CHAPTER 8. SCIENTIFIC COLLECTING

A. Overview

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). No one can foresee what valuable information specimens collected today will offer, or to what fascinating uses they will be put, 100 years from now, any more than one could have predicted 100 years ago how then-new specimens would answer intriguing questions today. For instance, many specimens used today to identify birds that have collided with aircraft were collected before airplanes were invented.

No other aspect of ornithological research generates so much controversy, yet the debate is disproportionate to the magnitude and impact of the activity. Most objections stem from personal value judgments and emotional responses rather than scientific considerations. Some oppose any collecting whatsoever, for any purpose, even of single individuals and even of abundant and widespread species, based on personal views and concern for the well-being of individual animals. Some who oppose collecting assume, wrongfully, that there are scientifically acceptable alternatives. Others do not oppose scientific collecting *per se*, but worry instead about impacts on declining or rare species, or on particularly sensitive populations. In fact, as discussed below, levels of collecting are extremely conservative, with negligible effects on populations, while engendering long-term benefits for bird conservation and science. Winker et al. (2010) offers a comprehensive review of the importance, effects, and ethics of scientific collecting.

Other definitions

The term "scientific collecting" has different meanings in other contexts. The regulatory (U.S. Fish and Wildlife Service) meaning of scientific collecting and the permits required for collecting encompasses the collection of various tissues and fluids, including whole birds, blood, feathers, or toenail clippings. It can also include tracheal or cloacal swabs or samples of crop or stomach contents. Scientists may also collect fecal sacs and nests. State permit agencies often use the term "scientific collecting" to refer to any research method that involves the capture of a live bird, whether for temporary holding or permanent removal from the wild, and even without the collection of samples.

In some cases, individuals are removed from the wild for study in captivity, in a laboratory, aviary, or specialized enclosure. This activity also requires federal scientific collecting permits and usually state permits. The disposition of wild birds studied in captivity varies. Federal and/or state permits may require that the birds be euthanized. Others require release, usually in situations involving very short periods of captivity. Institutional Animal Care and Use Committees may require euthanization out of concern that the individuals will not successfully re-adapt to the wild. Zoos or aviaries may be willing to accept wild birds that were taken into captivity for research projects. In the event that a bird can not be released and no zoo or aviary can accept the bird, and the bird must be euthanized, the carcass should be offered to a museum where it has can serve as a voucher specimen for studies for which it was used or for other research purposes. If no museum can accept the carcass, it should be offered to a teaching collection.

B. Purpose 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 and marking. 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 1879-1935 document 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, who often ask the researcher to state in the protocol how many individuals of each species will be collected. As it is impossible to make this determination in advance, the best answer is to state that collecting will not exceed permit limits.

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 United States.

The number of individuals collected is a simple matter of statistically valid inferences. Differences among a few individuals are meaningless as they could be due to chance. For scientists to draw reliable conclusions, series are necessary allow to allow the researcher to distinguish between real differences as opposed to normal variation among individuals.

C. Alternatives

Availability of specimens from other museums or institutions

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.

<u>Underrepresented species</u>: 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 both 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. Further, 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 (Winker 2004), 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, samples 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.

Genetic material, photographs, and recordings

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, as detailed above. And, in fact, 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.

For formal taxonomic descriptions, the role of scientific specimens is nothing short of fundamental. 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 (Smith 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.

D. Impact on Populations

Generally

The American Ornithologists’ Union has issued a clear statement that addresses the question of population impact:

> *The AOU regards responsible collecting of birds as an essential research method for studying the biology, ecology, systematics, and genetics of wild birds. As in laboratory research, methods of collecting used by field workers follow humane guidelines. Specimen collection plays an essential role in documenting the biodiversity of poorly known regions. Collecting specimens from populations known to be endangered or in precipitous decline also has important scientific value, but should be exercised with extreme caution and careful documentation that removal of the proposed number of animals will not adversely affect the*

population's projected trajectory in size and genetic diversity. The AOU recognizes the difficulty of making these judgments. The AOU is working to develop explicit procedures and criteria for projecting population effects of collecting and evaluating them relative to its benefits.

AOU Council, Laramie, Wyoming, 8-11 Aug 2007

Many decades of experience with scientific collections in many regions shows that the collection of scientific specimens typically has no lasting effect on avian populations. By looking at all birds taken under permits issued by the U.S. Fish and Wildlife Service for research and captive breeding, and deducting those taken for depredation control research and research involving hunted species or for propagation, and those taken under salvage permits (birds found dead), Banks (1979) estimated that at most, 15,000 birds per year were collected for scientific research per year, or one hundredth of one percent of overall direct annual mortality (defined in this paper as deaths resulting from the deliberate actions of man) and seven thousandths of a percent of annual avian mortality related to human activity.

More recently, the Ornithological Council analyzed data provided by the U.S. Fish and Wildlife Service for the years 1998-2002. Between 51 and 63 permits were issued per year. Cumulatively, the highest number of individual taken of any one species was 260 American Tree Sparrows, (*Spizella arborea*), an abundant, widespread species that numbers ~30 million individuals in North America (Partners in Flight Landbird 2009). In two of the five years, the highest number of individuals taken of any one species was the Steller's Jay (*Cyanocitta stelleri*): 135 taken in 1998 and 183 taken in 1999. Though restricted in range to the West Coast and the intermountain west, the species, with an estimated population of 4.4 million birds (BirdLife International), is considered stable. In the other two years, the Song Sparrow (*Melospiza melodia*) was the most-often taken (143 in 2000 and 159 in 2002). Birdlife International estimates the population of this species at 43 million birds. Only these three species and the White-winged Dove were collected in numbers exceeding 100 in any of the five years. Of the next eight most commonly collected species in each of those five years, the highest number was 89 Spotted Towhees (*Pipio maculatus*) with an estimated population of 14 million, and the lowest was 18 Snow Buntings (*Plectrophenax nivalis*) with an estimated population of 39 million. In sum, the scientific collecting enterprise removes individual birds in numbers that are nothing more than trivial in terms of impact on the population. For perspective, the U.S. Fish and Wildlife Service in 2008-2009 allowed the hunting 'take' of approximately

275,000 American Woodcock (*Scolopax minor*), a species that has been in steep, long-term decline (Cooper and Parker 2009). The species has been designated by the U.S. Fish and Wildlife Service as one of the top nine species for concerted conservation activity. The National Audubon Society estimates the population estimated at 5 million individuals. So, it is clear that no North American species is collected intensively enough even to begin to impact its numbers.

Even in the absence of population-level impact, ornithologists take measures to reduce the number of individuals collected. First, and most fundamentally, every effort is made to assure that the specimen and associated tissues and fluids are properly preserved and deposited in an institution that intends to keep the material permanently and make it available for future research (AOU Committee on Bird Collections 2009). Where biologically appropriate, existing specimens are studied. Ornithologists avoid collecting in conditions where retrieval of the carcass might not be possible. Shooting is often the most effective and practical means of collecting most birds species. Using the appropriate ammunition and avoiding difficult shots reduces the chance that the bird is wounded but able to escape. Wounded birds should be retrieved and sacrificed humanely. It is also standard practice to avoid concentrating the collecting effort in a small area or in a single breeding or roosting aggregation and to avoid collecting large numbers or gravid females, except as required for the purposes of the scientific questions being asked. Both to reduce the number of individuals taken and for humane reasons, ornithologists avoid collecting nesting birds unless the young will also be collected. To avoid taking gravid females or adults with dependent young, adults taken from breeding sites should be taken as soon after they arrive on the breeding grounds as possible or after the young have fledged. Where collecting is undertaken for a specific study, as opposed to general collecting, as in experiments intended to alter behavior, reproduction, or survivability, adequate sample size should be estimated before collecting begins.

Small Populations and Endangered Species

The American Ornithologists' Union stated,

> *Collecting specimens from populations known to be endangered or in precipitous decline also has important scientific value, but should be exercised with extreme caution and careful documentation that removal of the proposed number of*

animals will not adversely affect the population's projected trajectory in size and genetic diversity.

AOU Council, Laramie, Wyoming, 8-11 Aug 2007.

Assuring this outcome entails several considerations.

Permit limits: Most countries require permits for all scientific research, and certainly for scientific collecting. Some of these agencies are considered overly restrictive in that they set limits far below the level that would be biologically warranted. In the United States, for instance, collecting of species listed on the 2008 list of Birds of Conservation Concern – a designation that confers no legal protection that is not already afforded under the Migratory Bird Treaty Act - is limited to either five or ten individuals of each species per year, regardless of the actual size of the population, unless the researcher can justify the need to exceed the limit. Management authorities typically do not allow collection (other than salvage) for species that are truly rare, such as those listed as endangered or threatened under the Endangered Species Act, or even for "candidate species" under consideration for listing. As a rule, population impacts of collecting are limited by the fact that researchers work within the constraints of conservative permit limits that cannot be exceeded. In other countries, permit limits are likely to reflect the legal protection afforded to a given species, or if there is no system of legal protection, the status classifications of BirdLife International or the World Conservation Union (IUCN) Red List for Birds.

Personal responsibility and preliminary research: In some cases, permit agencies may lack adequate information about the status of a species or a population. Therefore, regardless of permit limits, when planning to collect species for which there are serious conservation concerns, researchers should seek robust recent information regarding the status of the population from which collection is planned. Indeed, in the absence of recent information, it may be reasonable to conduct preliminary field surveys to determine the status of the population. The natural history of the species of interest should be also taken into account. For instance, most passerines and other small- bodied birds have high reproductive rates and density-dependent mechanisms of population regulation such that populations can recover quickly from even large mortality events. In contrast, populations of a long-lived, slower-reproducing species such as condors or albatross may be affected more profoundly by removal of even small numbers of individuals. In most cases, population sizes will often prove a function simply of the extent of available resources, and will depend little on individual mortality (natural or science-related). If this preliminary research is undertaken in a thorough manner, the ornithologist may be the most knowledgeable person about the status of the population. With this knowledge and the exercise good scientific judgment, the researcher should be able to make science-based decisions about the extent to which a population can sustain collecting, again subject to permit limits.

Caveat: Official or authoritative conservation status assessments may not always provide reliable indicators of true population status. Over much of the world, so little is known about many bird populations that official listings such as the authoritative IUCN Red List err in both directions. This includes species as extinct or endangered that are neither, and failing to classify species that are probably extinct (Diamond 1987). These official classifications are thus insufficient to determine if (and how much) scientific collecting can be tolerated by a species or a population. For these understudied species, Diamond (1987) proposes a precautionary approach: that they be "extinct or endangered until shown to be extant and secure. In practical terms, this suggests that relatively more field survey work is needed to determine population status in the case of apparently rare species before collecting is undertaken, regardless of permit limits. Conversely, once it is known that official classifications are overly pessimistic, collecting (within permit limits) should be restricted only by the life history and population status of the species or population, subject to permit limits. Even in the face of unambiguous information, the process of changing conservation status is inherently slow. For instance, ornithologists have been recommending since 1980 that the California Brown Pelican (*Pelecanus occidentalis californicus*) be removed from the list of threatened or endangered species under the U.S. Endangered Species Act, and despite petitions to the U.S. Fish and Wildlife Service and an agency proposal for delisting in February 2008, the decision was still pending at the end of 2009. Appropriate permit limits and collecting levels should be based on the latest available data on population status, rather than potentially antiquated lists.

E. Methods

Researchers involved in scientific collecting should assure that the manner of collection is humane and conforms to established ethical standards of treatment for animals in research. Collecting commonly entails trapping birds and employing a humane method of euthanasia to bring about a rapid loss of consciousness and to minimize pain and suffering prior to death. Humane methods of euthanasia are discussed in the section on major manipulative procedures.

Any method chosen must avoid unnecessary damage to the specimen or injury to the body parts required for the investigation. Practical limits inherent in field work often precludes the use of some methods. For instance, it may not be possible to carry and use isoflurane (or other inhalant agents) in the field. Chemical methods are generally unacceptable, unless it can be shown that an agent will not compromise or bias potential tissue analysis. Further, access to many chemical agents is legally restricted (see discussion in section on anesthesia). It is often necessary to use a shotgun, particularly when collecting large birds or birds that will not enter nets or traps. Small bore shotguns minimize damage to the carcass. If attempting to collect a single individual or particular bird, the small bore shotgun will also minimize spread and reduce the likelihood of hitting other birds or animals in the vicinity of the targeted individual. Otherwise, it may be necessary to wait until the targeted individual moves away from other animals. Ornithologists who collect birds with a shotgun or other firearm should be experienced in their proper and safe use and must comply with laws and regulations governing their use. The firearm and ammunition load should be appropriate for the species to be collected to avoid nonfatal wounding. Every effort should be made to avoid wounding birds, not only to minimize suffering, but also to maximize the probability of retrieving rather than losing the specimen. Wounded birds should be killed promptly using a humane method of euthanasia.

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