SYSTEMATIC THEORY AND PRACTICE APPLIED TO AVIAN RESEARCH AND COLLECTIONS AT SOUTH AFRICAN AND NAMIBIAN MUSEUMS

by

A Kemp, R Earlé, J Mendelsohn, C Vernon, T Harris, J Komen and A Berrutti

Transvaal Museum, P O Box 413, Pretoria 0001; National Museum, Bloemfontein; State Museum, Windhoek, Namibia; East London Museum; and Natural History Museum, Durban
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ABSTRACT

This paper is the consensus of all ornithologists in permanent posts at museums in South Africa and Namibia. Our concept of what constitutes systematics has been published elsewhere (Crowe *et al.* 1989). The points we consider most important are:

1. That systematics is the area of research most relevant to ornithologists working at natural history museums and should be the principal determinant of how avian collections are developed.

2. That this perspective affects what is collected and how it is stored, including voucher specimens, and indicates how collection development has not kept abreast of modern requirements for systematics.

3. That avian systematics now requires development of consolidated research collections, centres of expertise and shared expertise for its proper execution.

SAMEVATTING

Hierdie referaat lewer verslag van die eenstemmigheid bereik deur al die ornitoloë in permanente poste by museums in Suid-Afrika en Namibië. Ons siening van wat sistematiek uitmaak is elders gepubliseer (Crowe *et al.* 1989). Ons beskou die volgende as allerbelangrik:

1. Sistematiek is die terrein van narvorsing mees van toepassing op ornitoloë werksaam by natuurhistoriese museums en dit behoort die rigtingwyser te wees vir die ontwikkeling van voëlversamelings.

2. Hierdie perspektief raak dit wat versamel word en hoe dit bewaar word, bewyseksemplare ingeslote, en toon hoe versamelingsontwikkeling nie tred gehou het met hedendaagse veresites vir sistematiek nie.

3. Voëlsistematiek vereis nou die ontwikkeling van verenigde navorsingversamelings, sentrums van kundigheid en gedeelde kundigheid vir behoorlike verrigting.

INTRODUCTION

The authors of this paper comprise the full complement of ornithologists in permanent posts at museums in South Africa and Namibia. The paper had its genesis when one of the authors (RE) requested our views on the role and future of our research and collections. Such remarkable consensus emerged that we considered it worth recording. The two senior authors also joined colleagues at universities to consider what constitutes modern systematic research, what role it plays in contemporary biology and how it might best be developed in southern Africa (Crowe *et al.* 1989). That paper has three conclusions relevant to the present paper:

A That systematics, the scientific study of the biological diversity comprising evolutionary trees, is the only biological science to study the historical component of organisms. This component, which is a logical consequence of evolution through modification by descent, demands a singular approach in the way in which it is conducted (Wiley 1981; Gould 1986);

B That systematics has four main goals: i) to describe the components of this diversity (species, subspecies and their taxonomy), ii) to discover the phylogenetic relationships between these components (systematics *sensu stricto*), iii) to summarize these relationships in classifications, and iv) to relate the patterns discovered to processes invoked in evolutionary theory;

C That systematics is a science in its own right, the basis for comparative biology and biogeography with important applications in conservation of biotic diversity, and that it is not just a service operation for other biologists (O'Hara *et al.* 1988).

The effect of these conclusions on how avian material is collected, stored and accessed, for the most effective undertaking of avian systematics, is the subject of this paper. Avian systematics is also more advanced than for most other classes of animals in recognition of species units, less so in analysis of phylogenies. This puts it at the forefront of many problems in and applications of systematics which may provide guidelines useful to all systematists.

SYSTEMATICS AND RESEARCH COLLECTIONS

Systematics in practice

The initial exploration of nature involved random collection of organisms, followed by their description and naming based on the Linnaean system of nomenclature. From this emerged the concept of a type specimen, the preserved remains of the organism chosen for the first description of a new species, and this established the necessity of maintaining permanent collections of natural history specimens. This type specimen had to be available for re-examination to assess whether another organism belonged

to the same or a different species. Later, series of specimens were collected from the type locality, to assess individual variation within the species, and this extended to series recording the extent of individual variation over the whole range of the species and formed the scientific basis for modern comparative research collections.

We consider that there are two main components to the modern practice of systematics. The first is descriptive (alpha taxonomy), detailing the extent of variation between organisms and the limits to species units. The second component attempts to unravel the relationships between species (beta taxonomy), and between the higher clades to which groups of species are allocated (gamma taxonomy). Only the second component comprises systematics useful for estimating the historical component of comparative biology. Each component requires the same basic data - as many characters, for as many organisms, from as wide a geographical area as possible - although the analyses used and data accentuated are different in each case. The variance in and distribution of characters across organisms are used to describe the attributes and limits of species. Characters identified as homologous are then used for comparisons between species to assess their relationships.

Neither component of systematics is ever complete, as organisms belonging to new species are discovered, as larger samples of organisms become available for study, or as new techniques of collection, preparation and analysis extend the characters available. Active systematics research requires repeated reassessment of species limits and revisions of monophyletic groups (revisions of revisions are not "visions"! — Stulp 1988), coming ever closer to understanding the limits of species and their unique pathways of evolution by descent.

What to collect

We consider that data required for systematics research is the primary determinant of what is relevant in museum collections, deciding when, what, how and where collections are to be established, maintained and extended. Comparative research collections must attempt, therefore, to store as many characters, for as many organisms, from as wide a geographical area as possible.

Traditional methods of preparation were a compromise between what was necessary for specific identification and what was practical for collection and storage. Such a compromise continues in all natural history collections, but we stress that characters chosen for systematic decisions must never be constrained by traditional practice or whether they are amenable to collection and storage. They must be chosen for how well they determine species limits and relationships. Later one can attempt to integrate findings from ephemeral or obscure characters with others more amenable to measurement, collection, permanent storage and application in descriptive taxonomy and identification.

Voucher specimens

Our perspective also influences what should be considered as voucher specimens, those samples placed in permanent storage to check the identity of any study animal. Storage of only those parts of the animal preserved by traditional techniques will be pointless if species limits are decided later by novel or refined techniques. We suggest that voucher specimens, above all others, should include as wide a range of characters as possible. For birds, this might include the whole carcass rather than just the dry skin, magnetic recordings of softpart colours, calls and displays, smears of blood, vials of tissues, nests, eggs, embryos and details of habitat.

Reference versus research collections

We also suggest a distinction between reference collections, where the specimen serves only as an example of its species, and research collections, where each specimen is of individual significance (Heppell 1979). Universities, conservation agencies and public sections of museums all retain examples of the fauna which they use for education and reference, but such specimens are replaceable. Research collections also fulfill this role but their main purpose is to include as large a sample of specimens of each species, from as wide a geographical area and preserving as many attributes as possible. This distinction, and the special charter of research museums to preserve such material for perpetuity, make comparative research collections of particular national importance that must be appreciated when deciding where to place research material.

New research collections

One of our primary contentions is that avian systematics has almost exhausted the sets of characters and series of specimens in traditional museum collections. We consider extension of research collections to store new characters and adoption of new techniques to extend the characters available as the major challenges we face.

Many new characters under consideration relate to molecular biology, genetics, behaviour and physiology but require field investigation for integration with energetics, nutrition and demography. Such documentation helps to decide character polarities, separates ecophenotypic from genetic effects, and records ephemeral characters. Comparison of related species also means that research extends over the whole range of the clade under study and may take some time to complete. The need for field work is greatest where new collection types are being established or traditional collections no longer resolve systematic problems. This has led to the impression, in some quarters, that museum-based ornithologists have deserted systematics and are no longer involved in collection-based research. We contend rather that we have broadened our concept of collections to make them once again relevant to the requirements of modern avian systematics.

WHY MORE AVIAN SYSTEMATICS?

Concern for systematics

There is concern, both in South Africa and abroad, about biological systematics, including that of birds, and about the future of research at natural history museums (Wilson 1985; Ricklefs 1986; Hadlington 1988; Williams 1988; Crowe *et al.* 1989). This concern stems from the inability to document the diversity of life before many species become extinct, lack of exposure of students and the public to biodiversity, and diminution of the role of museums in systematics.

The state of avian systematics

One may ask why we support more avian systematics when the subject is so advanced and there are several avian systematists in southern Africa? Whole classes and orders of animals have no students of their systematics in southern Africa and in many of these the number of species exceeds birds by orders of magnitude. We contend that only the descriptive component of avian systematics, the recognition and description of species, is well-advanced and even here new species are described at a slow but steady rate as problem groups or poorly-explored areas are examined in more detail.

The second component, assessing relationships between species, is much less advanced (Frost 1981). Application of cladistic analysis to limited sets of characters for restricted groups of species has been and is being applied at an increasing tempo. Molecular techniques, such as DNA-DNA hybridization, have been applied to most families and major genera of birds, and both approaches have resulted in revised classifications and taxonomies (Cracraft 1981; Sibley *et al.* 1988; Sibley and Ahlquist, in press: Sibley and Monroe, in press). Much remains to be done in testing these new arrangements of species using alternative sets of characters, extending these analyses to detailed relationships within southern African genera, and applying these new insights to comparative biology and biogeography.

Insights from avian systematics

Only once the historical component of character distributions is established can comparative biology distinguish homology from convergence. The insights that this would offer to comparative biology and evolutionary theory are considerable and birds, provided the second component of their systematics continues to develop, seem the group closest to this major advance.

Developments in avian systematics may also guide systematists of less-studied groups. More systematists are being requested to complete collection and description of all the species on Earth, an unattainable goal given the highly qualified manpower sought. However, the descriptive component of systematics may be possible with technicians. Primitive man, birdwatchers and collection managers are capable of identifying most species and often recognize new species as readily as professional systematists. If technikons offered training in collection and recognition of species then their students, under guidance of professional systematists, could fill in the specific names in the Linnean binomial nomenclature. Professional systematists might then grapple with the more demanding task of analysing phylogenies, assigning generic names and placing genera in their correct position among higher taxa.

ORNITHOLOGISTS AND COLLECTIONS AT SOUTH AFRICAN AND NAMIBIAN MUSEUMS

The present situation

Some 80% of vertebrate systematists in southern Africa are based at museums (M N Bruton, pers. comm.) and there are seven permanent research posts for ornithologists at museums in Pretoria, Bloemfontein, Durban, East London, and Windhoek, a post for mammalogy and ornithology at Kimberley, and honorary curatorial positions at Cape Town and Grahamstown. These museums ought to be at the forefront in providing comparative research material and undertaking systematics research on the approximately 850 bird species recorded from South Africa and Namibia — no less than 9% of the world's avifauna. There are also at least four ornithologists undertaking systematics research at universities in southern Africa, two at museums in neighbouring countries, and two operating privately.

Details are provided of the avian collections, researchers and collection managers at South African and Namibian museums (Table 1) and of the avian collections at the Transvaal Museum, the most diverse and extensive in South Africa (Table 2). It is obvious that the collections are neither comprehensive nor extensive and this imposes an immediate limitation on what research can be conducted. The research and curatorial staff are each expert on particular groups, geographical areas and techniques, but are limited in numbers, lack of formal training, and of facilities for training new personnel.

Who is responsible for collections?

No official body makes specific provision for development of collections. The Department of National Education (DNE), Cape Provincial Administration and Durban Municipality provide funds for salaries, maintenance of existing collections and some research by personnel under their jurisdiction. The Foundation for Research Development (FRD) provides research funds to ornithologists in South Africa who qualify for support. No organization provides funds specifically for the development of national collections, although some of the above funds may lead indirectly to improvement and expansion of collections. This is considered a serious limitation since improvement of existing collections or development of new collections incurs expenses which do not lead immediately to the research results that qualify for either increased subsidies (DNE) or additional research support (FRD).

Table 1. Avian reference collections at museums in South Africa and Namibia.

Collection Types	Museums							
	TM	DNHM	ELM	SAM	SM	NM	AM	MGM
Literature	x	x	x	x	x	x	x	x
Study skins	x	x	x	x	x	x	x	x
Eggs	x	x	x	x	x	x	x	x
Skeletons	x	x	x	x	x	x		x
Fossils	x			x		x		
Carcasses (wet or freeze-dried)	x	x			x	x	x	
Nests	x			x	x		x	
Embryos	x				x			
Historical records	x				x		x	
Distributional data	x			x	x	x	x	x
Calls/sonograms	x				x			
Film of displays	x				x			
Ecological data (eg stomach contents, gonads, fat status)	x	x	x		x	x		x
Moult/nest records	x		x		x	x	x	x
Tissues*	x				x	x		x
Parasites*	x				x	x		
Total holdings x 1000	96	36	17	16	8	5	4,5	2,4
Professional staff	2	1	1	0**	1	2	0**	0,5
Technical staff	3	1	0	1	1	2	0,5	0,5

TM = Transvaal Museum, Pretoria; DNHM = Durban Natural History Museum; NM = National Museum, Bloemfontein; ELM = East London Museum; SAM = South African Museum, Cape Town; SM = State Museum, Windhoek, Namibia; AM = Albany Museum, Grahamstown; MGM = McGregor Museum, Kimberley.

* some museums currently collect these materials but others send them abroad

** these museums do not have permanent curators but each has an honorary curator

Table 2. Approximate holdings of avian material at the Transvaal Museum, to illustrate coverage of some 850 species recorded for South Africa and Namibia. Some specimens of extralimital species are also retained for comparative purposes.

Collection type	Number of items stored	Number of species represented	Average/ species
Literature	extensive	?	
Study skins	50 000	1 000	50
Eggs	4 000	600	7
Skeletons	2 500	400	6
Fossils	1 000	?	
Carcasses	2 500	400	6
Nests	200	120	3
Embryos	50	50	1
Historical records	extensive	?	
Distributional data	extensive	?	
Calls	30 000	3 000	10
Sonograms	2 000	500	4
Displays	5 000	700	7
Ecological data	extensive	?	
Moult/nest records*			
Tissues*			
Parasites*			

* currently these materials are collected but sent to other institutions for storage and study.

Will collections appreciate in value?

Extensive and diverse collections stimulate active research programmes by their presence alone. Therefore, active collection programmes by museums, rather than just relying on what cats or cars drag in, would stimulate research. Good collections often serve additional purposes in the future unrelated to systematics, such as in reconstructing histories of pesticide use, allowing molecular studies of extinct or rare animals, and supporting aesthetic, educational or conservation applications. Collections will also become irreplaceable as libraries of natural history research material, given the decline of many species and increasing moral objection to killing animals.

Reconciling collecting with conservation

We wish to address the relationship between conservation and museum collecting since the latter could be viewed in a negative light as it often involves killing of animals for specimens. We are particularly aware of this issue since birds, more than most other groups, enjoy the sympathies of numerous conservation, preservation and protectionist organisations and individuals. The main step we have taken is to have museum collecting acknowledged by at least some conservation agencies as a form of low-intensity harvesting, effected through annual quotas determined by these agencies. We also have the stated objective of making maximum use of any material collected, and in addition we make every effort to obtain specimens killed for other reasons, as by accident, or in the course of other research or during management operations. These actions all save us from having to kill unnecessarily for specimens. Furthermore, many of our new collection types, such as tapes of calls and behaviour, blood smears, moult examinations, tissue collection and ecological observations, are non-destructive.

What systematics offers to conservation

The positive side is that the material and information collected for systematics research has wide application in conservation (Rautenbach, in press). Surveys have resulted in atlases of bird distribution in which museum personnel have played a major role (Earlé and Grobler 1987; Tarboton *et al.* 1987), and these provide the basic data on how widely and commonly each species occurs. Reference works on bird biology, starting with *The Birds of South Africa* by museum ornithologist Austin Roberts in 1940, have been produced by or have relied heavily on museum-based information and expertise. The broad set of characters now necessary for modern avian systematics, much of it derived from field studies documenting the basic biology of species, provides much of the basic information necessary (e.g. Kemp and Kemp 1980; Vernon 1984; Earlé 1987) or allows useful predictions (e.g. Kemp 1989; Harris *et al.*, in press) for sound conservation management.

IMPROVING MUSEUM-BASED AVIAN SYSTEMATICS AND COLLECTIONS

The suggestions we offer for improving avian systematics at museums in South Africa and Namibia are intended to be realistic, constructive and ordered by our assessment of priorities.

1. To develop collections and appoint researchers in fields neglected in southern Africa. Palaeo-ornithology and avian anatomy, parasitology, molecular systematics and genetics are obvious candidates (Frost 1981), with basic interest in and collections for the first three subjects already at the South African, Transvaal and National Museums respectively. Efforts to undertake molecular systematics and avian genetics are being explored by several museums through collaboration with specialists and systematists at universities, in particular the Percy FitzPatrick Institute for African Ornithology at the University of Cape Town.

2. To improve utility of collections by a common policy. This includes a common policy for documentation, preparation and storage of material, achieved by compiling lists of material available locally and of southern African material abroad, and by centralization of different collection types at museums that specialise in their particular care and study. This suggestion supports efforts already underway by the Southern African Museums Association and the DNE, and is in accord with the recommendation of the Council for Zoological Nomenclature that lists of type specimens be produced by museums. It is aimed at consolidating research collections and is not intended to deprive any museum of its reference collections: indeed most reference collections could be enhanced with surplus material from the main research collections, provided the national series for a species was sufficient. Several comprehensive reference collections would also provide some protection against the risk inherent in grouping most material into a national research collection at a centre of expertise.

3. To expand existing collections and start new types of collections. These developments would be based on gaps identified above and in world lists of sound, anatomical, oological and skeletal material (Chappuis 1986; Wood and Jenkinson 1984; Kiff and Hough 1985; Wood and Schnell 1986).

4. To explore possibilities to train systematists and technicians. This would include training in the special research fields outlined above and, for technicians, in collection expansion, management and identification services.

CONCLUSIONS

We consider that avian systematics has a leading role to play in a new era of comparative biology, and that museum-based avian systematists are well placed to contribute to this development. Efforts of systematists should not be dissipated into species description, collection management, faunal surveys and identification services, which can be undertaken by technical personnel under their supervision. Systematics research and the collections at our museums have an important contribution to make to biology which, if realised, can prevent the setbacks

that have afflicted natural history museums abroad.

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