

Collection building through salvage: a review

Paul R. Sweet¹

Abstract

Extant collections of bird specimens are often inadequate for many studies, hence there is a continued need to build collections, especially for anatomical and molecular research. There are two methods of obtaining fresh bird specimens for museums: active collecting and salvage of dead specimens. Through a questionnaire, current museum collection-building practices are analyzed with a focus on salvaged material.

Keywords: Avian collections, specimen collecting, salvage, bird specimen preparation, avian mortality.

Zusammenfassung

Für viele Untersuchungen, speziell in den Bereichen Anatomie und Molekularbiologie, erweist sich das Material in den derzeitigen Beständen von Vogelsammlungen als ungenügend. Daraus ergibt sich jedenfalls die Notwendigkeit fortgesetzter Sammeltätigkeit. Grundsätzlich sind dafür zwei Ansätze möglich: aktives Sammeln und die Aufsammlung von aus verschiedenen Gründen umgekommenen Vögeln. Derzeitige Museumspraktiken wurden anhand eines Fragebogens erhoben und speziell unter dem Aspekt der Aufsammlung verunglückter Vögel analysiert.

Introduction

The world's natural history museums currently contain over nine million bird specimens (GOODMAN & LANYON 1994, ROSELAAR 2003); however extant collections are often inadequate for many studies (ZUSI et al. 1982, KITCHENER & MCGOWAN 2003). Most collections are heavily biased towards study skins and may be deficient in or completely lack skeletal (OLSON 2003, CAUSEY & TRIMBLE 2005), spirit (LIVEZEY 2003), and tissue collections (CHRISTIDIS & NORMAN 2003, EDWARDS et al. 2005). Indeed many avian taxa are still completely unrepresented as these preparations (see e.g. WOOD & SCHNELL 1986). Furthermore many old skin specimens, although historically valuable, are of little use for many modern studies because of the poor quality of associated data or the specimens being from an inappropriate season or locality. Because of this deficiency there is a continued need to build collections if they are to continue to maintain their value as research tools (WINKER et al. 1991, REMSEN 1995). Given the need to build collections, museums have two ways of obtaining fresh bird specimens: (1) active collecting, in which museum personnel deliberately kill birds for preservation in a collection and (2) salvage, in which dead birds not deliberately killed for museum collections are obtained from various sources. The potential for obtaining salvaged birds is great. Total world bird population has been estimated at 100 billion individuals (FISHER 1951) but it may be much greater. Mortality rates in birds are high. Although a few very long-lived species may have an annual mortality rate as low as 10%, annual adult mortality rate in most birds is 40–60%. An estimate of 50 billion dead birds per year worldwide is probably conservative. Although the vast majority of these birds will die in anonymity to decay

¹ Department of Ornithology, Division of Vertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024; e-mail: sweet@amnh.org

or be scavenged, small numbers will die in situations that enable salvage. In addition to salvaging wild birds, captive birds salvaged from zoos and private aviculture can be valuable. Museum personnel can target these sources to obtain fresh material.

Collecting vs. Salvaging

Collecting remains the preferred method of obtaining museum specimens. When museum personnel collect specimens directly, associated data are excellent. Geographic, temporal, breeding, age, biometric and ecological data are recorded directly by the collector and are extremely reliable. Specimens are very fresh and more or less intact, and therefore suitable for all preparations, including skins, skeletons, and spirits, and they yield high quality tissues. Collectors can target particular species, from particular localities, at particular dates, for studies where specific birds are needed. Collecting is also the only viable method of obtaining specimens on expeditions to remote areas. The major hindrances to collecting are the difficulties in obtaining permits for many countries, the funding of expeditions and the availability of trained personnel who can spend the, often extended, field time required.

Conversely, salvaging is inexpensive and permitting is usually relatively straightforward. Because of the ways in which museums receive salvage, species composition is different from field collections. Often large-bodied, difficult to collect, protected, or extralimital species are obtained and aviculture can provide exotic material unavailable elsewhere. However, in most cases, because of the random accumulation of birds, large series from required localities and times are generally not available. Although mass mortality events do occasionally produce large samples of a single species (KITCHENER & MCGOWAN 2003), these events often occur during migration or outside the breeding season, when the specimens may be less useful for many studies. Because museums usually receive salvaged birds from third parties, data can be less reliable or non-existent. Specimens may be decayed or damaged and therefore may not be easily sexable and are unsuitable for certain preparations.

Although not a replacement for active collecting, salvage, as a supplement, can yield valuable material.

Questionnaire

To obtain data on current collection-building practices, a questionnaire was circulated on the list servers AVECOL (email bulletin board devoted to topics of interest to curators and collection managers of bird collections) and eBEAC (electronic Bulletin for European Avian Curators). A total of 65 institutions responded to the questionnaire (see appendix I): 39 from the USA (US), 3 from Australasia (AU) (2 Australia, 1 New Zealand) and 23 from Europe (EU) (4 UK, 4 Germany, 3 Czech Republic, 2 Austria, 2 Denmark, 2 Netherlands, 2 Norway, 2 Switzerland, 1 Sweden, 1 Belgium). Although, by no means a comprehensive data-set, several interesting patterns were revealed.

Due to the unpredictable nature of collecting and salvage, data were generally given as rough estimates averaged over several years and will be presented here as such.

How many birds per year are obtained by direct collecting?

Although museum collections historically consist primarily of field-collected specimens, the questionnaire indicated a marked change in collection-building practices, with almost half of respondents reporting no collecting. Data also reveal a wide geographic discrepancy with US institutions outweighing others in direct collecting efforts as noted by COOPER & STEINHEIMER (2003). Data are summarized in table 1.

Number of Birds Collected	Number of Institutions	% of Institutions
None	27 (11 US, 14 EU, 2 AU)	42
< 100 per year	20 (11 US, 8 EU, 1 AU)	29
100–500 per year	9 (8 US, 1 EU)	15
500–1,000 per year	4 (3 US, 1 EU)	6
> 1,000 per year	5 (5 US)	8

Table 1

How many birds per year are salvaged?

All institutions reported engagement in some form of salvage activity. Because most institutions known to collect actively (pers. obs.) responded to the questionnaire, but many non-collecting institutions did not, it appears that the majority of specimens currently added to bird collections worldwide are from salvage, as suggested by WINKER (2000). For example 50% of the entire collection and 90% of the Netherlands material in the Zoological Museum of the University of Amsterdam were obtained by salvage (Kees Roselaar, in litt.) and at the Auckland War Memorial Museum, New Zealand, no birds have been added by direct collecting for 70 years (Brian Gill, in litt.). Data are summarized in table 2.

Number of Birds Salvaged	Number of Institutions	% of Institutions
< 100 per year	17 (9 US, 8 EU)	26
100–500 per year	39 (24 US, 12 EU, 3 AU)	60
500–1,000 per year	6 (3 US, 3 EU)	9
> 1,000 per year	3 (3 US)	5

Table 2

How many of these salvaged birds are prepared? How many are discarded? How many are stored in freezers? Do you maintain an inventory of unprepared frozen birds?

Numbers of salvaged birds prepared by institutions vary widely from tens to thousands annually. Approximately 75% of respondents reported preparing more than 50% of the material obtained and 40% prepare more than 90%. Various reasons are given for not preparing all material. Many museums reported obtaining specimens that are perceived to be surplus to their needs; these are usually locally common species for which the

collection already has large series. Specimens may be damaged, decayed or lack date and locality data. The volume of salvage obtained was often beyond the resources of the museum to prepare, even if the specimens were of interest. Many institutions reported insufficient staff levels for preparation. This is particularly so in Europe where museums tend to rely on professional taxidermists. In the USA much of the preparation is done by students, volunteers and collections management staff. The disposition of unprepared material varies. Some material is discarded. About 40% of institutions reported “very few” or no discards. Conversely, some institutions discard hundreds of specimens per year. Most respondents reported large numbers of birds stored in freezers (table 3), but only about 50% maintain inventories of these holdings, which are an important prerequisite for exchange (COOPER & STEINHEIMER 2003).

Number of Birds Stored in Freezers	Number of Institutions
< 100 per year	19
100–500 per year	30
500–1,000 per year	7
> 1,000 per year	9

Table 3

Do you exchange salvage with other museums? Do you exchange nationally or internationally? How many birds do you exchange? Would you be interested in exchanging salvaged material with other museums? Do you think that list servers (e.g. AVECOL or eBEAC) are an appropriate venue for advertising available surplus salvage?

Although at least 75% of respondents reported exchanging some surplus material, the frequency of exchange and numbers involved is low. 31 institutions reported exchanging nationally, 5 internationally, and 12 both nationally and internationally. Exchanges have been made through shipping of whole frozen carcasses, roughed out and dried skeletons, whole birds in alcohol (pers. obs.) or via reciprocal exchange visits when preparators visit collections and prepare birds in situ, e.g between the American Museum of Natural History (AMNH) and the Natural History Museum, formerly the British Museum (Natural History) (BMNH) (pers. obs.). Although numbers are currently low, 90% of respondents expressed a strong interest in increased exchanges. There is particular interest in inter-continental exchange, although many respondents expressed concerns over shipping logistics and permitting, particularly since the emergence of H5N1 Avian Influenza. Most respondents thought that extant list servers were an appropriate venue for advertising available salvage; however it was suggested that the initiation of a separate list might be appropriate.

Do you need a permit to salvage?

In the USA it is technically illegal to pick up any dead bird protected under the Migratory Bird Treaty Act without both state and federal permits. However obtaining United States Fish and Wildlife Service (USFWS) Special Purpose (Salvage) permits is straightforward and all US respondents reported possession of these. Most other

respondents also reported requiring permits for salvage although in some cases there appears to be confusion, with institutions within the same country reporting different requirements. A notable exception is the UK, where the public may salvage birds that die of natural causes, have them prepared and retain them as personal property without a permit (RSPB 2007).

How is your salvaged material prepared?

Museums reported using salvaged material to prepare a variety of traditional and non-traditional specimens including: round skins, flat skins, spread wings, spread tails, skeletons, spirit specimens, combination preparations of the aforementioned in different states of completeness (such as round skin, wing and partial skeleton WINKER 2000, or “schmoo” skin and skeleton DICKERMAN 1989), cleared and stained anatomical specimens, loose feather collections and tissue samples.

What are the main sources of your salvage?

Based on responses to the questionnaire, as well as personal experience the following sources of salvage were identified.

Wildlife Rehabilitators

“Rehab” is reported as a major source of specimens, particularly in the USA, where there are approximately 1,500 licensed Wildlife Rehabilitators (E. Savage, USFWS Division Migratory Bird Management, pers. comm.) who possess both state and federal permits to take in injured birds and can legally donate casualties to museums. Listings of these organizations are easily found on the Internet. Specimens from this source tend to be in fairly good condition because they are brought in alive, are then euthanized or die at the facility and are frozen soon after death. Associated data can also be good if adequate training is given to staff, for example a small label with date and locality can be placed with the bird prior to freezing. Care must be taken to record the date the bird arrived at the facility as well as the date of death if these differ. This is an excellent source for larger birds, particularly raptors, which attract public attention when injured. Living birds from known locations held at rehabilitation establishments can also be useful in providing blood for DNA studies (e.g. BRITO 2005).

Ringed Casualties

This is a potential source of large numbers of good condition, data rich specimens. EURING reports over 4 million birds ringed per year in Europe, and United States Geological Survey (USGS) Bird Banding Laboratory reports over 1 million in North America. Inevitably some birds die during these operations and published data indicate a greater than 1% casualty rate (RECHER et al. 1985). However, few museums reported receiving casualties from ringers. Ringers may hide casualties because of concern that these deaths be perceived as failures (D. Bystrak, USGS Bird Banding Laboratory, pers. comm.). Museums should attempt to contact the ringing community to encourage donation of such specimens.

Roadkill

Collision with vehicles has been estimated to cause around 60 million bird deaths per year in the USA (BANKS 1976), and even greater numbers in Europe (ERRITZOE et al.

2003). Because of the trauma involved in the death and the time elapsing before salvage, particularly during warm weather, such specimens are often badly damaged or decayed and may not be suitable for certain preparations. Nevertheless most respondents cited roadkill as a major source of specimens.

Window-Kill

Collision with windows may be the highest human related cause of mortality in birds. KLEM (1990) estimated the annual mortality in the USA as at least 98 million birds. Most respondents reported this as a major source of salvage.

Cat Kills

Predation by domestic and feral cats is a huge source of mortality in birds. CHURCHER & LAWTON (1989) estimated 20 million birds per year killed by cats in the UK and WALSBURG'S (1994) estimate for the USA was 638 million per year. Despite this, few museums reported cat kills as a major source of salvage; presumably because the birds are consumed by the cats or because the cat owners are embarrassed.

Collision with Manmade Structures

Sporadic mass mortality has been reported at communication towers, tall buildings, lighthouses, oil rigs, chimneys and cooling towers (BANKS 1979, AVERY et al. 1980). These events are often associated with nocturnal migration and particular weather patterns, and lighting of these structures may play a significant role in the extent of mortality (EVANS-OGDEN 1996). Several museums actively target such structures to collect birds (e.g. D. Willard, Field Museum of Natural History, pers. comm.). Additionally some citizen and NGO groups monitor particular sites and pass salvage to museums, for example the Fatal Light Awareness Program (FLAP) in Toronto, has donated over 25,000 birds to the Royal Ontario Museum (ROM) between 1993 and 2007 (M. Mesure, pers. comm.).

Electrocution by and Collision with Power Lines

Significant mortality is reported due to bird interactions with utility structures (BEVANGER 1994) and several institutions reported this as a source of specimens, particularly for raptors and other large-bodied species such as waterfowl, pelicans and cranes.

Non-museum Research Projects

Government and non-government biologists kill birds for research projects such as monitoring of diseases, environmental contaminants and fisheries. These specimens are often passed on to museums after they have been used for the primary study: for example Alaskan seabirds, collected for studies of foraging ecology, were donated to the AMNH by the USGS and the USFWS (J. Pitocchelli, pers. comm.).

Airplane Strikes

Birds are routinely hit by planes, and airport personnel often monitor these strikes, e.g. at New York's John F. Kennedy International Airport (L. Francour, pers. comm.). Several museums reported collaboration with airport management to identify these remains. Birds often suffer extreme trauma in these strikes, but specimens may prove to be useful at least for tissue samples.

Fishery Bycatch

Tragically many birds, particularly Procellariiformes, are killed in commercial fisheries. Some governments place observers on fishing boats who retain casualties and pass them on to museums (C. J. R. Robertson, pers. comm.).

“Nuisance” Bird Control

Certain species of birds are legally killed when perceived to interfere with human activities or compete with native species. For example birds are shot, trapped or taken by falconry at airports; piscivorous species are shot at fish farms or lakes; blackbirds (*Icteridae* spp.) are killed to protect crops; and introduced species, such as Ruddy Ducks (*Oxyura jamaicensis*) in Europe, are culled when they compete with native species.

Disease

Die-offs from disease can produce large numbers of a few species. For example the recent outbreaks of type E Botulism on the North American Great Lakes killed large numbers of piscivorous birds. Fears of human infection from such diseases as Avian Influenza or West Nile Virus may prevent access to diseased specimens.

Legal Hunting

Many countries permit bird hunting. Although taxonomic diversity is limited (for example in the USA around 60 species of Galliformes, Anatidae, Rallidae, Columbidae, Gruidae, Scolopacidae and Corvidae are classed as game birds), hunted birds can be a valuable addition to museum collections. Game biologists often have access to large numbers of samples: for example in the USA hunters are often required to deposit wings, often with full data attached, in barrels provided in hunting areas. These are an excellent source of tissues for studies of geographic variation (e.g. BARROWCLOUGH et al. 2004).

Beach “Wrecks”

Sporadic extreme weather conditions such as winter storms or hurricanes can produce mass mortality at sea that cause large numbers of birds to be washed up along shorelines. These “wrecks” are excellent sources for large series of certain species that could not easily be obtained by direct collecting (KITCHENER & MCGOWAN 2003).

Oil Spills

Similar to “wrecks”, these sporadic events yield large numbers of a few species. Storage and preparation of oiled birds however presents several unique problems (KITCHENER & MCGOWAN 2003).

Wildlife Refuges & Bird Colonies

Many wildlife refuges have permanent staff and can also attract large numbers of visitors and researchers. This coverage in areas of high bird concentrations leads to increased encounters with casualties. This is particularly so when researchers are studying bird nesting colonies and can yield useful material otherwise not easily available e.g. a cleared and stained developmental series of Common Terns (*Sterna hirundo*) from Great Gull Island, New York (CANE 1993, 1994).

Customs Confiscation, Bird Imports and Quarantine

High mortality is reported in the legal and illegal trade in wild birds. Many birds arrive dead at airports or die during quarantine. Several respondents reported that customs or wildlife authorities donate these casualties to museums.

Wind Turbines

Significant numbers of large raptors, such as White-tailed Eagles (*Haliaeetus albicilla*) in Norway or vultures (*Gyps* sp.) in Spain, are reported to be killed by wind turbines.

Zoos and Private Aviculture

Although not strictly salvage as described in the examples above, obtaining specimens from captivity is an important source of specimens for many museums. Unfortunately most birds lack reliable locality data (the original capture site for non-captive bred species) and are often heavily necropsied for pathology studies which renders them less useful for some studies or preparations. However exotic species that would otherwise be hard or impossible to collect can be obtained from aviculturalists and zoos. Such specimens are particularly useful for tissue samples used in higher level phylogenetic studies in which precise locality is not so important. Because of uncertain origin of stock and unknown breeding pedigrees the danger of hybridization is high in birds bred in captivity, and great care should be taken in identifying them, particularly if saving un-vouchered tissue samples.

Any notable research projects where salvaged material was important?

Almost all respondents reported that salvaged material was crucial to many recent research projects. These are too numerous to list individually but include: regional handbooks; genetic studies, from DNA barcoding to higher level phylogenetics; taxonomic revisions; comparative osteology; pesticide monitoring; moult studies; migration studies; feather atlases; archaeozoology and parasite studies.

Any notable records based on salvaged material?

Many respondents reported significant numbers of important national (e.g. HARDY & CLENCH 1982, EBELS & ROSELAAR 2005) or regional (e.g. SWEET 1997, SWEET & MARTINELLI 1998) records of vagrant or rarities based on salvaged birds (see also DITTMANN & LASLEY 1992).

Discussion and Conclusion

Although active collection remains the preferred means of obtaining specimens (REMSEN 1995), salvage has become the primary method of obtaining new specimens for museums worldwide. However many valuable sources of salvaged material probably remain untapped. To make better use of this resource, museums can develop relationships with government and non-government organizations that have access to dead birds as outlined in the list of sources above. Museum personnel can also visit locations at times when mortality is likely, such as beaches after storms or TV towers during migration.

Salvage operations often yield large numbers of specimens that are surplus to a museum's research needs or beyond the resources of the museum to prepare. However, this material is often desirable to other museums in other regions, countries, or continents (COOPER & STEINHEIMER 2003). In these cases, efforts should be made to exchange with or donate to these institutions rather than discarding specimens. Museum list servers are an excellent venue for advertising potential exchange material. The logistics of shipping specimens can be complex, especially with the emergence of new avian diseases and laws protecting various species, regulations have become increasingly stringent and permits harder to obtain, but with effort, in most cases such permits can be obtained.

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Appendix I: Respondents to questionnaire

Peter Adamik	Museum of Natural History and Arts, Czech Republic
Claudia Angle	Smithsonian Institution, National Museum of Natural History
Keith Arnold	Texas Cooperative Wildlife Collections
Gerhard Aubrecht	Biology Centre of the State Museums of Upper Austria
Robert Barrett	Tromsø University Museum, Norway
John Bates	Field Museum of Natural History
Walter Boles	Australian Museum, Sydney
Kimberly Bostwick	Cornell University Museum of Vertebrates
Gerald Braden	San Bernardino County Museum, California
Daniel Brooks	Houston Museum of Natural Science, Texas
Angelo Capparella	Illinois State University, Normal
Steven Cardiff	Museum of Natural Science, Louisiana State University, Baton Rouge
Alice Cibois	Natural History Museum of Geneva
Carla Cicero	Museum of Vertebrate Zoology, University of California Berkeley
Charles Collins	Ornithology Collection, California State University, Long Beach
Katrina Cook	The Natural History Museum, Tring
Scott Cutler	Centennial Museum, The University of Texas at El Paso
Becky Desjardins	North Carolina State Museum of Natural Sciences
Robert Dickerman	Museum of Southwestern Biology, New Mexico
Thomas Labeledz	University of Nebraska State Museum
Per Ericson	Swedish Museum of Natural History
Johannes Erritzoe	House of Bird Research, Denmark
Krista Fahy	Santa Barbara Museum of Natural History, California
Robert Faucett	Burke Museum, University of Washington
Jon Fjeldså	Zoological Museum, University of Copenhagen
Maureen Flannery	California Academy of Sciences
Sylke Frahnert	Museum für Naturkunde Berlin
Peter Saenger	Sarkis Acopian Center for Ornithology, Pennsylvania
Anita Gamauf	Naturhistorisches Museum Wien
Brian Gill	Auckland War Memorial Museum, New Zealand
Janet Hinshaw	University of Michigan Museum of Zoology
James Ingold	Museum of Life Sciences, Louisiana State University, Shreveport
Andy Jones	Cleveland Museum of Natural History
Jeremy Kirchman	New York State Museum
John Klicka	Marjorie Barrick Museum of Natural History, Las Vegas
Andrew Kratter	Florida Museum of Natural History
Kimball Garrett	Natural History Museum of Los Angeles County
Wayne Longmore	Museum Victoria, Melbourne
Michel Louette	Collections of the Royal Museum for Central Africa, Tervuren
Gerald Mayr	Forschungsinstitut Senckenberg
Henry McGhie	The Manchester Museum, The University of Manchester
Robert McGowan	National Museums of Scotland, Edinburgh
Jiří Mlíkovský	National Museum, Prague
Kees Moeliker	Natural History Museum Rotterdam
Jackie Nooker	Kansas State University Teaching Collection, Manhattan, Kansas
Tony Parker	National Museums Liverpool

Nathan Rice	Academy of Natural Sciences of Philadelphia
Mark Robbins	University of Kansas Natural History Museum
Stephen Rogers	Carnegie Museum of Natural History
Kees Roselaar	Zoologisch Museum, Universiteit van Amsterdam
Walter Sakai	Santa Monica College, California
Gary Shugart	James R. Slater Museum of Natural History, Tacoma, Washington
Roar Solheim	Agder Museum of Natural History and Botanical Gardens, Norway
Paul Sweet	American Museum of Natural History, New York
Pepper Trail	USFWS National Forensics Laboratory, Ashland, Oregon
Jeremiah Trimble	Museum of Comparative Zoology, Harvard University
Renate van den Elzen	Zoological Researchmuseum Alexander Koenig, Bonn
Zdenek Vermouzek	Ornithological Station of Comenius Museum, Czech Rep
Walter Wehtje	University of Missouri Bird and Mammal collection
Kevin Winker	University of Alaska Museum, Fairbanks
Raffael Winkler	Naturhistorisches Museum Basel
Jean Woods	Delaware Museum of Natural History
Friederike Woog	Staatliches Museum für Naturkunde Stuttgart
Robert Zink	Bell Museum, University of Minnesota
Kristof Zyskowski	Yale Peabody Museum