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African Invertebrates in the International Year of Biodiversity

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The United Nations declared 2010 to be the International Year of Biodiversity to celebrate biodiversity, increase understanding about how biodiversity is critical for sustaining life on Earth, and to highlight the ongoing and increasing loss of biodiversity. The emphasis of this campaign is on people and biodiversity, and the monetary value of biodiversity in terms of goods and services, rather than the traditional focus on saving iconic threatened species and ecosystems. The change in emphasis away from species conservation may seem misdirected; we monitor biodiversity by tracking the number of species that have gone extinct and by the number of threatened species, species make up ecosystems, which provide people with services, and species are directly used by people. However, if we reflect on the progress made in terms of the commitments by governments at the World Summit on Sustainable Development in 2002 “to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth”, it is evident that the targets have not been met. Threatened species have become more threatened, natural habitats continue to decline, and the ecological footprint of humans exceeds that of the 2010 target. In addition, conservation and sustainable use are usually not integrated into national policies, and biodiversity is not considered when there are major plans for development. The driving factors of biodiversity loss have not been addressed. These were the main conclusions in The Global Biodiversity Outlook 3 document (Secretariat of the CBD 2010). The realisation in this report that “We can no longer see the continued loss of, and changes to, biodiversity as an issue separate from the core concerns of society: to tackle poverty, to improve the health, prosperity and security of our populations, and to deal with climate change” is a fundamental shift in the way that conservationists and scientists approach activities around biodiversity. Perhaps the International Year of Biodiversity also provides an opportunity for biologists, particularly taxonomists working on African invertebrates, to reflect on our contributions to biodiversity conservation and to consider real integration of the discipline into biodiversity conservation.

Invertebrates comprise the bulk of biodiversity at both biomass and species levels (1,359,367 or 72 % of all described species), and they play critical roles in the functioning of all ecosystems, so there is no doubt that invertebrates are a major component of biodiversity. They also remain a neglected component relative to the far less diverse chordates (64,788 species) and plants (297,857 species), with 75 % of the 18,000 new species described in 2007 being invertebrates and an estimated 5,396,465 invertebrate species still remaining to be described globally (Chapman 2009). In the IUCN Countdown 2010 scoping paper for the southern African subregion, the assessment of species diversity by taxon excludes estimates of species richness or threatened species for invertebrates, and this reflects the lack of awareness of the significance of invertebrates and also the paucity of accessible, co-ordinated information.

One of the major arguments used in promoting surveys, inventories and taxonomy is the need to know what species are present in an area before they can be conserved or used. Invertebrate taxonomists in Africa and international scientists working on the fauna of the region have for decades explored and documented the diversity through revisions and descriptions. Scientific journals such as *African Invertebrates* (formerly *Annals of the Natal Museum*) have a long history of consistently publishing this research. *African Invertebrates* provides taxonomists with an opportunity to broadcast their research both nationally and internationally. Its current Impact Factor (1.216) brings the journal to amongst the three most highly cited scientific periodicals in South Africa, showing that material published in *African Invertebrates* is in high demand. Each issue of the journal gives life to dozens of new scientific names, traditionally supplementing species descriptions with much-needed identification keys and often with an assessment of the conservation status of invertebrate taxa.

An important consideration is that highly specialist journals are not readily available to a wide range of society and are also generally inaccessible in terms of content and language. Consolidated and reconstituted data on African invertebrates are scarce, so the data generated by taxonomic research cannot be used directly for conservation, invalidating the rationale for the research. The UNEP (2010) document on the state of biodiversity in Africa gives the number of insects and arachnids for the continent as 100,000 species, which must be an enormous underestimate. However, we do not have a recent comprehensive estimate of invertebrate diversity in Africa, or even southern Africa, we have no idea how many species are described or synonymised each year, and we have no mechanism for sharing the classification or nomenclatural information we generate with those who are not in our specialist taxon field.

At a global level the Catalogue of Life (www.catalogueoflife.org) aims to compile and maintain a list of all species, but only 36,803 species are listed for Africa, and 12,098 for South Africa (2010 list). The Namibian Biodiversity Database (www.biodiversity.org.na) lists and provides basic information for all 10,470 invertebrate species recorded from Namibia, but this appears to be the only country for which this has been done.

The last comprehensive count of insect species for southern Africa was published by Scholtz and Chown (1995) but this was taken directly from Scholtz and Holm (1985), so the last multi-taxa count for insects (43,565 species) is now 25 years old. If other terrestrial invertebrates are added, this brings the total to about 50,000 species. In terms of marine invertebrates, Gibbons *et al.* (1999) provided a breakdown of South African faunal species richness, with invertebrates totalling 8,638 species.

A count of freshwater invertebrates, excluding the insects, mainly from the “Guide to the Freshwater Invertebrates of Southern Africa” series is 1,693 species. In total, the estimate available for southern South African invertebrates is therefore about 60,000 species, but we have to accept that this is outdated, and likely to be an underestimate. To put this value in perspective, Yeates *et al.* (2003) suggested that there are 253,000 terrestrial arthropod species in Australia, of which only about 25 % have been described. The estimated number of known insect species in Australia is 48,600 species, which is similar to that of southern Africa. Even if we have 50 % of our terrestrial arthropods still to describe in southern Africa, this is at least 50,000 species. (Expert estimates for different groups give the following figures of undescribed species in the Afrotropics: over 35 % for Diptera (Kirk-Spriggs & Stuckenberg 2009), 58 % for Formicidae (Robertson 2000), over 50 % for East African marine invertebrates (Griffiths 2005), and as much as 84 % for Ichneumonidae (van Noort 2010). A survey of spider diversity in Tanzania revealed that 80 % of species are still to be described (Sørensen *et al.* 2002).)

Taxonomists work furiously at describing southern African invertebrate species; however, even if a conservative estimate of 250 new species per annum are described this will have a minimal impact in terms of documenting biodiversity, and at least 200 years will be required to reach any finality in this task. However, if 25 of the species described are Red Listed, this will contribute to their conservation, as well as other species with similar distributions or habitats, and will play an important part in advocacy for invertebrate conservation (New 2009). If the ecological role of 10 of the species described can be identified and quantified, this will have a major impact for invertebrate and biodiversity conservation. If the revision of a higher taxon results in clarity about species, increased localities and refined distributions, and if these data are used for conservation planning, then there will be a biodiversity conservation impact of the taxonomic research. Thinking about how research outputs are used and how they link to conservation issues such as Red Listing and conservation planning, or to understanding ecosystem processes, is just as critical as carrying out the actual research.

Red Listing is a neglected activity, and a recent assessment of gaps unsurprisingly identified invertebrates as the most neglected taxon (Zamin *et al.* 2010). Large numbers of insect species have gone extinct or are highly likely to go extinct because of their narrow distribution or their relationship with other species that go extinct (Dunn 2005). Some of the arguments against Red List assessments for invertebrates are that there are insufficient data on distributions or populations to allow the use of the criteria (New 2009), or that Red Listing will only limit collecting by *bona fide* researchers and not assist in the protection of species. While the former argument may be valid in general, there are many taxa for which adequate data are available. Priority should be given to more conspicuous, better known taxa in terms of taxonomy or where there is at least some confidence that the distribution of the species has been reduced or is very limited in extent and falls within an area that is under threat. The second argument fails to recognise that conservation is one of the major motivations for allocating resources to taxonomic research and surveys, and that unless there are tangible outputs linked to conservation, this rationale will diminish in validity. In addition, Red Listing is the only globally recognised and credible mechanism for getting species conserved, and even the most obscure invertebrate species have the same weight as the largest mammal if they have the same formal threat status. Countries that are signatories to the

Convention on Biodiversity have to monitor Red Listed species, which means that invertebrate taxonomists can contribute directly to establishing national and international priorities.

In South Africa 492 species of invertebrates have been assessed according to the IUCN Red List criteria, including 250 insects (14 *Colophon*, 3 ant, 76 butterfly and 157 odonatan species), 29 crustacean, 31 diplopod, 97 cnidarian, 81 mollusc and four onychophoran species. Most of these assessments are outdated and no longer valid, apart from the Odonata, some of the molluscs and the diplopods. The butterflies have just been reassessed (Henning *et al.* 2009), but this has yet to be submitted to the IUCN. Overall, only a fraction of the potentially threatened invertebrate species has been assessed.

While South Africa has been recognised as one of the leading countries in terms of conservation planning (Balmford 2003), invertebrates have generally been excluded from these activities, which have focussed on plant and vertebrate species and vegetation types. The three global biodiversity hotspots recognised in South Africa exclude any quantification of invertebrate data, and the National Spatial Biodiversity Assessment (Driver *et al.* 2005) only included two superfamilies of butterflies, the Scarabaeinae and the scorpions since these were the only data sets that were useable. There is also a demand for baseline data for monitoring the impacts of various threats and conservation actions, and invertebrates are ideal for such monitoring. However, most invertebrate data are not useful for planning or monitoring because they do not allow comparison among areas at different spatial and temporal scales, do not provide some measure of inventory completeness (Kremen *et al.* 1993), do not cover enough of the region, and/or they are not accessible. Surveys are necessary to address such gaps (Rohr *et al.* 2007), but careful consideration needs to be given to the survey design. If conservation planning is used as a motivation to access funding for surveys and taxonomy, then the data should be useable for this purpose.

Quantified surveys for invertebrates are scarce, especially in Africa, probably because of the large amount of material collected, and the resources in terms of capacity and funds required to process the samples, coupled with the limited taxonomic expertise available to identify specimens. For example, 77 days of sampling in savanna in South Africa produced 49,961 individuals of 716 species and this was only for the 17 focus taxa (Lovell *et al.* 2010) and excludes most of the beetles, flies and wasps, i.e. the most diverse taxa. A survey of the same taxa at 55 sites in the Drakensberg region of South Africa provided 12,676 specimens of 832 species. However, in this study a large proportion of specimens could not be identified to species level because of a lack of knowledge or expertise to cover the family or order, or because some taxa are very poorly known. For example, the Curculionidae could not be identified below genus, most (85%) of the bombyliid flies could not be identified below genus, and the values for Tachinidae and Heteroptera were similar to this (unpublished data).

The taxonomic impediment has been one of the greatest obstacles contributing to invertebrates being sidelined from ecological and conservation projects. In many cases the specimens in ecological studies have been identified to morphospecies without a name for even the genus or family. Declining capacity for making invertebrate identifications, and the long time it takes to become an expert in a particular taxon, mean that there is little chance that the situation will ever improve. DNA barcoding offers

a major breakthrough in addressing these problems, and this approach will allow the development of a system for identifying species based on digital characters which will allow automated identification, using the large library of barcode sequences (Vernooy *et al.* 2010). This has enormous implications for invertebrate biologists involved in ecological studies, for carrying out surveys, and for identifying pests, disease vectors, alien invasive species and other species of relevance for society. While there has been debate about whether barcoding is accurate and whether it will deliver on its potential, the arguments appear to have diminished as the use of barcoding has increased. Janzen *et al.* (2009) found that of 100,000 specimens belonging to 3,500 species of moth, butterfly, tachinid fly and parasitoid wasp, less than 1% of the species could not be separated using barcoding. Barcoding will become an essential taxonomic tool and, rather than replacing taxonomists, will save time spent in species identification, while flagging specimens that are potentially new. Barcoding for various taxa is taking place in South Africa, and links with the International Barcode of Life project have been established, but it is important that the data generated are co-ordinated and made accessible in South Africa, and that the technology becomes widely available and is not trapped in the academic domain.

Material collected from surveys and for taxonomic research should ideally be housed in natural science collections. South Africa houses over 10 million animal samples or specimens in almost 70 collections across 22 institutions. The majority of the material comprises invertebrates, with the largest collections belonging to the Ditsong (formerly Transvaal), Iziko (South African) and Natal museums. Large quantities of material originating in Africa are also housed in European institutions. The challenges facing the South African collection institutions have been documented for at least 20 years (Drinkrow *et al.* 1994; Taylor & Hamer 2001), but this has not remedied the situation, and the challenges persist. The National Research Foundation (NRF) in collaboration with the South African National Biodiversity Institute (SANBI) carried out a detailed assessment of the collections in South Africa in 2009 and 2010. The report from this exercise is due in November 2010, and it will contain potential scenarios for the future of the collections. It must be recognised that the collections are mostly irreplaceable, and contain an enormous amount of information useful for a wide range of biodiversity-related questions. With an international focus on understanding climate change impacts and adaptation, and with technological developments relating to DNA, museum collections are being used innovatively to answer conservation-related questions (e.g. Crandall *et al.* 2009; Fišer *et al.* 2010; Lavoie & Campeau 2010; Major & Parsons 2010), which broadens the scientific value of the collections.

In addition to the specimens in natural science collections, the associated data potentially have a wide application if adequate access is provided. The Global Biodiversity Information Facility (GBIF) is responsible for co-ordinating and driving the mobilisation of collection data and serving this via the internet, through country nodes (e.g. SABIF, TANBIF). In South Africa, while 6.7 million records have been captured and made available (www.sabif.ac.za), over six million more animal specimens in collections are yet to be captured into databases. Databasing is, however, more complicated than simply capturing label information. In many cases outdated names and classifications are being used in databases, again providing a strong rationale for the compilation and maintenance of country or regional checklists. Digitization of specimens, labels,

field notes and catalogues is also a critical but neglected aspect of invertebrate data. SABIF offers grants totalling R1.5 million per annum for collection digitisation, and SANBI hosts an annual Biodiversity Information Management Forum that provides capacity development and networking opportunities.

Through SABIF, SANBI is co-ordinating checklists for all animal species, with basic classifications and information on species authors, synonyms, endemism and threat status. These will be made available via the SANBI website in the near future, and will be updated regularly, allowing tracking of diversity as well as access to valid taxonomic information, and the identification of knowledge gaps. The checklists will be provided to the Catalogue of Life (COL). This initiative will obviously require the collaboration of taxonomists, particularly in the case of invertebrate taxa for which lists do not exist. The ultimate aim of the SANBI checklists is for them to expand into species pages, linked to the Encyclopedia of Life (EOL) (www.eol.org), which aims to provide a web-page for all species on Earth, with information on biology, distribution, taxonomy and classification, as well as access to scanned publications through the Biodiversity Heritage Library or SABINET African Journal Archive. The information is relevant to a broad range of society, including scientists, consultants and the general public. Providing electronic identification keys and tools is an additional aim of the EOL. By 2010 EOL had compiled nearly one million pages with at least a link to primary literature, and 400,000 pages with at least text or an image.

Two invertebrate projects in South Africa have highlighted how the initiatives and research discussed here can be integrated to provide meaningful outputs for conservation and science. The South African Butterfly Conservation Assessment (SABCA) (<http://sabca.adu.org.za>), and the South African National Survey of Arachnida (SANSA) (www.arc.agric.za/home.asp) included teams across institutions to survey targeted areas identified from existing data, using quantified or standardised methods, databasing existing collections (50,000 arachnid and 300,000 butterfly records captured or compiled), making these data accessible through SABIF, and taxonomic studies, which have resulted in 130 new arachnid species being described (Young 2010). Both projects include conservation assessments of species. The approach taken for these projects illustrate that enormous advances can be made in a relatively short time, with limited budgets, and can produce a variety of outputs, including scientific publications. For both butterflies and arachnids, barcoding is being explored to expand the projects, and to expedite identifications in the case of the arachnids. Additional benefits have been the development of networks for collaboration, the involvement of young scientists, postgraduates and the public through on-line virtual museums, and in the case of SABCA, through partnership and collaboration with the Lepidopterists' Society of Southern Africa.

While these initiatives are changing the face of taxonomy, they in no way replace the need for fundamental taxonomic research, nor do they provide resources for this research. In South Africa, as a consequence of lobbying by the taxonomic community, the national Department of Science & Technology provided ring-fenced funding to the value of over R25 million over a five-year period for research and capacity development in taxonomy through the South African Biosystematics Initiative (SABI). This funding has improved the possibilities for carrying out research for some scientists, and has provided comparatively generous postgraduate bursaries. However, it has by no means

substantially improved the status of invertebrate taxonomy in South Africa. The number of professionals employed in the field continues to decline, postgraduate students are still difficult to attract, and there is no evidence of any major increase in knowledge output. This illustrates that the problems are greater than straightforward access to funding. It is worth reflecting on the approaches of the SABCA and SANSA projects to identify what does produce tangible change (Young 2010). Global initiatives like IBOL, EOL, COL and GBIF are visionary ways of co-ordinating and making widely accessible the data generated by taxonomists and required by a multitude of knowledge seekers, but they depend on the participation of taxonomists. The United Nations has recognised the need to embed biodiversity issues within society and politics, and perhaps invertebrate taxonomists need to follow suit.

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