Mammals should be processed as soon as possible to avoid mixing of data and loss of specimens.

Voucher specimens

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Specimens that permanently document data in an archival report are called *voucher specimens*. Such specimens and corresponding data assembled during field studies of mammals, particularly the small and medium-size species that are difficult to identify and often poorly known, are critical for accurate identification of the animals studied and for verification of the data gathered and reported as resulting from the investigation. In addition, voucher specimens are critical for a wide array of future studies. Voucher specimens with extensive associated materials, such as tissue samples, chromosomes, and parasites, are particularly valuable. Such complete vouchers allow many different research projects to be linked in a network through the primary voucher. Primary specimen identification is important not only for research documentation, but also for assessment of change caused by natural or human perturbation. Voucher specimens will, therefore, play an increasingly important role in research on biological diversity. We highly recommend that vouchers with high-quality ancillary data be preserved.

Vouchers physically and permanently document data by (1) providing for confirmation of the identities of mammals accumulated and used in a study and (2) assuring that the study can be repeated, reviewed, and reassessed accurately (Yates 1985). Vouchers are the only reliable means of corroborating provenance of data accumulated during a study and documented in any reports of that study. The accurate identification of mammals is essential for providing credibility to the studies of these animals and to the publications that result from such investigations.

It is convenient to view mammalian voucher specimens in three groups: (1) type specimens, upon which names of taxonomic units are based; (2) taxonomic support specimens, which document identifications in taxon-based studies other than nomenclatural studies; and (3) biological documentation specimens, which document identifications of individuals obtained for genetic studies or environmental impact projects. Through time, a voucher specimen collected in a biodiversity study may serve all three functions. Photographs may suffice to document observations of especially large mammals or of protected species. Handling of these valuable materials should follow procedures similar to those described for actual specimens.

Standardized requirements exist for the data that should be affixed to each voucher specimen (see Appendix 3 and Yates et al. 1987). In addition, a considerable array of ancillary materials and data may be obtained and recorded for each voucher specimen (see Appendices 4–6). Recording and handling of data associated with voucher specimens of mammals must be taken as seriously as the handling of the specimen itself, because voucher specimens without accurate data are either suspect or worthless.

Field Identification

Accurate specific identification of small mammals in the field is rarely possible except in areas for which the fauna has been studied in detail. Even there, diagnostic characters are often subtle and difficult to see without magnification or, sometimes, dissection. Even mammalogists with considerable experience in an area commonly provide only generic or tentative specific identifications of specimens in the field. These names serve for bookkeeping purposes rather than for identification, and they facilitate tracking of numbers of species and specimens sampled.

Accurate species identifications are such an integral part of all aspects of comparative biology that studies without voucher specimens violate a basic premise of scientific methodology, that is, the ability of subsequent workers to repeat the study. Only voucher specimens provide a basis for verification of identifications and thereby duplication of a study. The literature is replete with examples of comparative studies in physiology, ecology, behavior, morphology, and systematics for which research results are questionable or even useless because of species misidentifications or failure to recognize that more than one species was involved. Most decisions relating to the management and conservation of species also depend on accurate species identifications. Voucher specimens are the only means to verify or, if necessary, correct specimen identifications and, therefore, are essential to scientific investigation in the above-mentioned disciplines.

All field identifications should be verified by a person with experience with the group, through the use of reliable and authoritative keys, or by comparison with specimens in museum collections. Vouchers should be deposited in appropriate repositories, usually a natural history museum. With erroneous field identifications, specimens of poorly known species may be overlooked, and important data may not be collected because the investigator assumes the species involved is well known. For purposes of sampling in little-studied regions, we recommend that all field identifications be treated as tentative and that all species be considered equally important.

Except for well-studied areas, such as North America and Europe, few useful field guides or identification manuals for mammals exist, and for many countries even lists of the recorded species are not available. Many of the older monographs on mammal faunas (e.g., Cabrera 1957–1961; Ellerman and Morrison-Scott 1966; Kingdon 1971–1982; Prater 1980) were based almost entirely on (often poorly) prepared museum specimens and are of limited utility for field identifications or even as sources of general information on geographic and habitat distributions. We suggest, therefore, that investigators become familiar with available primary literature before commencing an inventory and, whenever possible, that they examine museum specimens of species from the area of interest prior to beginning the fieldwork. Notes on the mammal fauna of the region with a list of the species and their diagnostic features should allow the worker to identify the more common species, focus on those of specific interest, and recognize any taxa that may be protected (see the section "Permits," below).

Because vouchers serve as the sole means of verifying data collected during investigations of biodiversity and provide critical information for future studies, the importance of voucher materials should be generally recognized and their preparation considered essential to good science. We acknowledge, however, that the removal and preservation of specimens for scientific purposes can be an emotional issue. Therefore, it is essential that field investigators carefully plan their studies in advance, clearly identify their objectives, and evaluate the need to collect voucher specimens. It is also essential that governmental and nongovernmental agencies requiring and supporting biodiversity assessments recognize the critical need for vouchers and provide support in both field and museum budgets for their preservation and maintenance.

Sample Size

What constitutes an adequate or optimal sample for the purposes of identification is not easily determined. For some species identification is possible from a single specimen (although this is rare); for other species, 20 individuals would not adequately sample the variation in the population, and a larger sample would be necessary.

Some species are polymorphic; some have striking sexual, ontogenetic, geographic, and/or individual variation; and others are relatively uniform even across broad geographic areas. Modern systematics takes into account this potential for variation and the significance of ancillary biological data in attempting to determine species limits. Gone are the days of running a single specimen through a key and magically achieving a reliable specific identification. This "cookbook" approach and the idea that a single specimen could be "typical" of a deme or a population, much less an entire species, are scientifically unsound. Keys, if properly constructed, can be useful tools in providing identifications, but these preliminary identifications must be tested by comparisons with descriptions in the literature and with museum specimens. The quality of keys, however, varies widely on a global scale; in some areas of the United States, keys are adequate, and in some poorly studied areas, they are nonexistent.

We agree with Frith (1973:3) that the number of animals removed from a population "really has no [biological] significance unless it is related to the total number of animals in the population and their rate of replacement." Many mammals are prolific, with reproductive potentials sufficient to accommodate increased levels of predation, although some species have low rates of reproduction. As predators on small mammals, scientists usually are singularly inefficient compared to snakes, birds, and other organisms. Furthermore, preparing specimens and documenting species (Appendix 3) are time-consuming tasks, and when done correctly, discourage human collectors from random "oversampling" (see also Foster 1982:6–7).

It would be convenient if we could provide an absolute value for, or formula to calculate, the number of vouchers of a given species that should be collected, but science is rarely convenient. Providing a meaningful formula for all 4,629 species of mammals is beyond our capability. For areas where the mammal fauna is well known, a single representative adult specimen of each population at each site will suffice minimally as a voucher for an inventory or monitoring study, unless the objective is to measure genetic diversity. Normally, the first adult of every species encountered during a project is suitable. For monitoring studies, we recommend that a voucher be prepared at the initiation of the study. If additional vouchers are required, they can be taken at the end of the study or from an area adjacent to the study site. As an operational figure, we recommend that 10 to 20 specimens would better represent the species at each site in well-studied areas.

Because we are in the early discovery phase and do not understand the taxonomic relationships of many tropical forms, and because many tropical areas are poorly known and numerous species are undescribed or inadequately represented in systematic collections, we usually recommend collecting many more than one voucher specimen when working in tropical areas. Generally speaking (and with an awareness of the frailties of any generalization), we recommend a sample of 20 individuals (ideally 10 adult males and 10 adult females) for identification purposes. We strongly encourage additional sampling of polymorphic species and those known to be inadequately understood taxonomically or suspected to include several taxa; for such species, samples of up to 25 males and 25 females may be adequate. A researcher who is interested in assessing genetic diversity within and among sites should prepare tissue samples for biochemical analysis (Appendix 4) and preserve voucher specimens of a minimum of 10 to 20 males and 10 to 20 females from each site.

Factors other than sample size can also affect the potential for accurate identification of specimens. Improperly or carelessly prepared specimens are often difficult or impossible to identify because diagnostic features are obscured or modified. Anyone collecting material for scien-

tific purposes should be intimately familiar with proper techniques for specimen preparation and documentation. Ecological information also often aids identification. Generally speaking, a small number of carefully prepared specimens with detailed data is preferable to a large, carelessly prepared sample with inadequate biological data. Instructions for preparing and preserving mammal specimens as vouchers are provided in Appendix 3.

Specimen Data

To fulfill their function as vouchers of monitoring or inventory studies, all specimens must be thoroughly documented with locality and relevant associated data. Data associated with voucher specimens enhance the value of the vouchers and potentially make identifications easier, but those data must be accurate.

In addition to full locality data in a standard format and information on sampling procedures and habitat (see the section "Data Standards," above), the minimum information required for each voucher specimen includes the following:

1. *Unique sample designation.* This unique field number is assigned by the collector to a specimen obtained at one place and time during the inventory. The number is noted on a field tag that is tied to the specimen.
2. *Date and time of collection.* The date and time (24-hr clock) that the specimen was collected and the date it was prepared (if different) are essential. The month should be written out (i.e., numeric designations or abbreviations are not used).
3. *Name of collector.* The collector is the person (or persons) making the collection. The collector's name is never abbreviated, and the middle initial is included when available.
4. *Taxonomic identification.* Ideally each specimen should be identified to genus and species. This level of identification often is impossible in the field; a family or other taxon name (murid, mouse, *Mus*) can be substituted for the scientific name until the animal is identified.
5. *Standard measurements.* The sex of the specimen should be entered both on the specimen label and in the field notes. In addition, the traditional measurements of total length (head-body length), tail length, length of hindfoot, ear length, and weight should be included in both places (see Appendix 3).
6. *Other information.* The existence of an associated special preparation (e.g., tissue sample) or other specimen data (e.g., behavioral observation, photograph) should be entered in the field notes and associated with the unique field number of the voucher specimen. Maps of the study area and trip itineraries are always useful for identification, cataloguing, and historical or archival purposes.

Most institutions require that the original or clear photocopies of a collector's field notes and catalogue accompany any incoming collection. The importance of good field notes to all subsequent use of the collection cannot be overemphasized. Poorly recorded field data can seriously mislead the specialist and reduce the usefulness of specimens. If the data accompanying the collection are a secondary compilation from the original field notes, they should be clearly labeled as such.

Selection of a Specimen Repository

Voucher specimens of mammals, including the data associated with the specimens, must be placed in an appropriate, recognized repository. The repository must adhere to at least the minimal standards for collection care and maintenance recommended by the American Society of Mammalogists (Yates et al. 1987). The specimens must be managed according to standard-

ized collection management procedures, made available for use by researchers, and protected for use by future generations. Voucher specimens and their associated data should be transferred to a permanent repository as soon as possible after collection in order to avoid their deterioration in the field or in inadequate temporary storage facilities. All publications involving the specimens should provide the name and location of the repository that houses them. This is true for both accessory material, such as frozen tissues, and the actual voucher specimen.

Voucher specimens from faunal surveys that are accompanied by detailed field notes and associated documentation have almost incalculable scientific value. Given the inevitable widespread habitat destruction that may preclude collection of additional material from many areas, and the rapid technological advances that allow for previously unsuspected uses of specimens, we can only guess at the possible significance of such specimens in the future. Consequently, this often irreplaceable "time capsule" of information should be permanently stored in a secure institutional collection with a documented long-term commitment to conserving specimens and making them available for study by qualified researchers.

The amount of time, space, and money required to maintain a museum collection is enormous, and relatively few institutions are able to provide the long-term security necessary for large research collections. Therefore, selection of an appropriate institution for the deposition of field vouchers is of critical importance. Establishing a private collection unavailable for study by qualified researchers does a disservice to the scientific community and often imperils the long-term survival of the study specimens. Many important collections are lost or destroyed when the collector dies or retires and his or her home institution loses interest in them or realizes it no longer can provide the space or funds required for their maintenance.

When a researcher from one country carries out a study in another country that involves the collection of specimens, it is highly appropriate (and often a requirement of the collecting permit) for representative material to be returned, after identification, to designated institutions in the country of origin for the purpose of establishing functional reference collections. All such studies should involve appropriate in-country collaborators, a practice that will facilitate specimen deposition. The primary concern of all responsible biologists should be the long-term maintenance of specimens and associated data and their availability to qualified scientists for study.

Several variables influence the choice of a deposition site for collections; they are discussed by Lee et al. (1982). If identifications are required, an institution that has a history of research in the geographic area, an appropriate specialist on the staff, and access to extensive library facilities is optimal. Prospective donors should, however, obtain a statement of the museum's policies regarding acquisition, preservation, maintenance, and deaccessioning of collections to determine if these policies meet their needs. Most institutions will honor reasonable requests from the donor, but policy is determined by many factors.

The identification, distribution, and cataloguing of voucher collections is a service provided by museums to the scientific community. Many museums are currently suffering from budget cuts and staff shortages. The identification of a large collection often occupies many hours of staff time. It may require a curator to borrow specimens or visit other institutions so that pertinent materials may be compared directly, to lend specimens to specialists for identification, and to search the literature. Altruism, if it exists, has its limits. The donor must keep in mind that few museums can afford to invest the time and energy required to identify a major collection without the complete cooperation of the donor. If

assistance with identifications is requested of an institution but the collection is to be deposited elsewhere, the requester should offer at least to deposit representative material in the institution that provides the service.

Donors often expect institutions to maintain a voucher collection as a discrete unit, separate from the main collection. This desire is understandable, but most institutions cannot accommodate such requests, because of limited space and curatorial support. Whether a voucher collection should be maintained in a single institution or distributed among several is also debated. Each option has merit. The first obviously simplifies future study of the collection; the latter provides for greater access by researchers in many areas. Donors concerned about this issue should ask about an institution's exchange policy before depositing specimens there.

Permits

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During the past few decades, the number of laws regulating the collection, acquisition, study, transport, and disposition of wildlife and wildlife products has increased significantly. These laws have been proposed and promulgated in an effort to control activities that are deemed harmful to animals and plants. Although habitat loss generally is acknowledged to be the primary factor affecting species' distributions, abundances, recruitment, and extinctions, commercial exploitation also has had a detrimental effect on certain species of wildlife.

Some species considered to be endangered, threatened, or otherwise in need of protection have been protected by international treaty (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES]), or various federal (Federal Register 1973, 1995, and published amendments), state, and local laws. Additional regulations are stipulated by the International Union for the Conservation of Nature and Natural Resources. The laws and regulations contained in the U.S. Endangered Species Act and in CITES are those of primary concern, but many other foreign, federal, state, and local regulations may also apply to users of this manual. Many states, for example, require permits for the use of traps; permission to use such devices to sample mammals should be clarified with the local authority. Other regulations with which travelers should be familiar restrict the transport of liquid nitrogen, alcohol, and formalin, or the possession and transport of syringes and certain killing agents, drugs, or chemicals used in specimen preparation.

Laws regulating scientific collecting vary widely among states and countries and change constantly. Furthermore, the government agencies responsible for issuing collecting permits sometimes change or are restructured. Current information on most international and federal regulations and responsible agencies can be obtained by writing to or calling the U.S. Fish and Wildlife Service, Office of Management Authority (4401 N. Fairfax Drive, Arlington, VA 22203 USA; telephone: 703-358-1708). Interpretations of laws and regulations designed to protect animals in the United States are provided in the Code of Federal Regulations (1973, 1979) and a report from the National Research Council (1985). Information on state and local regulations can be obtained from the appropriate conservation or management agency in the jurisdiction of interest. The variation in requirements often makes obtaining collecting and export permits a trying process. Nevertheless, it is the responsibility of the individual collector to learn about and comply with the relevant regulations as they apply to mammals. Although certain provisions of a collecting permit may appear to have little bearing on the conservation of species