Bonner zoologische Beiträge	Band 51 (2002)	Heft 2/3	Seiten 91-96	Bonn, September 2003

Bird Collections and Biodiversity – The Scientific Contribution of Natural History Museums

Renate van den Elzen

Alexander Koenig Research Institute and Museum of Zoology, Bonn

Abstract. Biodiversity research explores, describes and names all organic life. Collection specimens, especially name-bearing types, are vouchers that document biodiversity as diversity of species. Collection series archive variability of and between species as information on diversity of life and its change in time and geographic space. It is reflected in any collection-based research on phylogenetic, morphological, evolutionary, biogeographical or historical topics. Natural history museums are networking to communicate and give access to their holdings and the information contained therein.

Key words. Scientific and political value of collections, diversity of species, diversity of life, Convention on Biological Diversity (CBD).

Information contained within biological collections is a key resource for countries fulfilling their obligations under the Convention on Biological Diversity (CBD) and other significant environment conventions. With the DARWIN DECLARATION (Environment Australia 1998) scientists worldwide agreed upon the value, importance and significance of biological collections as... *„records of genetic and morphological variation, past and recent geographical distribution and other biological information. Often they are the only remaining material of extinct species or the only record of species seen only once in the wild.*" Also the tasks, aims and obligations of institutions such as museums and universities housing biological collections are clearly defined therein: Collections (and all associated data) have to be documented, properly stored and freely accessible.

1. TAXONOMIC BIODIVERSITY

Approaching biodiversity includes two concepts: the first concentrates on the **taxic diversity of species**, also reflecting their phylogenetic relationships, while the second concept focuses on the **biological diversity of species** including their ecological adaptations and, respectively, the evolutionary history of a phenotype or any higher taxon. Regarding the first concept the primal task for any biodiversity research would be the „classical museum approach", which is to explore, describe, name and analyze all organic life inhabiting our planet. Thus the necessity of type catalogues and -databases was one major topic within the symposium followed by a discussion on how to realize a virtual European type catalogue in the near future.

The awareness of the importance of type specimens and their professional storing is also reflected in the new edition of the International Code of Zoological Nomenclature (ICZN 1999). The last edition adds a new article 72.10 entitled „Value of name-bearing types" giving a clear and precise statement that *„.....Holotypes, syntypes, lectotypes and neotypes are bearers of the scientific names of all nominal species-group taxa (and indirectly of all animal taxa). They are international standards of reference that provide objectivity in zoological nomenclature and must be cared for as such (see Recommendations 72D to 72F). They are to be held in trust for science by persons responsible for their safe keeping."* Captions 16C, 72 D-F of the ICZN recommend the deposition of types as international vouchers in museum collections or institutions and advise on naming and labelling of specimens to provide both accurate diagnosis and access to associated data. The ICZN emphasizes as well that information on name-bearing types is communicated to any party of the scientific community.

2. COLLECTIONS AND NATURE CONSERVATION

About one half of all extant bird species had already been described as early as 1843 (Peters 2000). Nowadays, the discovery of bird species new to science is rather exceptional (about 1-5 per annum), several of them just being previously overlooked sibling species which anyway had already been present in museum's collections prior their new description (e.g. *Glaucidium sp.*, Heidrich et al. 1995). Nevertheless, some of the newly discovered species are restricted range species, and thus often endangered or even threatened by extinction.

The latter was the case regarding the (Somalian) Bulo Burti Boubou *Laniarius liberatus* Smith et al. 1991. That species was described after a single specimen, captured alive, caged and studied for some time and

released back into the wild. The species diagnosis is based (for the first time) only on some moulted feathers, DNA, voice recordings and photographs with no preserved voucher specimen. Some important additions to the description of the species were added by Prinzinger et al. (1997).

This new way of taxon description without a voucher specimen has lead to some debate on standards in species descriptions, deposition (or not) of voucher specimens (LeCroy & Vuilleumier 1992), scientific collecting and conservation (Hustler 1996; Collar 1999, 2000; Stiles 1995).

While the nature conversation movement acknowledged this new approach as a step in the right direction (ISEE 1992), systematists and museum curators observed this trend shift away from keeping the type specimen more critically.

Their concern is that only specimens allow an objective examination of the taxon, that names have to be aligned to „real objects", that can easily be checked to provide detailed and accurate diagnosis, as well as a voucher (LeCroy & Vuilleumier 1992).

Molecular data are a welcome addition to the study of (co-)evolution of the phenotype and genotype.

Moreover, systematic collections worldwide are aging rapidly (Winker 1996) and some regional avifaunas are, if at all, inadequately represented in collections (Peterson 1998).

Stiles (1995) reconciles both parties by emphasizing... *that conservationists and birdwatchers have a major stake in the maintenance of museum bird collections, and are among the prime users of the results of museum-based research on taxonomy and distribution of birds. While new sources of data (molecular genetics, behavior, etc.) can often indicate where taxonomic changes might be desirable, the changes themselves must be made with respect to museum specimens, to provide both accurate diagnosis and type specimens for new and redefined taxa. The species, however defined, remains the focal unit for most conservation programmes. Changes in species-level taxonomy can affect our interpretations of patterns of biodiversity and endemism, and so directly influence conservation priorities and the allocation of funding.* Collar (1999) discusses the necessity of a stronger collaboration of amateurs and scientists towards bird collecting: ...*Ornithology still desperately needs the museum tradition, in all its manifestations, alive and well in all continents. To this end, I am convinced, that the most modern of birdwatchers and the most ancient of museums can find important common ground for taking forward taxonomic studies related to species limits and distribution studies.*

3. BIOLOGICAL DIVERSITY

Museum specimens can be applied for the understanding of the diversity of life - the variation and variability of and between species or populations observed and described and the underlying mechanism of evolution causing these changes. Furthermore, collection series also archive variability of and between species i.e. information on the diversity of life and its changes over time and geographic space. For example, most phylogenetical, ecological and behavioural interpretations are observed on the grounds of phenotypic or morphological variation, leading to an interpretation of the origin of species. The understanding of current distribution pattern and avi-biogeography is another important topic of collection based research.

Discussion on speciation and subsequently on different species concepts had already commenced on the basis of bird collections in the 18th century, culminating in the Biological Species Concept, which has been advocated by Ernst Mayr (1942,1992) since then. Also the alternative concept, Joel Cracraft's Phylogenetic Species Concept (1983), is based on observations in bird phylogenies.

The importance of specimens in collections as vouchers for the documention of biodiversity is still increasing; in ornithology particularly outweighing their importance for recording solely the pure taxic diversity. What can we learn from bird collections especially for the understanding of biodiversity? One can use data associated with specimens such as collecting localities and dates, but also information given by the specimen itself. Morphological studies allow hypothesis on special adaptations to the environment (Björklund & Merilä 1993; Björklund 1994; Gamauf et al. 1998; Leisler & Winkler 1985, 2002; Leisler et al. 1989, 1997; Potapova & Panov 1977), each study being objectively provable, and repeatable at any time.

Furthermore, the role of function as an important key factor in avian morphology was recognized relatively early (Bock 1959, 1963, 1965; Bock & Gans 1965; Bock & von Wahlert 1965).

The on-going process of co-evolution of form and function adapts functional complexes within each body plan (Wagner & Altenberg 1996) correlating morphological structures to accomplish common biological roles (Nemeschkal & van den Elzen 1990; Nemeschkal et al. 1992; Nemeschkal & van den Elzen 1994). Some of these morphological structures can even be traced back to their genetic origin, the genes for developmental control (Nemeschkal 1999). These genes, in turn, constitute the main modules in the architecture of bird design (Björklund 1991, 1993, 1994; Wagner & Altenberg 1996) .

Morphological characters which have been evaluated by phylogenetic methods allow statements not only on phylogenetic relationships between species but also their phylogeography and evolutionary history. Quoting all references published on this topic would exceed the scope of this article. In an ideal case, that may be implemented as a standard of any future bird collecting, blood or tissue samples as well as study skins from extant species are taken into consideration for the study of the evolutionary and phylogenetic history of any organism. A one to one alignment allows a simultaneous comparison of the variation of molecular and morphological characters of certain species, populations and even single individuals. One can also assess the distribution of characters within gradients of populations and geographical areas.

Bird collections also can offer access to even extinct species. Samples of ancient DNA can be taken from collection specimens. Non-destructive methods are now available (MUNDY et al. 1997) and are in use for rare or extinct species (e.g. PAYNE, this issue). HADDRATH & BAKER (2000), for instance, combined in an analysis the complete genom of mitochondrial DNA of two extinct moas from New Zealand with five extant ratites as well as two tinamous to solve the contradictory dispute on the phylogenetic relations and biogeographical distribution pattern of ratites. Only by including these extinct species, have the authors achieved proof that most of the major ratite lineages fit the hypothesis of vicariance biogeography.

Avian museum's skins from remote areas and rare taxa documenting collecting localities and dates have often been (HALL & MOREAU 1970; SNOW 1978) and still are (HERREMANS et al. 2002; PETERSON et al. 1998, 2002) the only available source for reconstruction of bird distribution patterns, and thus are very valuable tools for nature conservation issues. Hotspots of biodiversity and endemic bird areas are often identified using museum-stored data (e.g. HERREMANS et al. 2002; PETERSON et al. 1998, 2002). Once only seen as a side track of systematic or taxonomical studies, this data can be used for historical maps of bird distribution.

STILES (1995) gave the following statement: ... *A specimen also provides evidence of the occurrence of a particular species at a particular place. Without this, one cannot prove the subsequent disappearance of the species, which is critical in many conservation and biodiversity assessments. Museum collections are like books in a library: they can be used again and again for different studies, or re-examined in the light of new data or different studies, or re-examined in the light of new data or different criteria.*

Plotting any historical collecting localities on maps allows easy identification and verification of historical habitats and documents possible habitat destruction. Historic changes in the British avifauna have been documented using i.a. this approach (HOLLOWAY & GIBBONS 1996).

4. PERSPECTIVES

Data from a single ornithological collection may not always be sufficient enough for achieving these new research goals (PETERSON & NAVARRO-SIGÜENZA, this issue). However, it may be realized by co-operational networks between collections sharing collection data. Older collections might be valuated higher for reaching further back in time, giving a better general picture on pattern changes of bird distribution (FRAHNERT 2001).

The future and survival of (not only) bird collections will be up to those institutions that participate in documentation of change in biodiversity (like BIOLOG), biodiversity documentation in third world countries (like the historical bird atlas of Congo that is prepared at the Royal Museum for Central Africa, Tervuren), or Global Networks like the Species Analyst, GBIF-International, ETI, IABIN, TDWG, CETAF or MAB of UNESCO and GEF.

The Global Biodiversity Information Facility (GBIF), for instance, aims at making the world's biodiversity data freely and universally available. GBIF works cooperatively together with several other international organizations dealing with biodiversity. These include the Clearing House Mechanism and the Global Taxonomic Initiative of the Convention on Biological Diversity. The term Clearing House Mechanism refers to any organisation that brings together seekers and providers of goods, services or information, thus matching demand with supply. For this reason, the Convention on Biodiversity (CBD) has established a „clearing-house mechanism" to ensure that all governments have access to the information and technologies they need for their work on biodiversity. A German node of GBIF International e.g. was established to document type specimens of plants and animals. A catalogue of bird types held in German museums and research institutions is in progress. Several European Museums are participating on other GBIF topics.

The very first step towards a network of collection databases at a European level is simply the acquirement of the knowledge on museum holdings and collection inventories. Therefore, scientists of several institutions have been invited to present information on the bird collections in their care drawn upon historical studies on certain collections (this issue). A valuable and most welcome general contribution to our knowledge on bird collections is the recently published inventory of major European bird collections (ROSELAAR 2003).

The wide acceptance of the first symposium and the international efforts sketched above are indications that the scientific community has recently adopted a more positive attitude towards taxonomical expertise, historical aspects of ornithology and phylogenetic research.

Articles on these topics published in the Journal für Ornithologie, the official organ of the German Ornithologists' Society (DO-G), have been summarized since WWII (Fig. 1; shown in pentades). One can observe well that, after a period of stagnation between 1970 and 1990, the number of articles on avian systematics and phylogeny has slowly increased. The „record" height of historical and taxonomic articles in 2000 is due to the 150th anniversary of DO-G, when ornithological research traditions received special attention.

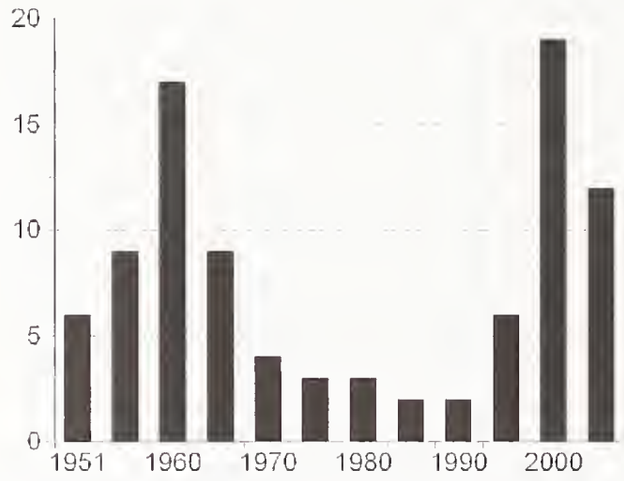

Fig. 1: The amount of papers on systematics, taxonomy and phylogeny published in Journal of Ornithology shown in pentades.

Not only have new molecular methods led to a new interest in species limits and phylogenetic research, but also the worldwide loss of biodiversity at both geographic and taxonomic levels has found a political response, reflected in increased funding for biodiversity programmes over the last decade. Besides...*birdwatchers, ornithologists and bird conservation organizations*... (Herkenrath 2002)... also institutions housing scientific bird collections play an important part in this respect (Collar 2003).

LITERATURE

Björklund, M. (1991): Patterns of morphological variation among Cardueline finches (Fringillidae: Carduelinae). Biol. J. Linn. Soc. **43**: 239-248.

Björklund, M. (1993): Phenotypic variation of growth trajectories in finches. Evolution **47**: 1506-1514.

Björklund, M. (1994): Processes generating macroevolutionary patterns of morphological variation in birds: a simulation study. J. evol. Biol. **7**: 727-742.

Björklund, M. & Merilä, J. (1993): Morphological differentiation in *Carduelis* finches: Adaptive vs. constraint models. J. evol. Biol. **6**: 359-373.

Bock, W. (1959): Preadaptation and multiple evolutionary pathways. Evolution **13**:194-211

Bock, W. (1963): The role of preadaptation and adaptation in the evolution of higher levels of organization. Proc. XVI Internat. Cong. Zool. **3**:297-300.

Bock, W. (1965): The role of adaptive mechanisms in the origin of higher levels of organization. Syst. Zool. **14**: 272-287.

Bock, W. & Gans, C. (1965): The functional significance of muscle architecture – a theoretical analysis. Ergebnisse der Anatomie **38**:115-142.

Bock, W. & Wahlert, G. von (1965): Adaptation and the form-function complex. Evolution **19**:269-299.

Collar, N. J. (1999): New species, high standards and the case of *Laniarius liberatus*. Ibis **141**: 358-367.

Collar, N. J. (2000): Opinion. Collecting and conservation: cause and effect. Bird Cons. Intern. **10**: 1-15.

Cracraft, J. (1983): Species concepts and speciation analysis. Current Ornithol. **1**: 159-187.

Environment Australia (1998): The Darwin Declaration, Australian Biological Resources Study. Canberra, Environment Australia.

Frahnert, S. (2001): Databasing in ornithologischen Sammlungen als Grundlage für Studien zu Veränderungen von Biodiversität. J. Ornithol. **142**, Sonderheft 1: 191.

Gamauf, A., Preleuthner, M. & Winkler, H. (1998): Philippine birds of prey: interrelations among habitat, morphology, and behavior. Auk **115** (3): 713-726.

Haddrath, O. & Baker, A. J. (2000): Complete mitochondrial genome sequences of extinct birds: ratite phylogenetics and vicariance biogeography hypothesis. Proc. Royal Soc. London, Biological Sciences: 939-945.

Hale, B. P. & Moreau, R. E. (1970): An atlas of speciation in African passerine birds. London: Trustees Brit. Mus. (Nat. Hist).

Heidrich, P., König, C. & Wink, M. (1995): Bioacoustics, Taxonomy and Molecular Systematics in American Pygmy Owls (Strigidae: *Glaucidium* spp.) (in German). Stuttgarter Beitr. Naturk. Ser. A. Nr. **534**. Staatl. Mus. Naturk. Stuttgart.

Herkenrath, P. (2002): Opinion. Birds and the Convention on Biological Diversity: can ornithologists and bird conservationists make a difference? Bird Conserv. Intern. **12**: 99-106.

Herremans, M., Louette, M. & Meirte, D. (2002): The importance of historical bird collections for in-situ conservation in the Albertine Rift of Africa. 23rd Internat. Ornithol. Congr. Abstract volume. Beijing.

Holloway, S. & Gibbons, D.W. (1996): The Historical Atlas of Breeding Birds in Britain and Ireland: 1875-1900. London: Poyser

ICZN (1999): International Code of Zoological Nomenclature. 4th edition. London: International Trust for Zoological Nomenclature.

ISEE (1992): Issues. Newsletter **4,4.**

Lecroy, M. & Vuilleumier, F. (1992): Guidelines for the description of new species in ornithology. Bull.Brit. Ornithol.Club **112A** (Suppl):191-198.

Leisler, B. & Winkler, H. (1985): Ecomorphology. Current Ornithol. **2**: 155-186.

Leisler, B. & Winkler, H. (2002): Morphological conse-

quences of migration in passerines. In: Avian migration. Berthold, P., E. Gwinner & E. Sonnenschein (eds.) Berlin, Heidelberg: Springer-Verlag. p. 175-186.

Leisler, B., Winkler, H. & Siebenrock, K.-H. (1997): Ecomorphological analysis with Weaverbirds (Ploceidae) and Kingfishers (Alcedinidae)(in German). Mitt. Zool. Mus. Berl. **73**, Suppl.: Ann. Orn. **21**: 17-43.

Leisler, B., Ley, H.-W. & Winkler, H. (1989): Habitat, behaviour and morphology of *Acrocephalus* warblers: an integrated analysis. Ornis Scand. **20**: 181-186.

Nemeschkal, H. L. (1999): Morphometric correlation patterns of adult birds (Fringillidae: Passeriformes and Columbiformes) mirror the expression of developmental control genes. Evolution **53**: 899-918.

Nemeschkal, H. L. & Elzen, R. van den (1990): Funktionskreise im Skelettsystem der Cardueliden. – Ein morphometrischer Ansatz. In: Current Topics in Avian Biology (van den Elzen *et al.*, eds.) Proc. Int. 100. DO-G Meeting, Bonn, 1988, 37-41.

Nemeschkal, H. L. & Elzen, R. van den (1994): Macrosystematics and infraspecific character coupling – an analysis of morphological integration in avain skeletons. Zool. Jb. Syst. **121**: 265-302.

Nemeschkal, H. L., Elzen, R. van den & Brieschke, H. (1992): The morphometric extraction of character complexes accomplishing common biological roles: avian skeletons as a case study. J. zool. Syst. Evolut. Research **30**: 201-219.

Peters, D. S. (2000): The situation of avian systematics – progress and immanent obstacles (in German). - J. Ornithol. **141**: 263-274.

Peterson, A. T., Navarro-Sigüenza, A. G. & Benítez-Díaz, H. (1998): The need for continued scientific collecting: A geographic analysis of Mexican bird specimens. Ibis **140**: 288-294.

Peterson, A. T., Ball, L. G. & Cohoon, K. C. (2002): Predicting distributions of tropical birds. Ibis **144** (Electronic edition): E27–E32.

Potapova, E. G. & Panov, E. N. (1977): Structural patterns of jaw apparatus in wheatears of the genus *Oenanthe*, with special reference to the ways of decrease of food competition between closely related species. (in Russian). Zool. Zh. **56(5)**: 743-752.

Prinzinger, R., Becker, P. Kleim, J. P., Schroth, W. & Schierwater, B. (1997): Der taxonomische Status von *Laniarius dubiosus* (Rchw., 1899) mit ergänzenden Daten zur Typusbeschreibung von *Laniarius liberatus*, Bulo Burti Boubou (Smith, Arctander, Fjeldsa & Amir 1991). J. Ornithol. **138**: 283-289.

Roselaar, C.S. (2003): An inventory of major European bird collections. In: Why museums matter: Avian archives in an age of extinction (Collar, N. J., Fisher, C. T. & C. J,. Feare, eds.). Bull. Brit.Ornithol.Club **123A**: 253–337.

Snow, D. (1978): An atlas of speciation in African non-passerine birds. London: Trustees Brit. Mus (Nat. Hist.).

Smith, E. F. G., Arctander, P., Fjeldså, J. & Amir, O. G. (1991): A new species of shrike (Laniidae: *Laniarius*) from Somalia, verified by DNA sequence data from the only know individual. Ibis **133**: 227-235.

Stiles, G. (1995): Museums and bird conservation. World Birdwatch **17,3**: 24.

Wagner, G. P. & Altenberg, L. (1996): Perspective: complex adaptations and the evolution of evolvability. Evolution **50**: 967-976.

Dr. R. van den Elzen, Alexander Koenig Research Institute and Museum of Zoology, Adenauerallee 160, 53113 Bonn, Germany