

DISCUSSION PAPER

The Smithsonian Institution: The life of natural history museum specimens

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Introduction

The natural history museums of the world are a mixed bag – from small, local, organizations dedicated to single taxa to global reference collections. However, the vast majority of them pursue basic science research on taxonomy and systematics: understanding the variety and variability of life. Perhaps no group of organizations or researchers has been more impacted by the access and benefit-sharing discussions (ABS) under the Convention on Biological Diversity (CBD). Movement of specimens across borders is an important aspect of access. It is fundamental in taxonomy (the describing and naming taxa) and systematics (studying the evolutionary relationships between species).

The museums of the world have collaborated for centuries – sharing collections, loaning specimens for research and education, and collaborating in the field and the laboratory. The ABS process has seriously undermined these fundamental and necessary collaborations by making it difficult to impossible to collect or legally move new or existing specimens.

We hope this short paper will explain how basic research collections organizations work, and why ABS regulations should be modified to facilitate taxonomic, systematics and ecological research. Burdensome, regulatory systems impose costs that far exceed the benefits, and even more importantly, transfer those costs to the provider or/and organizations least able to bear them. Systems that do not recognize how basic science works reduces the efficiency of these scientists who the leaders of the world have acknowledged as being too few already.

Demystifying the use of Specimens and Collections

The ABS discussions enable the nations of the world to negotiate rules and processes that protect their rights to fair and equitable sharing of benefits from the utilization of genetic resources. However, a narrow focus on the admittedly important area of disclosure of origin for patent applications and subsequent commercialization of genetic resources has inadvertently created a simplified and simplistic model of specimen use.

First, this simplistic model regards all collecting as commercially oriented. Second, it assumes a short lag time between collecting, research, extraction, product development, and patenting of that specimen. While this model may fit a small amount of collecting targeted explicitly at bioprospecting, it does not fit basic taxonomic and systematic research, nor most ecological research or monitoring. It also does not reflect much of the plant and animal breeding research, but this topic will not be addressed in this paper.

Natural History Collections – the real world model

Scientists unanimously agree that most of the species of the world are not as yet described and named. Basic discovery, analysis, and naming of the biota is the core work of natural science collections organizations (not all are museums, but we use the generic term museums to cover them all). The first step in this research is to access, e.g. find, discover, or locate unknown biodiversity in situ. Historically, collectors gathered and preserved many specimens in the field. Field trip costs (financial, personnel, logistical) were sufficiently high that scientists collected as much as they could, knowing that some specimens would be studied only decades later. Indeed the majority of baseline information on most of the world's biota and ecoregions resulted from subsequent study of these "latent" collections.

Increased ease of international travel and heightened sensitivities to large collecting trips, has made scientists in many specialties calculate carefully just how many specimens are necessary to answer the questions at hand, be it taxonomic, systematic or ecological. Therefore, researchers nowadays seek to limit the numbers of specimens collected. The minimal collection size necessary for taxonomic research varies widely with taxonomic group. For lesser known groups such as invertebrates, relatively more specimens are required to solve taxonomic problems; for well-known groups such as mammals or birds, only one or a few specimens may effectively answer the question posed.

Why are many specimens required? Why is one specimen generally not enough? Just as all humans do not look alike, there is variation among individuals in other species. No matter how similar, two specimens always differ in some characteristics (morphological, physiological or genetic) and those differences do sometimes denote distinct species. The only way to tell if such differences are species or population-level variation is to examine a sufficiently long series of specimens from throughout the species range. For example, ideally, the series should reflect variation in males, females and juveniles. The series enables full description of intraspecific variability and precise differentiation of closely related species. Such work is crucial to prevent misidentifications and to discriminate cryptic, sibling, or semi-species properly.

Such comparisons require loans from other museums. For example, a potentially new butterfly species from Brazil will probably be identifiable to family and genus based on existing literature. Furthermore, the literature may document a very similar butterfly species known only from Peru and Costa Rica and may also indicate which collections may house those specimens. The Brazilian specimen must be directly compared with to the Peruvian and Costa Rican specimens to resolve its status. To obtain them, a scientist must either visit those museums or request a loan. Loans are obviously far more cost effective and efficient than visits and thus the free movement of specimens between taxonomists is crucial to the continued existence of this science. Many of the ABS rules either do not make allowances for such exchanges or impose increased costs and uncertainties on the borrowing or loaning of specimens for study. Each potentially new species encountered during fieldwork requires such comparisons, thus necessitating further loans and borrows. On average, the Smithsonian requests around 327,000 loans from other collections, and sends about 170,000 loans to colleagues in over 100 countries annually. If taxonomy is going to continue within its existing budget and maintain productivity, a mechanism for material exchange that is clear, expeditious, and cheap, is absolutely essential.

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Smithsonian loan forms are clear: the loans are only for non-commercial research. As ABS discussions evolve, we continuously examine our procedures to make certain that we conform to the terms and conditions of specimen movement and transfer and we continue to modify forms and procedures as necessary. Transaction costs of specimen movement must however be minimized. Some current proposals would require constant approval from country of origin/source/legal provenance for transactions; such regulations on purely taxonomic transactions are time consuming and costly in terms of paper work and human resources and should be avoided whenever possible. Clearly, heightened scrutiny, mutually agreeable terms from the country of origin/source/legal provenance, and clear mandates are fully appropriate when material is requested for commercially oriented research and/or extraction of new chemicals or metabolites.

A real life example

We will use Dr. Terry Erwin's (1993) research in Ecuador as an example. Dr. Erwin is well known for his systematic and ecological research. His research has multiple goals, but his collecting methodology is designed to answer ecological questions regarding rain forest species diversity. Subsequently the same specimens are used in finer-grained taxonomic and systematic research.

His basic research on beetles has already multiplied by a factor of 20 accepted estimates of global species diversity. By fogging the canopies of many tropical tree species with a biodegradable insecticide mist and analyzing the fallen specimens, he documented a vastly greater number of new species than anyone had ever expected. From the canopy of a single species of tree Erwin found more than 1,100 species of beetles. Given the specificity of beetle species on trees, and the number of tropical tree species, he extrapolated to conclude a global insect species diversity of 30 million.

In 1993, Dr. Erwin conducted 1,800 fogging events in tropical forests in Ecuador, obtaining approximately 9 million specimens. These specimens continue to be used today for ongoing and new taxonomic and biodiversity research. The project trained Ecuadorian students to sort specimens to Class and Order and when possible to family and genus. All specimens were placed in jars containing "restriction" labels that refer to the mutually agreed terms (MAT) between the Smithsonian and Ecuador. These restriction labels accompany every loan of these specimens to scientists all around the world obligating those receiving the material to the conditions of the MAT.

The Smithsonian returns 20 identified species per family to the Ecuadorian Politécnico University Museum in order to build their collection. Although Smithsonian is agreeable to sending more specimens to Ecuador, space and personnel capacities at the University limit the number of specimens that can be stored and maintained there. The remainder stay at the Smithsonian or are transferred to other natural history collections to improve global reference collections. Nevertheless, the original terms and conditions accompany all specimens.

These scientists, usually world authorities on particular families or genera, further sort and identify the collection, often sending subsets of the original collection to even more specialized experts. Specimens are kept by experts for several years and eventually (often many years later), the material is returned to the Smithsonian. In taxonomy, identifications are done free of charge and frequently the only remuneration for the scientist is that they are allowed to keep 2-3 specimens (when possible) for their collections.

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Proposed ABS rules would force museums to archive and review correspondence to reconstruct how many scientists in which countries examined the specimens; the costs of such work will far outweigh the benefits. In the case of Dr. Erwin's Ecuadorian collections, specimens went to 20 scientists in 17 organizations/universities/museums in 4 countries over the last 21 years (Ecuador, Mexico, USA and Canada). Many, however, are still being processed as new research projects are started or new experts appear on the scientific scene. Indeed, the loaning and borrowing of these specimens will continue essentially forever as long as museums are willing to keep and provide maintenance to these collections. Archival storage of the material is essential to guarantee the value of these research specimens for future generations.

Finally, it may be decades or centuries before someone collects in that particular locality again, if ever. Given current trends, the habitat may be greatly altered before anyone can return. The original, serendipitous collection then becomes the only available baseline data for that area to understand human-induced and natural changes.

The Importance of Natural History Collections

As discussed above, the natural history museum "collecting model" is nearly the opposite of the bioprospecting model. Basic questions in taxonomy, systematics, and ecology drive the collecting. One of the many ironies of contemporary biodiversity science and politics, is that due to the low funding for basic science around the world, museum scientists sometimes have to look for funding from sources that have other interests – such as commercially oriented enterprises. These field trips need heightened scrutiny and the work on the materials that is commercially oriented needs to be done under clearly negotiated terms of benefit-sharing. This has been done successfully, such as in the ICBG work. We know of no researcher who cannot differentiate between the commercially oriented and the basic science applications that the material may be subjected to. If there were increased funding for taxonomy, these scientists would not need to be put into this mixed, and frequently volatile, position. Collections are seen as resources for the future. Museums preserve collections in perpetuity, legally and lovingly, and from past experience we know that they will be used for analyses that we cannot now even envisage. Museum collections are constantly re-examined as new techniques and technologies of analysis develop. Museum collections continue, and will continue, to reveal more and new information about nature and its processes.

Material transfer agreements should therefore recognize that museum collections are multi-purpose. These purposes include documentation of existence, taxonomy, systematics, natural history (life cycle, habits, habitats, specialized structures, evolution, etc), ecology, and, yes, bioprospecting and commercialization. However, the latter two are very minor elements in museum research and can be carefully delimited by rules consistent with CBD principles while still allowing the bulk of museum research and transactions to continue.

The Obligations of Negotiators

It is essential that CBD negotiators understand how taxonomy is done by whom, where, and why and keep this in mind during their discussions. Museums are generally non-profit enterprises; taxonomy *per se* generally generates no revenue. Increased transaction or accounting costs in taxonomic research, whether from demands for non-monetary benefits (training, equipment, etc) or from additional paperwork and permits, cannot be passed on to

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consumers as they can by bioprospecting companies. These costs come out of a relatively small, and if anything, decreasing resource pool. The net effect is that less taxonomic research gets done, the "taxonomic impediment" burgeons, and sub-optimal natural resource management decisions are made, money is wasted due to misidentification, and opportunities are lost. Taxonomy is basic to all research, conservation, and bio-industry; correct taxonomy benefits everyone. All developed countries and their museums have recognized the need for the sharing of non-monetary benefits, and indeed practiced this type of benefit-sharing well before the CBD occurred and increasingly after its ratification. Major world museums are completely committed to training and institution building. To maximize taxonomic and training benefits, we believe transaction costs should be minimized.

The solution is a dual track system: expedited transactions for basic science (regardless of its funding source) and heightened scrutiny and increased obligations for applied and commercially oriented research. A generic material transfer agreement (MTA) that allows for free movement of specimens for basic research is imperative for the survival of museums and non-commercial research.

The Obligations of Museums

Natural history organizations do need to be more proactive in revising their internal regulations and practices to make them clear, transparent, and consistent with CBD principles. The Royal Botanical Gardens at Kew spearheaded such a process for the botanical community, as did others for zoological and microbial communities, but best practices should be summarized and disseminated widely. Within North America, the Natural Science Collections Alliance has begun the process, and in Europe the Consortium of European Taxonomic Facilities (CETAF) is an appropriate vehicle. These and other appropriate organizations should collaborate and coordinate closely to move forward this program.

The Obligations of National Implementers

The importance of prior informed consent (PIC) or mutually agreed terms (MAT) is not in dispute. However, the implementation of these concepts at the national level has not always been practical, easy or consistent. As an institution that transacts with most countries in the world, the Smithsonian must navigate the rules and regulations of each of these countries. PIC and MAT transverse multiple parts of every government's administration. These concepts minimally include research permits, collecting permits, export, and import permits. In most countries, different offices, even different Ministries, have the responsibilities for some or all of these permissions. Research on lands managed by local and indigenous communities, or based upon their biodiversity knowledge can require additional agreements (not formal permits, *per se*). It is naive and simplistic to believe that the different concepts and implementation of rules underpinning PIC and MAT can be delegated to a single authority in most countries.

A clear, transparent, low-cost process to obtain appropriate permits and to transact specimens in basic science research is required. Since the vast majority of collecting and specimen shipment is for basic research, most permits, certificates, and/or other documents apply to non-profit uses. Tracking these events falls to government agencies on the one hand, and museums and research centres on the other. Commercial organizations will ever only manage a small fraction of events. The costs of compliance will fall on those least able to

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afford it – governments of Megadiverse countries and non-profit museums and research organizations.

Closing the Circle

Most new collecting of biological specimens today serves the basic sciences of taxonomy, systematics, natural history and ecology. Paradoxically, most of the discussion in the international community focuses on the small percentage intended or used for commercialization. This fundamental incongruity needs to be addressed as negotiations continue.

Each of the key players has roles and responsibilities to improve transparency and appropriateness in international regime. Understanding biodiversity, developing the fundamental information to support conservation, sustainable use, and equitably shared commercial benefits are all based on the non-sexy, non-profitable, yet fundamentally important basic sciences of taxonomy, systematics, natural history and ecology.

Perhaps we need to develop a principle of Taxonomists Rights, similar to Farmers Rights in the International Treaty on Plant Genetic Resources. Recognizing that taxonomy is based on principles and practice of access and exchange rather than exclusivity, the CBD could go far in addressing the current bottleneck on taxonomic research and begin to free up capacity to overcome the taxonomic impediment, if the COP clearly reiterated its advice to Parties that access for taxonomy, systematics, natural history and ecology is needed for the success of the Convention.