The Importance of Avian Collections and the Need for Continued Collecting

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"The well-known spring and summer call of the Chickadee, consisting of three clear whistles, is uttered by both sexes. I am not aware that record has ever been made of this fact, which I determined some time ago through the judicious use of firearms." (Dwight 1897).

"Because the higher-level systematics of birds actually has a poorer foundation than in any other division of vertebrate zoology, research based on museum specimens will be absolutely essential to lifting this pallium of ignorance." (Olson 1981).

"...conservation organizations do the conservation of biological diversity a disservice by ignoring some subspecies and even opposing or prohibiting the collecting of material needed to understand the variation of life on earth. Subspecies are vital to such understanding. And without understanding, *we cannot conserve." (Phillips 1986).*

"This study demonstrates the accuracy and routine nature of the use of museum specimens in the analysis of mitochondrial sequence variation in natural populations, and, importantly, that a temporal aspect can now be added to such studies." (Thomas et al. 1990).

"Understanding the diversity of nature is, in various forms, a fundamental problem of ecological research. New techniques have extended the temporal and spatial scales over which patterns of diversity can be detected... Characterizing patterns of diversity is a critical first step in preserving that diversity." (Lubchenko et al. 1991).

Abstract

1. The purpose of a bird collection is to preserve the avian record, providing a source of material for both present and future research. A museum collection, much like a library, is a storehouse of reference material. Unlike books, however, each bird specimen is unique and cannot be replaced.

2. Avian collections have been the basis for our general understanding of birds. There are essentially four types of variation that we attempt to document through specimen preservation: individual, geographic, short- (within-year or lifespan) and long-term (decades) temporal variation.

3. Properly preserved specimens are useful for centuries, but older specimens often lack the data needed to answer modern questions. In general, existing collections do not have enough material for thorough investigations.

4. Specimens are added to museums today through salvaging birds found dead and through limited active collecting.

5. Preparation of specimens often includes preservation of the skeleton, skin, stomach contents, and a tissue sample, maximizing the usefulness of every bird.

6. Our understanding of avian diversity and classification is currently undergoing a revolution through the application of new techniques to bird specimens.

7. Hundreds of new bird species have been discovered in the past decade, mostly through the accumulation and examination of specimens

8. Conservation efforts rely upon accurate knowledge of avian diversity. Our knowledge

of avian diversity is rapidly changing.

9. Given the likelihood of future change in climate, habitat, and populations, tracking these changes through time by regularly sampling populations is very important.

10. Biological productivity enables the vast majority of avian populations to sustain regular harvesting of some portion of an annual surplus.

11. Scientific collecting is overzealously legislated. A single licensed hunter in Minnesota can legally take more than 5,190 game birds in a year, while an entire institution with many scientists collecting under scientific collecting permits can take only 120 birds of the same game species.

12. Collection of birds for scientific and educational purposes contributes 0.00011% to all human-caused avian mortality. More birds of a *single species* (e.g. Mallard) are killed by hunters in one year than the scientists of North America have preserved of all species in the last century.

13. Continued documentation and examination of biological diversity will be essential to successful conservation efforts. Museum collections and researchers will continue to be at the forefront of this research.

Introduction

During interactions with people who are not familiar with the nature of our work in a museum of natural history, we frequently encounter questions about why birds are collected and how they are preserved and used. As the quotations above suggest, birds are collected for many reasons and specimens are used in a variety of researches. Let us state at the outset that we care deeply about birds, and that we have a strong commitment to their continued well-being. At the same time, we feel that judicious collecting and continued specimen-based research are essential to solving a number of the problems in avian evolution and conservation. A communications gap between avian researchers and others interesed in birds often results in hostility against scientific collecting. We hope to bridge that gap and to show how the state bird collection and avian collections in general are being used to further our knowledge of birds.

Mission of a museum collection

The purpose of a bird collection is to preserve the avian record, providing a source of material and data for both present and future research. The state bird collection, started late in the last century, is housed in the Bell Museum of Natural History, at the University of Minnesota in Minneapolis. Much of the early material was collected by Thomas Sadler Roberts and his friends, and this nucleus of the collection served as the basis for Roberts' two volume "Birds of Minnesota" (1932), still widely regarded as one of the best state bird books. Most of the birds that Roberts collected are still available to researchers today. During the past 100 years the collection has grown to its current size of about 40,000 specimens. It is now broad in scope and has many strengths, both in species composition and geographic coverage. It is used by scientists throughout North America on a regular basis. Recent grants from the National Science Foundation have demonstrated that this collection is of national importance, and it is currently being computerized to make it more accessible to researchers everywhere.

Typically, specimens are collected by a researcher working on a particular problem and are ultimately deposited in a collection. Other material is added by museum staff, who carefully choose and prepare many of the hundreds of birds brought in each year ("salvaged") that have died from a variety of causes (e.g. road kills, window kills, starvation, etc.). The Bell Museum collection has grown by an average of 1.7% per year during the past decade. This growth is sustained through salvage, acquisition of older material (e.g. ancient personal collections), and limited active collecting.

How bird specimens are used

Ornithological collections have been used to form much of the basis of our present understanding of birds. Modern field guides are derived largely from careful consideration of tray after tray of bird specimens collected over a span of time and geographic space. You are the direct beneficiary of collections when you consult most field guides, since the plates in these guides are usually painted using specimen "consultants." Field guides improve as more of the variation in species is included. We know about this variation (e.g. individual, age, sex, and geographic) through large series of specimens patiently accumulated over many decades. This, the major contribution of specimens to the birding community and natural history art, is only a very small way in which collections are used.

Modern preparation of specimens includes preservation of the skeleton, skin, stomach, and a tissue sample, in order to maximize the usefulness of every bird received or collected. Research skin specimens are not like taxidermy mounts. Skins are prepared by removing the body (including most of the bones) and replacing it with cotton. The result is a stylized, rigid bird with cotton eyes that lies on its back. Skeletons are prepared by placing the dried carcass, without skin, into a colony of dermestid beetles, which eat the meat but leave the bones. Skeletons are usually then disarticulated by soaking in water until the joints come apart and the bones separate. Skins and skeletons are kept in insect-proof cases when not being used by researchers. Properly preserved specimens are useful for centuries.

A museum collection is a storehouse of reference material. In some ways collections are similar to libraries, but specimens are not books; each specimen is unique and cannot be replaced. Once a specimen has been used for the purpose for which it was collected, its careful preservation allows it to be examined by future researchers. As an example, Parkes (1989) reexamined some Bell Museum specimens collected over a century ago to revise the classification of some Philippine birds. Specimens may later be used for purposes that the original collector could not have imagined. We have been asked about our Greater Prairie-Chicken (*Tympanuchus cupido*) holdings from the last century by a researcher who would like to explore historical genetic diversity in this species by examining DNA in the dried skins and comparing it to that found in today's remnant populations. A loss in genetic diversity would have serious implications for prairie-chicken conservation.

Our understanding of species and subspecies limits, indeed, our understanding of avian phylogeny (lineages and their relatedness) as a whole, is presently undergoing a revolution through the application of new techniques to bird specimens. This area of research is probably the single most active in bird collecting today, since it often requires materials not traditionally saved: tissues and skeletal material, for example. Most people think that bird taxonomy is well understood. This is not so. The lead quote of Dr. Storrs Olson shows that the relationships among higher taxa (genera, families, and orders) are poorly understood. Similarly, our knowledge of geographic variation within species is only "skin deep."

Examination of geographic variation in specimens was instrumental to Darwin's development of the theory of evolution. This type of research is alive and well today, and is experiencing a dramatic surge in activity, since we are now able to examine the genetic bases of the visible differences that gave Darwin and others so much food for thought. A tremendous amount of current specimen-based research is directed toward the examination of the connection between phenotypic (visible) and genotypic (genetic) characteristics. Already-classic studies (e.g. Zink 1986) show that geographic variation in allozymes (various forms of enzymes) does not always reflect geographic variation in morphologic and plumage characters, upon which subspecies limits in particular have been traditionally based. The general finding that patterns of genetic variation frequently do not match patterns of phenotypic (externally visible) variation, as was frequently assumed in phenotypic studies of yesteryear, makes this an exciting area of evolutionary research.

Many studies that examine geographic variation in molecular characters (e.g. Zink 1986, Avise 1989) imply that what the early taxonomists learned by looking at study skins may not reflect the underlying genetics of the birds examined. While this general finding is revitalizing museum-based studies of avian evolution, it also holds important consequences for conservation. A last-ditch effort to save some of the genetic stock of the Dusky Seaside Sparrow (*Ammodramus maritimus nigrescens*) failed because it was based on flawed taxonomy (Avise 1989). Another situation with conservation implications occurs when separate populations or groups traditionally treated as subspecies may actually be full species. Analyzing blood proteins, Barrowclough and Gutiérrez (1990) recently discovered that the Spotted Owl (*Strix occidentalis*) of New Mexico is genetically quite distinct from Spotted Owl populations in Oregon and California. A careful examination of new material will probably reveal that the two groups represent separate species —

a very important consideration for Spotted Owl conservation strategies.

Relatively few specimens are collected today to determine species' ranges, although this continues to be an effective means of learning the avifauna of poorly understood areas (e.g. Gibson 1981, Remsen et al. 1987, Winker and Klicka 1991). Studies that fail to secure voucher specimens (representative specimens of the organisms being studied) are criticized both for their own incompleteness and for the lost opportunity to make material available for future study (Johnson 1983). Changing taxonomies (e.g. splitting one species into two) often rely upon the examination of specimens to determine distributions (e.g. *Empidonax* flycatchers; Johnson 1980, Zink and Fall 1981; Western and Clark's Grebes [*Aechmophorus* spp.]; Storer and Nuechterlein 1985). Classic studies of migration and distribution (e.g. Aldrich and Duvall 1958) depend on large numbers of specimens accumulated over a long period of time, and they can only be as complete as the specimen base itself. The migration patterns and wintering grounds of North American birds south of the United States are still known mainly through museum specimens (Barlow and Flood 1983). As Ramos (1988) has recently shown, tremendous advances in our knowledge of migration strategies, timing, route selection, and wintering ranges of songbirds can be made through the collection and careful analysis of specimens. Skeletal specimens are being used heavily for comparative purposes in the study of paleo-ornithology (avian fossils; cf. Olson 1981) and for identification in archaeological studies. Pickled (or spirit, or fluid) specimens are seeing a revival in the systematic study of anatomy, especially of musculature. Specimens can also play important roles in studies of population and community ecology (Ricklefs 1980, Fitzpatrick 1985).

In 1980, experts considered that there were approximately 9,021 species of birds in the world (Bock and Farrand 1980). The most recent book on the taxonomy and distribution of birds of the world (Sibley and Monroe 1990) recognizes 9,672 species. How did scientists discover 651 new species of birds in the past decade (including many new species in North America)? Mostly through the patient accumulation and examination of specimens. Using the ever-more-powerful tools available to us to discern differences between groups of birds, we are finding that the class Aves contains a lot of diversity that wasn't evident before with limited techniques and often more limited preserved material. Now, in addition to sometimes minor differences between populations in morphology, we are finding that there are frequently differences in habitat associations, vocalizations, behavior, body proteins, and even gene frequencies that clearly indicate very different populations — often recognized at the species level. Some might think that we are entering an era of rampant splitting (creation of new species by splitting old ones), but the qualities that a population must possess to qualify as a species have probably never been more stringent than they are today. What we are seeing in this increase in avian species is the beginning of a more complete understanding of true avian diversity.

Why collecting must continue

Every specimen represents a point unique in space and time. Have you ever seen anyone who looks exactly like you? Just as in humans, there is a tremendous amount of variability within bird species. This variability takes several forms: birds from one population are different from each other (individual variation). Birds of a single species from one area are often different than those from another (geographic variation). Birds also show changes with season and age (short term temporal variation). Finally, at any given locality a population probably changes genetically (and possibly morphologically) through time (long term temporal variation). The object of specimen preservation is to document these types of variation both for present and future research. Ultimately, investigating variation furthers our understanding of speciation and other aspects of evolution; along the way we learn much of practical value (e.g. species limits, population uniqueness, distribution and dispersal patterns, and sex and age-related characteristics). The amount of variation found in a species determines the number of specimens adequate to document and fully understand that variation. To satisfy statistical analyses, samples from any given locality often have to be at least ten individuals, preferably of each sex and age class (e.g. ten adult females, ten immature males, etc.). In general, existing collections do not have enough material for thorough investigations (Zusi 1982), and new specimens tend to be collected by project-oriented researchers. General collecting is still warranted, however. Given the likelihood of change over time in climate, habitat, and populations, temporal samples (regular sampling through time) are very important. In addition, the worldwide holdings of both skeleton and fluid specimens have been inventoried and found to be far short of current and future research needs (Jenkinson and Wood 1985). Perhaps part of the problem is that there appears to be a widespread misconception that patterns of geographic variation (at least in North America) and their evolutionary significance are well understood; this is not so (Zink and Remsen 1986).

Collection of individual birds carefully studied in life is often still necessary to learn the age or sex of birds showing certain behaviors. Thus, Dwight's collection of chickadees revealed that both sexes sing. Winker et al. (1990) used this technique to learn that in Wood Thrushes (*Hylocichla mustelina*) both sexes defend individual winter territories, an important aspect of nonbreeding population dynamics.

Vagrants, which are unlikely to survive and reproduce anyway, and individuals of certain problem species, should probably be collected more frequently so that we can confirm their species (e.g. *Larus* sp. Hoffman and Hoffman 1986; *Myiarchus cinerascens* Svingen and Risen 1991), what subspecies (and thus geographic region) they belong to (e.g. Curve-billed Thrasher [*Toxostoma curvirostre*] Carlson 1991), and whether they are of wild or captive origin (e.g. Magnificent Hummingbird [*Eugenes fulgens*] Eckhardt 1987). These four recent Minnesota records do not have specimen documentation, which has proven useful with other recent distributional records in the state (e.g. confirmation of immature female California Gull [*Larus californicus*], Janssen 1986; decision of captive origin of Common Black Hawk [*Buteogallus anthracinus*] **The Loon** 60:14). Having said this, we hasten to say that we have no intention to deny birders their opportunity to see rarities by routinely collecting them upon discovery.

Although collecting a bird has an undeniably immediate impact, on a population level this loss is usually inconsequential and only temporary. If a breeding bird has been taken, the following year, or perhaps later in the same year, there will probably be another breeding pair at that location. The loss of habitat, on the other hand, has a less-noticed but far more detrimental and permanent impact upon avian populations. Worldwide, many habitats are disappearing quickly, and the job of collecting and preserving specimens of populations that will vanish with these habitats is falling upon museums worldwide. Because of inadequate levels of support, this job is not being satisfactorily performed, and smaller museums have quite a job in attempting to keep up with adequate preservation of the fauna of their regions.

A factor dealt with daily in collections is that older material tends to have fewer data than newer specimens. Because of this paucity of data many older specimens cannot be used to answer current ecological questions (Stiles 1983). For example, specimens collected and used for taxonomy in the last century are usually of no use in the examination of things such as diet, gonad development, fat levels, breeding seasons, or molt schedules. The lack of data on older material may necessitate further collecting, with more thorough documentation (see Parkes 1963). With current rates of habitat alteration, however, species may be displaced from an area where formerly common, and new material may be impossible to obtain. Failure to collect recent specimen examples may prevent us from answering both current and unknown future research questions. For example, good specimen samples of House Finches (*Carpodacus mexicanus*) taken today in Minnesota would enable us in the future to view evolution in action as these populations adapt to environments that they did not formerly occupy. As another example, consider that egg collectors of the pre-DDT era had no idea that their specimens would prove crucial to demonstrating the noxious effects of DDT on avian reproduction.

General collecting activities have decreased markedly in the past few decades. This stems not only from a decline in active collectors, but also from a slow bureaucratic throttling of legitimate collecting activities. The Bell Museum holds just one set of permits for the institution — with 35 people authorized to salvage dead birds and perform limited collecting under it.

Legal protection of birds

Current legal restrictions on scientific collecting are quite severe. This severity has been imposed only during the past decade. Permits used to be issued regularly to individuals, and there were no limits to the number of birds that might be taken (except that endangered species could not be taken). Generally, this freedom was not abused by scientists. Individual permits became discouraged by federal authorities, however, who now issue permits (in our region) only to institutions. Shortly after this change, institutional permits began to impose limits. At the Bell Museum in 1986 there were no limits to the number of birds of non-endangered species that could be collected by its scientists. In 1987 our federal institutional permit had a limit imposed of no more than four individuals of permitted species.

Presently, federal collecting permits in our region allow only three birds of most species to be taken in a single year (in other regions it is as low as two). This figure is not based on any reasonable biological criteria; it is lower than the *daily* bag limit of most game species for a licensed hunter (see Table 1). In addition to federal permit restrictions, many states add further restraints (Minnesota is one exception here). Protection is certainly warranted, but many scientists are finding that the restrictions are too severe, often preventing them from taking advantage of unforeseen opportunities when they get into the field. Exceptions to a limit of three can be applied for on a species-by-species basis, but because permit application procedures take months, a fleeting chance in the field often has to be passed up. As an example, two of us were recently unable to collect mortally wounded waterfowl under our permits because we hadn't anticipated encountering them. It is ironic that these birds were legally protected from us (who wanted to preserve their skins, skeletons, and tissues for future study), but not from the hunters who had injured them. We think that over-restrictive regulation of collecting probably arises from a misguided attempt to safeguard avian populations.

In the ornithological community the current permit restrictiveness is a widely recognized problem (King and Bock 1978, Diamond 1987). Researchers feel frustration at this situation, because while there is an urgent need for new specimen material to generate the knowledge needed to formulate effective conservation policies (among other uses), misguided conservation concerns thwart efforts to collect birds. The biological laws of

How Many Birds Can A Minnesota Hunter Harvest?

Table 1. If the appropriate hunting licenses are purchased, how many birds of protected species can an individual hunter take in a year in Minnesota? These figures are from the 1990 hunting regulations.

Species	Season	Days	Daily limit	Season limit[1]
Ruffed & Spruce Grouse	15 Sep-31 Dec	107	5 combined	535
Sharp-tailed Grouse	15 Sep-30 Nov	76	3	228
Gray Partridge	15 Sep-31 Dec	107	5	535
Ring-necked Pheasant	13 Oct-9 Dec	56	2	112
American Crow	1 Jul-1 Nov	124	no limit	no limit
American Woodcock	1 Sep-4 Nov	65	5	325
Sora & Virginia Rail	1 Sep-4 Nov	65	25 combined	1625
Common Snipe	1 Sep-4 Nov	65	8	520
Ducks (excluding mergansers)	6 Oct-4 Nov	30	3	90
Mergansers	6 Oct-4 Nov	30	5	150
Coots & moorhens	6 Oct-4 Nov	30	15 combined	450
Geese	29 Sep-17 Dec	80	7 combined	560

[1]Limit for entire season if daily limit is taken on every day of the open season.

productivity and an examination of sources of avian mortality show that scientists constitute a negligible threat to birds, excepting only such easily dealt with special cases as truly endangered species or local populations.

Sources of avian mortality

Avian populations generally fluctuate widely in size during a given year. After the reproductive season a population is at its largest, and usually more individuals exist at this time than the environment can support through the coming year. Annual mortality eliminates the surplus, and the number of birds alive at the beginning of a reproductive season is usually near the number that existed at the same time the year before. Natural causes of avian mortality are responsible for about 98.1% of the estimated 10 billion birds that die annually in the United States; the remaining 1.9% is directly or indirectly related to human activities (Banks 1979).

Hunting is the major direct human-related cause of avian mortality. Banks (1979) noted that five million Mallards (*Anas platyrhynchos*) were killed in both 1970 and 1971. As Dr. Kenneth Parkes has said (pers. comm.), this *annual* haul of a single species exceeds the total number of research specimens of all species in North American museums, which have been accumulated over about a century and a half (see also King and Bock 1978:23). Over one million American Woodcock (*Scolopax minor*) were shot by hunters in the 1970-71 season. Between 1942 and 1965, the national kill of Mourning Doves (*Zenaida macroura*) was from 11 million to 42 million annually. Clearly, some species can withstand tremendous levels of human predation in complement with natural factors causing mortality. The population dynamics of many nongame species are comparable, except that hunting does not contribute significantly to the elimination of the annual population surplus.

An individual who purchased the requisite annual hunting licenses in 1990 could legally take over 5,190 birds of game species in the state of Minnesota (Table 1). The Bell Museum's 1990 scientific collecting permits allowed the entire institution (tens of scientists) to take only 120 birds of these same species (including waterfowl and American Crows [*Corvus brachyrhynchos*]).

Your house may kill more birds per year than we collected under the Bell Museum's collecting permit during the last calendar year (1990: 22 birds). Klem (1990) monitored window kills at two houses in southern Illinois and found that a rural and suburban home killed 33 and 26 birds respectively through window strikes during a 12-month period. Klem (1990) has been investigating avian mortality due to window strikes since 1974, and estimates that between 97.6-975.6 million birds are killed annually in this fashion in the United States.

Communications towers (usually television), which are of necessity tall structures supported by a network of cables, are another common human-related cause of avian mortality. By law, they must have flashing lights every 100 ft. On nights during migration when the cloud ceiling is low, the lights on these structures somehow confuse nocturnal migrants (most songbirds) and attract them like moths to a flame so that they fly in circles — many strike the tower or its cables and are killed or mortally injured. On a single night during migration a tall television tower might kill hundreds or even thousands of migrants. Using several independent sources, Banks (1979) estimated that approximately 2,500 nocturnal migrants are killed annually at each of these towers, and that the annual U.S. toll from this source was approximately 1.25 million birds.

Birds are also killed at phenomenal rates along our roads. Again, using figures from several studies, Banks (1979) estimated that approximately 15.1 avian deaths occur annually per road mile, resulting in about 57.2 million deaths per year in the United States. Churcher and Lawton (1989) examined a poorly understood source of bird death: the domestic cat. They found that at least 20 million birds a year are killed by Britain's cats. If cats in the United States hunt as effectively, and if cat numbers correspond to human populations, then we might expect more than 80 million birds to be killed annually by domestic felines in the United States.

In comparison, scientific collecting is an infinitesimal contributor to avian mortality. About 0.00011% of all human-related avian mortality is caused by collection for scientific or educational purposes (King and Bock 1978). Paulson (1989) compared collecting levels at the Burke Museum in Washington state to that state's avian population. In a "good" year, scientists at the Burke Museum collect approximately 700 birds. By using breeding bird census figures from *American Birds*, Paulson estimated that Washington state produces about 70 million birds each year. The Burke Museum, then, collected about one out of every 100,000 birds produced in Washington state on an annual basis.

Conclusion

We hope that this communication convinces persons unfamiliar with the functions of a bird collection that maintenance of a collection is important and that continued collecting will be instrumental in answering a variety of research questions. Continued documentation of biological diversity and an increased understanding of geographic variation will be essential to successful conservation efforts. Museum collections and researchers will continue to be at the forefront of this research. Most populations of birds can easily withstand the loss of a few individuals each season, and if these individuals allow us to gain a more thorough understanding of the species or population, then we are in a better position to successfully perform our duties as stewards of the environment. Modern scientific collecting is carried out with due concern for population levels at local and global scales, and samples are not taken from populations that cannot replace themselves. Every effort is made to acquire specimens through salvage by picking up birds killed inadvertently through contact with man (e.g. television tower, window, and road kills). As the mandated state repository for avian specimens, we will accept any prepared or unprepared specimens for which the date and locality of collection (or salvage) are known.

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