are sustainable, i.e., have users, custodians or others who will pay to maintain reference collections and databases of barcode data.

The priority barcoding projects identified by the meeting participants are:

- Pest species related to plant quarantine (fruit flies, white flies, mealy bugs, plant nematodes, pathogenic fungi);
- Macro-invertebrates used for water quality assessments;
- Fisheries stocks and participation in CBOL's All Fishes Barcoding Initiative (FISH-BOL);
- Endangered vertebrates threatened by bushmeat hunting and trade;
- Wildlife species and their related parasites and pathogens;
- Pests on livestock species, e.g., ticks, biting flies, parasites;
- Invasive alien species;
- Rare/endangered species such as those in the Cape Floristic Kingdom;
- Plants and animals used medicinally or culturally;
- Nematodes in general; and
- Groups of interest to specific sectors such as public health (mosquitoes), commercial fishermen (abalone), pet trade (birds)

Regional Needs for Capacity-building and Training. Meeting participants discussed the challenges to implementing barcoding projects in the region. Like the great majority of countries of the world, southern Africa has an inadequate and declining supply of expert taxonomists and funding for reference collections. Understanding of and appreciation for taxonomy is low, and there is significant concern in many countries about bioprospecting and the potential loss of genetic property rights. For this reason, many southern African countries have very restrictive policies towards collecting and exporting specimens, tissue samples, and DNA extracts. Some countries are starting to differentiate between commercial research activities and biodiversity research for non-commercial purposes. For example, South Africa recently passed a new biodiversity act (NEMBA, no.10 of 2004) that will bring some clarity to the issuing of permits. Regulations are now being developed to allow the effective and efficient implementation of the new act.

There was general agreement that even though scientific and technological capacity is unevenly distributed among countries, southern Africa can develop the ability to conduct barcoding projects independently, without relying on foreign labs. One break-out group assembled an informal country-by-country survey of capacity and priorities for barcoding in southern Africa (see Appendix 4). Many participants felt that a more systematic survey of regional capacity would be useful. Such a survey could be conducted through the SADC Secretariat and could compile information on the availability in the region of: diagnostic labs, automated extraction systems,

PCR machines, clean labs, sequencers, trained technicians, microarrays and array readers, herbaria, museums, other reference collections, and digitized collection catalogs.

Participants agreed that a regional approach would be needed for most large barcoding projects. Networks within the region, south-south and north-south networks can help to overcome shortages of facilities and expertise in individual countries. Sequencing facilities exist in only a few African institutions, and establishing them in every country would not be cost-effective. Participants agreed that the optimal configuration would be to have many local labs that are capable of extracting DNA from samples, performing PCR amplification, and sending PCR products to a central sequencing facility in the region or to a commercial sequencing facility elsewhere.

Several very successful networks have been established in the region (e.g. in support of IPPC / WTO-SPS implementation), and SABONET and SAFRINET provide excellent models for a successful regional effort. SAFRINET and SABONET have been effective in building international projects, establishing international MOUs, and in getting Ministerial-level attention for taxonomy in some SADC countries and beyond. Other possible models for cooperation are:

- African Plants Initiative, funded by the Mellon Foundation;
- Belgian Global Taxonomy Initiative training and research programme;
- GBIF nodes;
- National networks and nodes such as SANBI, SAIAB, SA Biobank (National Zoological Gardens, Pretoria), and the Namibian Biodiversity Institute;
- North-south partnerships such as those among herbaria (e.g., SANBI, University of Johannesburg and Royal Botanic Gardens Kew); and
- BioNET's global network, for south-south and south-north partnerships.

These networks have confronted the need for information sharing and management, and the IT specialists they employ are creating regional models of how to manage and maintain online databases.

South Africa has the best developed laboratory facilities and taxonomic collections in the region and would likely form the hub for networks of participating labs. Many other countries have or could develop labs for performing the initial steps in the barcoding process (DNA extraction and PCR amplification). PCR products could then be sent to sequencing labs in South Africa or other countries, subject to the creation of Material Transfer Agreements. Participants felt that obtaining permits for collecting and material transfer is difficult but not impossible. Regional networks already in place provide models of successful collaborations within the region that may be used to secure the necessary permits.

Capacity to curate and maintain voucher specimens is a special challenge in the region. Reference collections and potential vouchers are not available in museums/herbaria throughout the region. In many cases, the best collections from southern African countries are in northern hemisphere collections. In these cases, a serious impediment to developing regional capacity focused on meeting regional needs could be that barcoding projects may be less inclined to use and support African collections. However, all barcoding projects will need new specimens to complement existing collections. To be relevant and useful, southern African institutions will need to develop a new culture of vouchering specimens to document their biodiversity.

There are many signs that some taxonomic collections are growing in the region, while others are declining. Biomaterial banking/tissue banking are underway in several places for different taxonomic groups. Manuals are available for the identification and collection of insects, arachnids, fungi and nematodes (through SAFRINET). However, these manuals do not cover collection and storage of tissue for the purposes of DNA extraction. To complement specimen and tissue collections, DNA banks with Material Transfer Agreements need to be established. As these efforts continue, better linkage between museums and universities should be encouraged.

Some institutions that have deposited material with international collections (e.g., RBG Kew) have a Memorandum of Understanding with regard to access and utilization of material from South Africa. RBG Kew in association with other institutions, including SANBI, has published a manual regarding the establishment of a memorandum of understanding, and guidelines for setting up

legal agreements between collectors and collections. CBOL has worked on some of these issues and templates for such agreements will be made available on the web.

Training in taxonomy, curation, barcoding and the more general area of molecular biology is an important need. Some participants called for development of an African equivalent of the US National Science Foundation's PEET programme (Partnerships for Enhancing Expertise in Taxonomy), through which young taxonomists are trained and mentored. This can be pursued through both in-country training and by international fellowships, after which trainees can return to their countries of origin with a good knowledge of the entire process from collection, vouchering, preparation of material, extraction of DNA, PCR and potentially sequencing. Participants suggested:

- Developing new graduate programs (focusing on masters' level) to place students in laboratories with good barcoding expertise, as part of those students' taxonomic research training. Laboratories could be in Africa or in other regions where there is both taxonomic and barcoding expertise;
- Developing regional training centres. Within southern Africa, SANBI would be a reasonable choice for such a centre; and
- Approaching SADC or NEPAD to help with funding scholarships for students to work in other countries (inside or outside of Africa).

Overall, participants agreed that the southern Africa region should initiate barcoding projects that address its own needs, and should also participate in global barcode projects. To do so, new sources of funding will be needed so that barcoding won't interfere with other taxonomic research activities. For this reason, most barcoding projects should have identified end-users who are willing to support the construction and sustained use of the barcode reference library of a taxonomic group. The interest of taxonomic specialists alone will not be sufficient to implement most large barcoding initiatives.

Next Steps

During the final discussion session, participants compiled the list of priority projects listed above (see Meeting Results). For each of these proposed projects, individuals expressed their willingness to take leadership roles.

Meeting participants outlined the following action items that CBOL and BioNET should implement:

- Create Steering Committees for selected projects, identify Chairs, market idea;
- Facilitate the formation of a Regional Barcode Network, possibly extending an existing network;
- Identify Leading Labs for information/staff exchange with Guelph, Smithsonian, EU;
- Identify Participating Labs involved in regional or global projects for local training;
- Find and customize or develop template Material Transfer Agreements;
- Create short courses, train-the-trainer program, advocacy presentations;
- Respond to requests for assistance in writing proposals to funding agencies for barcoding projects, training, and capacity-building; and
- Provide copies of successful barcoding proposals on request.

APPENDIX 1: MEETING ANNOUNCEMENT

DNA Barcoding of Biodiversity in Southern Africa
Call for Participation in a Regional Meeting
7-8 April 2006, Cape Town, South Africa

The South African National Biodiversity Institute (SANBI), in partnership with the Consortium for the Barcode of Life (CBOL) and BioNET-SAFRINET (SAFRINET), announces a two-day regional meeting on "DNA barcoding" to be held at the Kirstenbosch Research Centre in Cape Town. Potential participants from Southern African countries are invited to send expressions of interest to the organizing committee. Limited funds will be available to support participation in this two day workshop.

The workshop is directed at upper level researchers and project managers/coordinators. The organizers seek the participation of:

- biodiversity researchers and policymakers
- taxonomists with and without experience in molecular biomarkers
- agricultural, environment, and public health scientists
- private sector companies who use, or will use barcoding

DNA barcoding is a new technique that uses a short gene sequence from a standardized position in the genome as a diagnostic tool for identifying species. Barcoding is intended as a reliable, cost-effective tool for documenting biodiversity research, controlling disease vectors, pests, and invasive species, protecting endangered species, and other regulatory areas in which species identification is critical. CBOL is an international initiative that promotes the development and use of DNA barcoding. The Consortium is supported by the Alfred P. Sloan Foundation and is hosted by the Smithsonian Institution in Washington, D.C., USA. CBOL has 80 Member Organizations from more than 35 countries on six continents, and is devoted to the full participation of developing countries.

Goals of the workshop are to:

- Clarify concepts and applications of barcoding
- Raise awareness as to the uses of DNA barcoding among researchers, research organizations, and potential users
- Raise awareness to the pitfalls of barcoding, focusing on the responsible application of the technique
- Explore the potential applications of DNA barcoding to environmental challenges facing countries in southern Africa
- Clarifying funding opportunities to participate barcoding thrusts

In addition, a component of the workshop will be used to:

- Assess the greatest needs and opportunities for DNA barcoding in the region. Some emphasis will be put on promoting barcoding in the least developed countries;
- Initiate the formation of a steering committee for barcoding with the intent that this committee will draw up an action plan for Southern Africa, and establish an intra-regional network and intercontinental partnerships to implement the action plan.

CBOL and BioNET-SAFRINET anticipate working with institutes and countries in Southern Africa to implement the resulting action plan, and to cooperate with regional partners through:

- In-country training activities such as short courses for researchers and advanced students on technical aspects of DNA barcoding and associated specimen curation;
- Research training fellowships that will allow researchers and technicians to spend adequate periods of time in partner laboratories for advanced training and pilot research projects;
- Infrastructure improvement such as equipment acquisition; and
- Other forms of high-priority capacity-building identified during the regional meeting.

Send expressions of interest to Suseth Foster (foster@sanbi.org)
Please indicate if you wish to apply for travel funding, as some funding may be made to a limited number of participants (contingent upon availability of funds).

For more information on CBOL: www.barcoding.si.edu.
For more information on BioNET: www.bionet-intl.org.

APPENDIX 2: MEETING AGENDA

DNA Barcoding in Southern Africa

Friday, 7 April 2006:

Session Chair: Scott Miller, Smithsonian Institution/CBOL

9:00 am: Welcome to SANBI: Gideon Smith, SANBI

9:15 am: Overview of DNA Barcoding, its relation to other biodiversity initiatives and its use in taxonomy: Scott Miller, CBOL and Smithsonian Institution

9:45 am: Introduction to the Consortium for the Barcode of Life: David Schindel, CBOL

10:00 am: Barcoding, bioinformatics, and taxonomic research infrastructure: Jim Edwards, GBIF

10:30 am: Coffee/tea break

Session Chair: Richard Smith, BioNET International

10:45 am: The Process of DNA Barcoding and management of barcode data: Bob Hanner, University of Guelph

11:15 am: National and International Networks for DNA Barcoding: Simon Tillier, National Museum, Paris

11:40 am: Applications of DNA barcoding, with national examples:

- Biodiversity conservation and taxonomic applications: José Alves-Gomes, INPA
- Control of invasive species and agricultural pests: Scott Miller
- Control of disease vectors: Richard Lane, Natural History Museum, London
- Forensics and illegal trade in wildlife products: Helida Oyieke, National Museums of Kenya

1:00 pm: Lunch

2:30 pm: Session Chair: Connal Eardley, BioNET-SAFRINET

Setting the scene for break-out group discussions of Regional Opportunities

Topics for discussion in break-out groups:

1) What are the greatest needs and opportunities for employing DNA barcoding?
   - For which scientific problems?
   - For which socio-economic issues?
2) How should DNA barcoding be implemented in the region?
   - In which research institutes?
   - In which taxonomic groups?
   - By which national or regional organizations (government ministries, NGOs)?

3:00 pm: First break-out sessions organized according to area of application

Break-out Group A. Environmental issues/conservation/taxonomy
Moderator: Helida Oyieke; Rapporteur: José Alves-Gomes

Break-out Group B. Agriculture & pests
Moderator: Richard Lane; Rapporteur: Scott Miller

4:15 pm: Coffee/tea break

4:30 pm: Discussions resume in break-out sessions

5:30 pm: Session Chair: Connal Eardley

Readout from rapporteurs of first break-out sessions, Group Discussion

6:30 pm: Adjourn for day

7:30 pm: Dinner for all participants at hotel

Saturday, 8 April 2006:

9:00 am: Session Chair: Helida Oyieke, National Museums of Kenya

Setting the scene: Second break-out group discussion of Regional Capacity and Needs

Topics for discussion in Break-out groups: Regional capacity and assessment of regional needs:

1) What is the region's capacity for generating and using DNA barcodes?
2) What are the principal obstacles to generating and using DNA barcodes?
3) What information resources (e.g., databases, e-voucher collections, digital libraries, internet connectivity, etc.) are available for generating and using DNA barcodes?
4) What structures (infrastructure, networks, programs, regulations, legal agreements) need to be in place for the effective use of barcoding?
5) What issues of intellectual and data property rights are important for generating and using barcode data? Who owns the data, who can access it, who can utilize it? Are there reasons why research organizations in the region should or should not contribute to their barcode data to a public database?
6) What should the highest priorities be for developing capacity in southern Africa to generate and use barcode data?

9:30 am: Second break-out sessions

Break-out Group C. Generating barcode data (the supply side)
Capacity and needs concerning: research infrastructure; specimen collections; networks of researchers; human resource training opportunities; other aspects of scientific capacity
Moderator: José Alves-Gomes; Rapporteur: Simon Tillier

Break-out Group D. Using barcode data (the demand side)
Capacity and needs concerning: policies, regulations, legal agreements concerning species identification; permits for collecting/exporting/importing specimens; funding programs; technology development; regulation; and other political/managerial issues
Moderator: Jim Edwards; Rapporteur: Helida Oyieke

10:45 am: Coffee/tea break

11:00 am: Discussions resume in break-out sessions

12:15 pm: Session Chair: Helida Oyieke

Readout from rapporteurs of second break-out sessions, Group Discussion

1:00 pm: Lunch

2:30 pm: Plenary discussion:
Moderator; Richard Lane; Rapporteur: David Schindel

- Priorities and needs
- Formation of regional networks
- Synergy with other biodiversity initiatives (e.g., GTI, GBIF, BioNET-SAFRINET, SABONET)
- Longer-term goals, milestones, next steps

4:15 pm: Coffee/tea break

4:30 pm: Final discussion of priorities and next steps:
Moderator: José Alves-Gomes; Rapporteur: David Schindel

6:00 pm: Summary and conclusions: Scott Miller

6:30 pm: Adjourn for day

7:30 pm: Dinner for all participants at hotel

APPENDIX 3: MEETING PARTICIPANTS

APPENDIX 3 (continued): MEETING PARTICIPANTS

NAME	INSTITUTION	COUNTRY	E-MAIL
1. Alves-Gomes, José	Instituto Nacional de Pesquisas da Amazônia (INPA)	Brazil	puraque@inpa.gov.br
2. Ausubel, Jesse	Program Director, Alfred P. Sloan Foundation Suite 2550 630 5th Avenue, New York NY 10111 1 212 649 1650; 1 212 757 5117 (fax)	USA	ausubel@mail.rockefeller.edu
3. Banda, MHP	Director of Agricultural Research Services	Malawi	agric-research@sdnp.org.mw
4. Bartels, Dr Paul	Head, BioBank SA,	South Africa	bartpaul@gmail.com
5. Boakye, Daniel		Ghana	dboakye@noguchi.mimcom.ne
6. Bowie, Rauri	Evolutionary Genomics Group, Fitzpatrick Inst., Univ. of Stellenbosch Private Bag X1 Matieland 7602 STELLENBOSCH	South Africa	bowie@sun.ac.za
7. Brodie, Gillianne	PACINET Program Coordinator Secretariat of the Pacific Communityc/- Institute of Applied Sciences University of the South Pacific P.O. Box 1168, Suva	Fiji Islands	brodie_g@usp.ac.fj
8. Cerino, Harry	JRS Foundation	USA	harrycerino@yahoo.com
9. Chimimba, Christian	Zoo & Entomology, Univ. Pretoria	South Africa	ctchimimba@zoology.up.ac.za
10. Chipili, Dr Jack -	Agriculture Research Inst., Zambia P/B 7 Chilanga	Zambia	jackchipili@yahoo.co.uk
11. Conrad, Ferozah	Leslie Hill Molecular Systematics Lab SANBI, Kirstenbosch Research Centre, Rhodes Drive, Newlands (Private Bag X7, Claremont 7735) Cape Town,	South Africa	conrad@sanbi.org
12. Crowe, Tim	Percy FitzPatrick Inst, University of Cape Town Rondebosch, Cape Town	South Africa	tmcrowe@botzoo.uct.ac.za
13. De Wet, Helene	University of Zululand, Durban (North)	South Africa	hdewet@pan.uzulu.ac.za
14. Delport, Wayne	Molecular Ecology and Evolution Programme Dept. of Genetics, Univ. of Pretoria Pretoria 0002	South Africa	wdelport@postino.up.ac.za
15. Donaldson, John	SANBI, Kirstenbosch Research Centre, Rhodes Drive, Newlands (Private Bag X7, Claremont 7735), Cape Town	South Africa	donaldson@sanbi.org
16. Dreyer, Leanne	University of Stellenbosch Stellenbosch University Private Bag X1, Matieland 7602 Stellenbosch	South Africa	ld@sun.ac.za
17. Eardley, Connal	ARAC & SAFRINET co-ordinator Bee Systematists & Safrinet Co-ordinator Plant Protection Res. Institute Private Bag X134	South Africa	EardleyC@arc.agric.za

NAME	INSTITUTION	COUNTRY	E-MAIL
	0121 Queenswood, Pretoria		
18. Edwards, Jim	Executive Secretary GBIF Universitetsparken 15 DK-2100 Copenhagen	Denmark	jedwards@gbif.org
19. Embaye, Kassahun	Deputy Director General, Institute of Biodiversity Conservation of Ethiopia, P.O. Box 30726, Addis Ababa	Ethiopia	Ddg-ibc@ethionet.et
20. Fritzsche, Meg	Administrator Consortium for the Barcode of Life (CBOL)	USA	FritzscheM@si.edu
21. Hanner, Bob	University of Guelph & Database Working Group Chair, CBOL	Canada	rhanner@uoguelph.ca
22. Hedderson, Terry	University of Cape Town	South Africa	thedders@botzoo.uct.ac.za
23. Herbert, Dai	Natal Museum, P/Bag 9070 Pietermaritzburg 3200	South Africa	dherbert@nmsa.org.za
24. Irish, John	Coordinator, Namibian Biodiversity Database Windhoek	Namibia	jirish@mweb.com.na
25. Jackson, Lynn	Global Invasive Species Programme (GISP) CBC Building, Kirstenbosch Nat. Bot. Garden Rhodes Drive, Newlands, Cape Town	South Africa	jackson@sanbi.org
26. Jacobs, Riana	ARC, Pretoria, SA SAFRINET	South Africa	jacobsR@arc.agric.za
27. Kaaya, Godwin (Prof.)	Head, Dept. of Dept of Biology, University of Namibia Private Bag 13301 Windhoek	Namibia	gkaaya@unam.na
28. Kalaba, Justine	Ministry of Agriculture, Food & Fisheries PQPS Zambia Agriculture Research Institute	Zambia	kalabajustine@yahoo.co.uk
29. Koekemoer, Marinda	Curator, National Herbarium SANBI Private Bag X101, Pretoria, 0001 physical addr: 2 Cussonia Avenue, Brummeria, Pretoria 0002	South Africa	koekemoer@sanbi.org
30. Kotze, Prof Antoinette	Head Research, National Zoo , NRF Pretoria 0002	South Africa	Antoinette@zoo.ac.za
31. Lane, Richard	Natural History Museum, London	UK	R.lane@nhm.ac.uk
32. Lesufi, Madimane M	Dept. of Agriculture Private Bag X258, Pretoria 0001	South Africa	mosesl@nda.agric.za
33. Lotz, Leon	Arachnology Dept., National Museum Private Bag 266, Bloemfontein 9300	South Africa	arachnol@nasmus.co.za
34. Makwarela, Mactavish	Knowledge Fields Development Directorate, SABI/SABIF	South Africa	mactavish@nrf.ac.za
35. Mansell, Mervyn	Agricultural Scientist, USDA-APHIS, Pretoria	South Africa	W.Mansell@aphis.usda.gov
36. Marais, Rina	SANBI Private Bag X101, Pretoria, 0001	South Africa	marais@sanbi.org
37. Maulana, Tonny	Entomologist, Dept. of Agric. Res. in Plant Prot.	Malawi	pesticideboard@malawi.net
38. Maurin, Olivier	University of Johannesburg	South Africa	mvdb@na.rau.ac.za
39. Mguni, Cames	Head of Plant Protection Research Institute	Zimbabwe	zpgs@gta.gov.zw
40. Miller, Scott	CBOL, Smithsonian Institution	USA	MillerS@si.edu

NAME	INSTITUTION	COUNTRY	E-MAIL
41. Molyneux, David	Chair of JRS Foundation Board	UK	David.Molyneux@liverpool.ac.uk
42. Mphahlele, Kgoale	Department of Science and Technology	South Africa	Kgoale.Mphahlele@dst.gov.za
43. Muacanhia, Thomás	Inhaca Island, Eduardo Mondlane University (EMU) Director of Inhaca Marine Biological Research Station and manager of Forests and Marine reserves of Inhaca and Portuguese Islands	Moçambique	tmulakha2000@yahoo.com.br
44. Mulenga, Dorothy Kangwa	Chief Science and Technology Officer, Ministry of Science, Technology and Vocational Training, P.O. Box 50464, Lusaka	Zambia	dkmulenga@mstvt.gov.zm
45. Nantulya, Vinand			Vinand.Nantulya@TheGlobalFund.org
46. Oyieke, Helida	National Museums of Kenya, Nairobi	Kenya	oyiekeh@yahoo.com
47. Perera, Athula	University of Peradeniya	Sri Lanka	profaperera@sltnet.lk
48. Phiri, George SADC, Botswana	SADC	Botswana	george.phiri@iucn.org
49. Pieterse, Welma	Entomology, Plant Health Private Bag X5015 Stellenbosch 7599	South Africa	WelmaP@nda.agric.za
50. Prinsloo, Gerhard	Biosystematics Division, ARC Plant Prot. Res. Inst., ARC-Plant Protection Research Inst. Private Bag X134 Queenswood PRETORIA 0121	South Africa	PrinslooGL@arc.agric.za
51. Rakouth, Bakolimalala	Head of the Botany Dept. Science Faculty, BP 906 University of Antananarivo	Madagascar	ba.rakouth@simicro.mg
52. Rambau, R.V. (repr. Steven Chown,)	Dept. of Botany & Zoology Evolutionary Genomics Group Stellenbosch University Private Bag X1, Matieland 7602 Stellenbosch	South Africa	rvr2@sun.ac.za
53. Roux, Koos	SANBI Kirstenbosch Research Centre Private Bag X7, Claremont 7735 or Rhodes Drive, Newlands 7700	South Africa	roux@sanbi.org
54. Saka, V.W.	Bunda College of Agriculture/ NBSAP SAFRINET	Malawi	norma@malawi.net
55. Schindel, David	Executive Secretary, CBOL	USA	schindeld@si.edu
56. Scholes, Bob	CSIR Group Manager: Research & Development	South Africa	dwalwyn@csir.co.za
57. Seeboruth, Preeti	Principal Res. & Dev. Officer, Ministry of Agro Industry & Fisheries, Reduit	Mauritius	moa-pathology@mail.gov.mu and preetisheila@yahoo.com
58. Simiyu, Stella	BGCI/SCBD Programme Officer. Global Strategy for Plant Conservation. c/o IUCN Eastern Africa Regional Office, NAIROBI	Kenya	Stella.Simiyu@iucn.org
59. Singh, Yashica	SANBI, Durban	South Africa	Singh@sanbi.org

NAME	INSTITUTION	COUNTRY	E-MAIL
60. Sithole, Rudo	Director of the Natural History Museum of Zimbabwe P O Box 240 Bulawayo	Zimbabwe	rudosith2002@yahoo.co.uk
61. Smith, Gideon	Chief Director, SANBI, Pretoria	South Africa	smithg@sanbi.org
62. Smith, Richard	BIONET DIRECTORATE Director BIONET INT.	UK	r.smith@cabi.org
63. Solomon, Bamidele Ogbe	Director General of the National Biotechnology Development Agency, Arthur Unegbe Street (Former CAC Building), Area 11, Garki, Abuja	Nigeria	nabdamails@yahoo.co.uk
64. Swartz, Ernst	South African Institute Aquatic Biodiversity Private Bag 1015, Grahamstown 6140	South Africa	e.swartz@ru.ac.za
65. Theu, Matthew	Head, Plant Protection Services	Malawi	penjani@malawi.net
66. Tillier, Simon	Muséum national d'Histoire naturelle in Paris	France	tillier@mnhn.fr
67. Tjelele, Esiah	Dept. of Agric.	Lesotho	etjelele@yahoo.co.uk
68. Tolley, Krystal	Leslie Hill Molecular Systematics Lab SANBI, Kirstenbosch Research Centre, Rhodes Drive, Newlands (Private Bag X7, Claremont 7735) Cape Town	South Africa	tolley@sanbi.org
69. Tshivhandekano, Itani	Pest Risk Analysis, Nat. Dept. Agric., Pretoria	South Africa	ItaniT@nda.agric.za
70. Turner, Queen	Curator, Botswana Nat. park SAFRINET	Botswana	turnerq2003@yahoo.co.uk
71. Van der Bank, Michelle	University of Johannesburg	South Africa	mvdb@na.rau.ac.za
72. Van Wyk, Ben-Erik	University of Johannesburg	South Africa	bevw@na.rau.ac.za
73. Van Wyk, Braam	University of Pretoria	South Africa	avanwyk@scientia.up.ac.za
74. Venter, Jan-Hendrik	NDA, Pretoria SAFRINET	South Africa	janhendrikv@nda.agric.za
75. Villet, Martin	Dept. Zoology & Entomology, Rhodes University GRAHAMSTOWN 6140	South Africa	M.Villet@ru.ac.za
76. Yameogo Laurent		France	yameogol@oncho.oms.bf
77. Zuke, Stephen M.	Senior Environment Officer, Swaziland Environment Authority, P.O. Box 2652, Mbabane H100	Swaziland	seabiodiv@realnet.co.sz sea@realnet.co.sz

APPENDIX 4:

COUNTRY CAPACITY AND PRIORITY BARCODING PROJECTS

The following informal survey of national capacity to perform DNA barcoding, and possible national priorities for barcoding projects, was compiled by one of the breakout discussion groups.

South Africa

Capacity is good and the infrastructure/services is available in several universities, research institutions and national facilities:

- SA has national facilities mandated with work not only nationally, but also in SADC and the rest of Africa. SAIAB and the NZG are biological national facilities under the National Research Foundation (Department of Science and Technology) mandated with research in South Africa and the rest of Africa. SAIAB has the national fish collection and a tissue bank and have close links with Albany Museum (National Aquatic Invertebrate collection). NZG hosts SA Biobank that banks many different types of biomaterials (at this stage dominated by mammals and birds). SANBI (Department of Environment and Tourism) has a collaboration with Kew (UK) in terms of biobanking. These national facilities would be good regional nodes for southern Africa in terms of biomaterial banking and keeping databases of vouchers.
- Several Universities have their own research programs. For example the University of Pretoria's Department of Zoology does lots of mammal research (has a Mammal Research Institute as well). They voucher with Transvaal Museum. There is a centre of excellence at the University of Stellenbosch on Invasion Biology. University of Johannesburg work with SANBI on plants and does barcoding already. Several other universities and research groups not represented in our group have the capacity to sequence and voucher with museum nationally.
- There needs to be better collaboration between Universities, Museums and National facilities to co-ordinate databases and accessioning of vouchers.
- National facilities needs to make SADC aware of their mandate to assist the region in capacity building, tissue banking and long term preservation of voucher specimens
- South African Museums are under pressure and there is a need to build capacity
- Sequencing costs can be prohibitive (exchange rates and import costs). We can't buy directly from US suppliers?
- There is a problem to collect DNA samples from herbarium samples (not allowed). These policies need to be revisited. Possible differences in viewpoint between traditional taxonomists and molecular biologists, but the specific concerns needs to be investigated.

Priority barcoding projects:

- Fisheries to identify poaching
- Abalone, crayfish and poaching of other marine resources
- Medicinal plants
- Crop parasites
- Game trade
- Floral diversity
- Water quality – macro-invertebrates (River health program – a South African national initiative)

Madagascar

Capacity:

- University of Antanarivo has some capacity
- Museum voucher curation, but no tissue bank
- Well-trained molecular biology students but little infrastructure for them
- Permitting issues – have to link to Madagascar institute to do research and have to leave a voucher (plants)

Priority barcoding projects:

- Cites listed species (illegal trade)
- Medicinal plants (about 5000 potential plants)
- Water quality

- Agricultural pests
- Malaria (disease)

Swaziland

Capacity:
- Museum voucher curation, but no tissue bank
- PCR lab

Priority barcoding projects:
- Game trade
- Water quality
- Alien invasive organisms
- Medicinal plants

Burkina Faso

Capacity:
- National Research Centre
- Labs working on vectors and parasites
- Technicians have to be trained
- Lots of work on fish and macro-invertebrates, but no tissue bank

Priority barcoding projects:
- Identifying parasites, fish and macro-invertebrates
- Water quality

Malawi

Capacity:
- National herbarium, botanical garden
- Smaller collections that needs co-ordination
- Traditional insect collections
- Museum in fisheries (Lake Malawi), but no tissue bank

Priority barcoding projects:
- Biodiversity identification (to identify biological resources)
- Microbes
- Specific project on mushrooms
- Invasive aliens (aquatic and terrestrial plants)
- Game trade
- Red data species
- Fish biodiversity
- Agricultural pests
- Water quality

Zimbabwe

Capacity:
- Traditional museums
- Dried specimens
- Formalin fixed alcohol samples
- Staff have to be trained in new techniques

Priority barcoding projects:
- Biodiversity
- Water quality
- Biological control

APPENDIX 5: MEETING ORGANIZERS

Consortium for the Barcode of Life
The Consortium for the Barcode of Life (CBOL; see www.barcoding.si.edu) is an international initiative devoted to exploring and developing the potential of DNA barcoding to be a global standard for species identification. At the time of the Cape Town meeting, CBOL had more than 100 Member Organizations from more than 35 countries. The Secretariat Office of the Consortium is hosted by the National Museum of Natural History, Smithsonian Institution, Washington, DC. The Consortium and its Secretariat are supported by a grant from the Alfred P. Sloan Foundation of New York.

SANBI
The South African National Biodiversity Institute was established on 1 September 2004 through the signing into force of the National Environmental Management: Biodiversity Act 10 of 2004. The Act expanded the mandate of SANBI's forerunner, the National Botanical Institute, to include responsibilities relating to the full diversity of South Africa's fauna and flora, and built on the internationally respected programmes in conservation, research, education and visitor services developed over the past century by the National Botanical Institute.

SANBI is mandated to undertake research, maintain biodiversity collections, and supply related products and services that support the Institute's strategic objectives relating to the taxonomy, systematics, status, functioning, conservation and sustainable use of the exceptionally rich biodiversity of South Africa, and beyond. The results of the research efforts are precipitated into databases and other instruments that are used to inform sound decision-making in bioregional policy and planning.

SANBI also excels at growing, displaying and interpreting living collections of southern African plants in a network of National Botanical Gardens for horticultural, educational, scientific, conservation and recreational purposes. Through environmental education and outreach activities, the NBGs are used, among other things, to inspire and enable people in all walks of life to take responsibility for their environment.

SANBI has hosted and participated in a number of regional and continental African meetings of global taxonomic significance, and the recent CBOL meeting constructively expanded its earlier hosting of the first ever continental-level workshop on the Global Taxonomic Initiative (GTI) in 2001[6] and the World Flora Steering Committee meeting held in 1999[7].

BioNET-INTERNATIONAL and SAFRINET
BioNET is an international, not-for-profit, donor funded initiative that contributes to human well-being and conservation worldwide by building capacity to discover and name the world's living organisms. BioNET is comprised of affiliated partner institutes in over one hundred countries plus individual Members in over one hundred and fifty countries. Our work depends on effective partnerships both locally and with leading international technology and capacity development programmes. With a Secretariat hosted in the United Kingdom by CABI, our global programme is currently focused on supporting less industrialised countries, see www.bionet-intl.org.

SAFRINET, BioNET's southern African partnership, was formally established in 1996 as an official programme of the Southern African Development Community (SADC) by the SADC Council of Ministers. Coordinated regionally for SADC by the Plant Protection Research Institute, Pretoria, SAFRINET has since its inception provided training for BioNET Fellows from east Africa and given a number of training courses in taxonomic techniques, particularly for applied entomology, arachnology, mycology and nematology. Currently, SAFRINET's priorities are building capacity to support plant quarantine inspectors and implementation of the African Pollinator Initiative.

---

[6] KLOPPER, R.R., SMITH, G.F. & CHIKUNI, A.C. (eds) 2001. The Global Taxonomy Initiative: documenting the biodiversity of Africa. Proceedings of a Workshop held at Kirstenbosch National Botanical Garden, Cape Town, South Africa. (27 February –1 March 2001). *Strelitzia* 12: 1–203. National Botanical Institute, Pretoria.

[7] SMITH, G.F. 1999. Documenting plant diversity on a global scale: recent progress with the Species Plantarum: Flora of the world project. *South African Journal of Science* 95: 55-56.