**SCIENTIFIC COLLECTING: WHY? HOW MANY?**

Scientists use the term “scientific collecting” to mean permanent removal of individual birds from the wild. That is, scientific collecting entails the capture and sacrifice of a living bird to address myriad scientific questions. The specimens —preserved corporal parts and associated data —are retained, managed, and conserved permanently in scientific collections.

Bird specimens have been used to answer questions that few would have anticipated when the specimens were collected. For example, environmental change and its effects on bird populations have been detected from museum specimens. Seabird specimens collected over 14 years yielded the only evidence of increased consumption of plastic pollutants (Moser and Lee 1992) and later provided critical support for restriction of offshore oil extraction (Lee and Socci 1989). Bird specimens have also been instrumental in forecasting conservation implications of climate change for biodiversity (Gardner et al. 2009).

Museum specimens collected over a span of 100 years showed that body size of four passerine species decreased over time, causing a seven degree shift in a latitudinal cline over a period of 60 years. By studying feathers on the specimens to rule out nutritional causes, the researchers determined that the differences were most likely due to global warming. The specimens studied were taken decades ago for an entirely distinct purpose. Were it not for collection and careful preservation of specimens, this information would not be available (Remsen 1995).

Winker et al. (2010) offers a comprehensive review of the importance, effects, and ethics of scientific collecting. Scientific collecting is a method of obtaining scientific information. Some questions can be answered with observation, some require some kind of manipulation, and others...
require capture. Other questions can be answered with blood, feather, or tissue samples. An entire range of questions require the collection of an entire bird.

Scientific collections document the world’s biodiversity. Each animal collected serves as a voucher for the existence of that species in its place and time, providing scientifically rigorous documentation that can be reexamined visually, structurally, or biochemically for centuries into the future. Each specimen also holds staggering amounts of information in the tissues of its body. Information about the ecological placement (what an individual is eating and what is eating it), reproductive status, migratory routes, exposure to pollutants, demographic patterns, genetic distinctiveness, and much more is represented in the various tissues and organs of an individual, and can be used to infer important facts about whole species. These data can address ecological or evolutionary questions, many of which are critical to species conservation.

For instance, provenance and genetic data taken from 238 museum specimens collected from 1879 through 1935 document that the range expansion of Greater Prairie Chickens (Tympanuchus cupido) did not result from human alteration of habitat (Ross et al. 2006). Conservation policy and practice often exclude populations or regions that are thought to exist due only to human activity, such as the deliberate introduction of non-native species. On this basis, legal protection and recovery efforts for the species excluded populations on the northern prairies of the United States and the central plains of Canada. The specimen-based analysis showed that the supposed cause of range expansion was not feasible and that the historical range of the species in fact included these areas. Recognition of the species severe decline (and extirpation in Canada as of 1987) and conservation efforts began about five decades after the specimens used in this study were collected.

Scientists may not know at any given moment what is important to study. Some of the most important questions involve how organisms change over time. Preserving information over time through scientific collecting allows us to increase knowledge today and to answer the unanticipated questions of the future.

Scientific collecting generally entails collection of a wide range of species throughout the species’ ranges and of enough individuals to permit scientifically valid inferences. Typically, the collector will not know in advance of the expedition exactly what species will be collected; it is, to some extent, a matter of chance. Some species that are sought-after may not be found,
whereas others not anticipated may be encountered. It is difficult, therefore, for the ornithologist to identify all species and the numbers to be collected when submitting a protocol for approval.

This may pose a dilemma for Institutional Animal Care and Use Committees, which often ask the researcher to state in the protocol how many individuals of each species will be collected. As it impossible to make this determination in advance, the best answer is to state that collecting will not exceed permit limits.

Below we discuss the application of the “3Rs” to scientific collecting. This central principle of animal welfare calls for reduction, replacement, and refinement. Reduction and replacement are discussed below; refinement entails the use of methods that alleviate or minimize potential pain and distress and enhance animal well-being, and is less applicable to scientific collecting.

**HOW MANY IS ENOUGH? (REDUCTION)**

Some studies that entail scientific collecting focus on specific, immediate questions. In these cases, the study design determines the number of individuals of each species to be collected. An adequate sample is the minimal number of specimens necessary to ensure investigative and statistical validity. The sample size required for a study depends on the nature of the investigation and the extent of variation in the parameters being studied. Field studies often require larger samples than do laboratory studies, because field investigators have less control over the conditions that produce variation. The precise number of individuals required for statistical inference can be difficult to predict at the outset of a study because the extent of natural variation may not be known.

Many studies requiring specimens are studies of variation per se, and thus require large sample sizes. For example, empirical results demonstrate that at least 20 and preferably 30 individuals per locality would be appropriate for accurate estimation of population genetic parameters in microsatellite studies that assess genetic diversity when working in a population that has an unknown level of diversity (Pruett and Winker 2008). In general, large data sets allow a wider variety of scientific questions to be addressed and therefore have a greater ability to aid conservation and management decisions and address unanticipated future questions. Even in the case of focused studies, however, the ornithologist, who may have devoted considerable time and resources to travel to a field site, and to obtain permits, may choose to collect other birds while in the field to maximize the contribution of the scientific effort.

Some assume that because museums already hold very large numbers of specimens, no
additional collecting is necessary or warranted, or question the need to collect the number of species or number of individuals typical of a general collecting effort. In fact, as detailed below, museum holdings are inadequate in myriad ways. Furthermore, the growth of museum specimen holdings is a by-product and not the purpose of scientific collecting. Recognizing that because it is impossible to predict what questions will be asked about any particular species, it becomes evident that collecting as many species as possible is not only justified, but necessary to document populations and archive materials for future studies of environmental change. For instance, if a species that is common today suffers a sudden decline 30 years from now, the specimens collected decades earlier, across place and time, can be used to determine when problems started, where, and what form they took (pollutants in body, new parasite introduced, genetic variation within populations, demographic shift such that suddenly young animals became rare, reduction in number of individuals migrating from a given breeding site, etc.).

Comparisons can be made to other populations of the same species, or other species collected at the same sites. A classic case of this principle in action was the use of nearly 1800 eggs accumulated over 100 years of collecting from 39 different museum collections to document sudden changes in eggshell thickness as a result of the accumulation of DDT in the bodies of fish-eating birds. This scientific finding resulted in the end of the use of DDT in the U.S.

A common misperception is that scientific collections worldwide hold ample representations of the world’s avifauna, so additional scientific collecting is not needed. This notion belies misunderstandings both of the scientific uses of specimens and the composition and condition of existing collections.

**Underrepresented species:** Representation of some species in collections is simply not adequate. The avifaunas of many geographical areas remain poorly documented by specimens. Peterson et al. (1998) examined data pertaining to 221,757 specimens from 26 museum collections, among them the four largest collections in the world and largest collection in Mexico. This sample represented an estimated 70% of all bird specimens from Mexico. The origin of the specimens was mapped, leading to the determination that most regions were severely unrepresented in museum collections, even for the best-sampled species. Basic taxonomic information for many species is still not adequately represented in museum collections in the form of representatives of males, females, immatures, juveniles, basic and alternative plumages, and geographic and individual variation.

**Insufficient number of individuals:** It is often mistakenly believed that museums specimens serve only to document identifications, so if a scientific collection holds a specimen of a given species, no additional collecting would be warranted. It is true that a single specimen, known as a holotype, documents the first, or formal, description of a species. However, even to identify species, single specimens are vastly insufficient. Frequently, species or subspecies are distinguishable only via careful comparison of series of individuals, to be able to account for individual variation. In addition, at times, what might seem to be a distinct species proves to be an aberrant individual or different color morph of the same species. Birds are often sexually
dimorphic, underscoring the need for a full specimen to document phenotype. Many species, especially the migratory species, have two or three different plumages as adults across the year. Juvenile plumage can differ dramatically from adult plumages. This within-species variation increases the numbers of individuals needed to answer particular questions. Therefore, documenting basic information about that species, such as differences between sexes, seasonal variation, developmental stages, and geographic variation all depend on series of specimens to document individual variation, which itself is frequently considerable.

**Availability to researchers:** Access for all is critical for maintaining a worldwide network of knowledgeable professionals. For existing specimens to serve the purpose of education and guiding identification, they must be available at least regionally. Frequently, species are represented in a single or very few institutions, impeding efforts to make use of those specimens. International movement of specimens and associated materials is becoming increasingly difficult and costly due to permit restrictions and biosecurity concerns.

**Inadequate information:** Existing specimen resources are also inadequate in terms of information content. The vast majority of bird specimens were collected prior to 1960, which means that they are not completely adequate from a number of perspectives. Older specimens often consist only of the skin and feathers and bear minimal data documenting provenance. Retention of soft tissue, stomach contents, and related material developed as the standard practice in most major museums approximately 30 years ago; some museums still preserve and retain only the skin and part of the skeleton. Anatomical material, tissue samples, soft-part coloration, ecological notes, and precise locality references are frequently lacking.

Given that most specimens are older, sample sizes of recent, data-rich specimens are quite inadequate, and certainly not sufficient for every (or even most) species on Earth. Stoeckle and Winker (2009) found that of the world’s 9,933 avian species, fully 2,705 (27%) were undocumented in tissue collections in the 32 institutions surveyed.

**Age of collections:** Species and populations are changing constantly, so series need to be continually updated to be maximally informative. Even if the world’s collections held complete series of males, females, different age classes in sufficient numbers to document variation, the dimensions of time and place require continual reassessment. Species, populations, and their environments are continually changing, so continual collection is necessary. Winker (2004) examined the date range represented in bird collections. He found that they “suffer from temporal inadequacy, poorly representing the present, especially in developed regions” including the United States, the United Kingdom, and Canada. This situation may make these collections less useful for answering questions about changes in avian biodiversity and the environment causes of those changes.

*Ornithological Council Fact Sheet: Scientific Collecting (revised 2020)*
GENETIC MATERIAL, PHOTOGRAPHS, AND RECORDINGS (REPLACEMENT)

For formal taxonomic descriptions, the role of scientific specimens is nothing short of fundamental. Some consider blood samples and photographs adequate replacements for physical specimens. This view presumes that the primary or sole purpose use of a specimen is identification. That is simply not true.

Recent years have seen descriptions of small numbers of new bird taxa based on photographic evidence, gene sequences, living individuals, or feathers taken from “catch and release” studies (Smith et al. 1991, Sangster and Rozendaal 2004, Athreya 2006). Each of these cases provoked strong statements by the community of scholars and curators whose expertise is in systematics and who consider specimen evidence as sine qua non for formal documentation of bird taxa (LeCroy and Vuilleumier 1992, Bates et al. 2004).

The International Commission on Zoological Nomenclature recommends strongly that taxon descriptions be based on specimens (Wakeham-Dawson et al. 2002, Polaskek et al. 2005). Most of these descriptions met the requirements of the International Commission on Zoological Nomenclature; the babbler description was based, in part, on collected feathers and Athreya planned to obtain a full specimen if census work indicated a larger population than was known at the time of the capture of the individual upon which the description was published (Athreya 2006). In the case of the Bulo Burti Bush Shrike (*Laniarius liberatus*; Smith et al. 1991), genetic analysis led to the determination that the individual upon which the description had been based was in fact a color morph of another species (Nguembock et al. 2008). It is also worth noting that none of these descriptions could have been made without comparison to the dozens of specimens collected over many decades.

Even for identification purposes, photos and genetic material are insufficient. The scientific community considers a physical specimen the best evidence and documentation of biological material. Specimens provide a definitive picture of the individual organism, in terms of its genotype, phenotype, and context. Genetic samples without a full specimen provide only a genotype, which lacks key information such as the phenotypical characteristics that form the basis of much of taxonomy and identifications (particularly of genetically distinct individuals) may remain forever in doubt. If genetic samples are lost, destroyed, or contaminated, or improperly processed before analysis, no information is available. It is highly unlikely that the individual can be recaptured. A specimen makes it possible to obtain and study genetic material from that individual hundreds of years into the future.
Photographs can be of poor quality or subject to digital alteration, and key characteristics of the phenotype distinguishing species may be too subtle or missed in photography. A photograph of course provides no information about genotype. Recordings similarly may be of poor quality or altered. Birds of the same species can have different local dialects that reflect phenotypic, not genotypic, variation (Marler and Tamura 1962). Sound can be affected by habitat and climactic conditions, and even the most skilled recordists may find it difficult to obtain a recording when conditions are very noisy. Even high quality recordings and photos provide limited information and are no substitute for physical specimens.

REFERENCES


*About the Ornithological Council*

The Ornithological Council is a consortium of 10 scientific societies of ornithologists; these societies span the Western Hemisphere and the research conducted by their members spans the globe. Their cumulative expertise comprises the knowledge that is fundamental and essential to science-based bird conservation and management. The Ornithological Council is financially supported by our ten member societies and the individual ornithologists who value our work. If the OC’s resources are valuable to you, please consider joining one of our member societies or donating directly at Birdnet.org. Thank you for your support!