Report of the Committee on Resources in Herpetology

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THIS Committee was organized in 1973 as the result of discussions between officers of the American Society of Ichthyologists and Herpetologists (ASIH) and a variety of interested parties. Members of the Committee held preliminary discussions in June, 1973, at the ASIH meetings in San Jose, Costa Rica, and formulated the basic concept of a broadly-based investigation of herpetological resources. We sought and were granted recognition as a joint committee of the ASIH, the Society for the Study of Amphibians and Reptiles (SSAR) and the Herpetologists' League (HL). Subsequently, we were appointed as an Advisory Committee for Herpetology by the Association of Systematic Collections (ASC). A proposal to the National Science Foundation was funded in the Fall of 1973. The fundamental objective of the Committee was stated in that proposal: “to determine the nature of the resource in systematic herpetology, to identify problem areas both in terms of resource management and utilization, to consider the state of current research in systematic herpetology, and to prepare a report which will include recommendations for effective use of the resource in the fulfillment of scientific and societal goals.”

As a result of our deliberations, we herein characterize the field of herpetology and consider a number of issues related to resources in this field. We have developed the following series of recommendations; these are discussed in detail in the body of the report:

Museum Collections
1. Provide funding for the general support of management activities of systematic collections.
2. Encourage the use of modern data processing by collections.
3. Develop and maintain depositories for viable tissues, and encourage the development of other special collections.

Living Resources
4. Support a coordinated effort in research and development of basic husbandry projects for reptiles and amphibians. Priority should be given those projects involving species of present or potential importance in education and research, or selected species that are threatened by habitat destruction.

Natural Resources
5. Support development of a coordinated plan for the preservation and management of wild populations of reptiles and amphibians.

Human Resources
6. Employ with greater efficiency and imagination the rich pool of human expertise needed for proper development, optimal care and intelligent utilization of collections, living and natural resources.

HERPETOLOGY IN PERSPECTIVE

Herpetology is that field of biology concerned with the study of amphibians and reptiles, organisms that are used extensively in research, education and commerce. Our charge was to survey resources in systematic herpetology and to make recommendations concerning their use, preservation, management and development. We interpreted the charge broadly and considered all use of the groups as well as the users. Herpetological resources considered here include organisms in nature and captivity, museum preparations, the literature, and human resources such as collectors, breeders and suppliers of amphibians and reptiles (for research, education, food, recreation and other uses), researchers, curators, technicians and students.

Frogs, salamanders, lizards, snakes and turtles play a much larger role in the lives of many people than is ordinarily recognized. Amphibians and reptiles have been studied from the
Amphibian eggs, embryos and larvae have been essential to embryologists and developmental biologists from the time of von Baer's classical descriptive embryology through the period of experimental studies by Harrison, Spemann and many others, to Gurdon's present studies of nuclear transplantation. Physiologists use amphibian and reptilian organs for studies of kidney function, membrane phenomena, retinal function, muscle physiology and in other ways. Studies on amphibians have disclosed the nature of diuretic and antidiuretic hormones, have shown how input into the nervous system can be modulated by other than central mechanisms, and have elucidated details of immune responses (T and B systems). The unique specificity of snake venom nucleotidases played a crucial role in the sequencing of transfer RNA which earned Holley the Nobel Prize. Amphibians and reptiles live their lives in "slow motion" and are convenient for many kinds of physiological and biochemical analyses.

Use of amphibians and reptiles in biomedical research is increasing. An example is their use by transplant immunologists; another is the culture of their large, easily maintained cells and tissues for studies of cell growth and association. Reptiles, the "first" amniotes, are studied during the development of techniques to be applied to more derived, less malleable mammals. The ecologically endangered crocodilians are the only higher vertebrates with highly alkaline urine; this condition is being studied to provide understanding of the dynamics of kidney function. Comparative studies of protein evolution in frogs and snakes reveal perplexingly higher evolutionary rates than do their morphological features. Amphibian cells are useful for studies of gene amplification because of the size and delineation of meiotic chromosomal strands.

Reptiles and amphibians are frequently used in ecological and behavioral studies. They are less "buffered" from the environment than are warm blooded organisms, and often rapidly reflect environmental change. Moreover, recent studies on lizard field ecology hold promise for elucidating the effects of interspecific competition on community structure. Amphibians and reptiles play major roles in biotic communities. They are important predators and prey. In some ecosystems, such as ponds, amphibians are dominant elements in energy transfer. Behavioral studies such as innate response vs. learning are facilitated by use of reptilian subjects.

Educational use of amphibians and reptiles is extensive. The first vertebrate a prospective physician dissects is usually a frog. Turtles are frequently used in physiology courses, where they are ideal animals for demonstrating principles of cardiac function. Tadpoles are raised in classrooms to demonstrate metamorphosis.

The non-scientific public contacts amphibians and reptiles in diverse ways. Children chase frogs and raise tadpoles. Reptiles, particularly turtles and snakes, are popular pets. In 1970 and 1971, over five million amphibians and reptiles were imported into the United States. Most of these were destined for the pet trade (Busack, 1974). In this country reptile houses are among the most popular exhibits at zoos, which attract about 100 million people each year. Frog legs are traditionally found on restaurant menus throughout the world (in 1973, over 3,000,000 kg of frog legs were sold in the United States alone). Turtle meat and eggs are supplemental protein sources, and are major food items in some areas. Reptile hides serve in wearing apparel, wallets and purses and "tortoise shell" is valued for jewelry and buttons. Amphibian hides are important in high fashion decorations. These organisms frequently appear in pre-Columbian art, and from dragons to salamanders they have been major elements of folk legends. Their place in literature spans Aristophanes' The Frogs and Koestler's The Case of the Midwife Toad.

THE HERPETOLOGICAL COMMUNITY—GOALS AND PRIORITIES

In order to provide a profile of the herpetological community and to determine needs and priorities of herpetologists, a detailed survey was conducted. This survey provided statistical information that has served as the basis for our discussions and has guided our thinking in preparing recommendations.

Background of survey.—The mechanisms of our survey took several forms: two questionnaires,
regional meetings and special depositions. By these techniques we collected data for guidance of the Committee, granting agencies and other interested groups. However, recognizing the limits of each type of survey instrument, we also depended on the experienced judgment of members of the Committee.

The initial questionnaire was sent to individuals in the United States who were on the mailing list of the Herpetological Information Search System. This list includes the membership of the Herpetologists' League, Society for the Study of Amphibians and Reptiles, American Society of Ichthyologists and Herpetologists, and several smaller, regional organizations. In addition, questionnaires were distributed to suppliers and other users of herpetological materials. Thus, the questionnaire reached essentially all systematic herpetologists in the United States, as well as others with different orientations. Over 3,000 questionnaires were distributed. By evaluation time, 15 June 1974, 1,544 responses were received. Of these, 443 were incomplete or had to be rejected for other reasons. A total of 1,101 questionnaires were keypunched and analyzed. Portions of the user community, such as general educators and bio-medical researchers, perhaps are underrepresented in our sample. We recognize from the relevant small samples in the survey that nonherpetologist users missed in our sample may have different priorities than self-professed herpetologists.

Result of questionnaire.—Herpetologists have diverse interests ranging from physiology through ecology to museum-oriented systematics. Some herpetologists focus on a particular organism and a specific research area, whereas others deal with many species in many areas. Some workers are highly oriented to the organisms, and develop research projects around them; others are more problem oriented, using these animals because they have unique characteristics. Herpetologists are not all researchers; some are teachers, some are hobbyists, others are commercial suppliers.

All areas of the United States were represented, with highest response from the populous states and poorest representation in areas of low population density and low herpetological interest (Alaska and the northern plains states). Almost 46% of the sample was between 25 and 35 years in age, over 12% was less than 25 and only about 5% was over 55. Nearly 13% of the individuals spent more than 80% of their working time in herpetological pursuits, but almost 30% spent less than 20% of their time in such a manner. About 43% of the sample had more than five years of professional experience.

The breadth of interests was great. Nearly half of the total (1,101) had ecological interests (541) and the next most heavily represented areas were education (436), behavior (395), systematics and taxonomy (356) and evolutionary biology (268). Most (825) respondents regularly used living materials, but preserved animals were also used extensively (431). Surprisingly, 689 individuals maintain some kind of collection, and 400 were involved with organized or unorganized collections of whole preserved specimens, skeletons, or both. Primary goals of respondents vary from research leading to technical publications (574) to teaching (422), self education (398), conservation (299) and public education (228). Only ten had profit as a primary goal, while 33 listed public health and 179 listed recreation.

The principal services provided ranged from basic research (649) through educational (556) and environmental (250) to public communication (174) and biomedical (64) service. The principal source of funding for support of the primary goals was personal funds (445) (254 respondents listed state or local government, 177 federal government and 169 private institutional donors).

The priorities question was answered by 658 of the 1101 individuals listing each priority level only once. Other respondents (443) completed this question by scoring each priority on a scale of 1 to 5. Among both groups support for individual research projects received the highest priority. A total of 78.3% of the 658 respondents placed support for individual research projects in the first five priority categories. Setting aside and managing natural areas (72.5%) and team research (70%) also ranked very high. Mean priority levels for these three top priorities were 2.3, 2.4 and 2.8, respectively. A total of 345 (78%) of 443 respondents who used the alternative response mechanism listed individual research among the first five priority items. Setting aside and managing natural areas (76%), team research (74%), general aid to museums and computerization of museum collections (69%), special facilities (68%), and training programs (67%) were frequently listed among the first five priorities. Only natural areas (207) was more frequently placed in the top priority level than individual research projects (152).
These priorities were to be expected from a group of university-oriented professionals who identify themselves as herpetologists. Research interests led many of them into biology, and the priority for individual and team research support is reinforced as it is the basis for the publications on which the established academic reward system is based. Further, most biologists are deeply concerned over the decay of the natural environment, and have strong conservation interests which could best be expressed in this questionnaire by placing high priority on support for natural areas.

Certain subgroups of respondents had special priority interests. Of interest are the shifts in priority associated with amount of time spent in working with reptiles and amphibians, experience of the individual, and his age. For example, those who spend less than 20% of their time working with amphibians and reptiles placed natural areas as the top priority, while those who spend over 80% of their time in such pursuits strongly favored individual research. Professionals employed less than one year also chose natural areas as the top priority, but those with over five years' professional employment strongly favored team research, with individual research having a higher priority listing than setting aside and managing natural areas. General aid to museums was important to professionals with more than 15 years' experience, who placed it as a close second to support of individual research. Strong support for certain special programs was apparent. For example, support for breeding colonies, although included in the priority lists of only 32%, ranks highly among these respondents [mean priority level 3.0, higher than all but individual research (2.3) natural areas (2.4) and team research (2.7)].

**Resources in Herpetology**

*Museum collections.*—Museums, the traditional sites of systematic research and the archival units of science, are the only permanent institutional elements in systematic herpetology. They are the repositories of standards for the biological sciences as the Bureau of Standards is for the physical sciences. As organisms become increasingly difficult to obtain in the field, new specimens should be preserved even more effectively than in the past. To an increasing degree material preserved now will determine the nature of future systematic research.

The Committee has identified, evaluated, and categorized existing collections in the United States. An initial study was conducted by a committee of the American Society of Ichthyologists and Herpetologists, under the chairmanship of George B. Rabb (other members were Richard Estes, Richard Etheridge, David Jameson and Thomas Parsons). The Rabb Committee evaluated 21 of the larger collections, and advised the National Science Foundation on its evaluation of their relative importance. Their report to the National Science Foundation in 1972, and relevant background information collected by that committee, have been available to us. We expanded the survey and added information obtained from both of our questionnaires and from suggestions of individuals made at our open meetings in Lawrence, Berkeley and Ottawa.

Collections are highly diversified, and we recognize six general categories.

Five major collections (over 200,000 specimens) have wide cosmopolitan representation and house large numbers (over 350) of primary types (holotypes, synotypes, lectotypes, neotypes): AMNH, CAS, FMNH, MCZ, USNM.¹ These are old established collections that have long been the basis of much fundamental research in systematic herpetology. Together they hold nearly one and a half million specimens and over 4,300 primary types. Four are associated with large public museums and the fifth (MCZ) with a major university. Three collections have two or three professional herpetologists as curators, but two (CAS, MCZ) have only single curators.

A second group of five large collections (100,000 to 250,000 specimens) gives special emphasis to New World materials and has varying degrees of cosmopolitan representation. Together they house 700,000 specimens and

¹ The following abbreviations are used: AMNH (American Museum of Natural History); ANSP (Academy of Natural Sciences, Philadelphia); BYU (Brigham Young University); CAS (California Academy of Sciences); CM (Carnegie Museum of Natural History); FMNH (Field Museum of Natural History); KU (University of Kansas Museum of Natural History); LACM (Natural History Museum of Los Angeles County); MCZ (Museum of Comparative Zoology, Harvard University); MVZ (Museum of Vertebrate Zoology, University of California); SDNHM (San Diego Natural History Museum); TCWC (Texas Cooperative Wildlife Collection, Texas A&M University); TNHC (Texas Memorial Museum); TU (Tulane University); UAZ (University of Arizona); UCMM (University of Colorado Museum); UF (Florida State Museum); UMNH (University of Illinois Museum of Natural History); UMMZ (University of Michigan Museum of Zoology); USNM (National Museum of Natural History).
over 700 primary types (from 40 to 283 per collection). Three collections (KU, MVZ, UMMZ) are associated with major universities that have long traditions of graduate education in systematic and evolutionary biology. Two (CM, LACM) are associated with smaller museums, and have somewhat limited cosmopolitan collections. This group is fairly disparate. UMMZ is the largest and oldest, with the largest number of primary types, and it has three curators. LACM, the most rapidly growing collection, has been actively consolidating regional collections.

A third group includes 10 collections of moderate size (about 30,000 to 100,000 specimens), with regional specializations or special historical significance: ANSP, BYU, SDNHM, TCWC, TNHC, TU, UAZ, UCM, UF, UIMNH. They house a total of about 500,000 specimens and over 800 primary types (500 at ANSP). Only two (ANSP, SDNHM) are associated with public museums. Eight are associated with universities, and three of these have developed principally as departmental collections without (at least until recently) special autonomy. ANSP is an old and very important collection that has grown very little in recent years. UIMNH is the largest collection in the group, but, regrettably, it lacks a professional herpetologist, even though it is still maintained. UCM unfortunately did not replace the recently retired curator with a professional herpetologist.

The fourth group includes a number of relatively small collections (fewer than 50,000 specimens) of regional significance. They house few primary types, and several of them are maintained by individuals who are not systematic herpetologists. Most originated as teaching collections that subsequently expanded.

Private collections in the United States range in size from a few specimens to nearly 100,000. Most of the owners of the larger private collections have provisions for eventual deposition of their specimens in some major institutional collection. Many private collections are “special,” emphasizing one group or one geographic area, or are comprised of special material, e.g., skeletons, slides, etc.

About 30 individuals who returned questionnaires maintain herpetological material in the “vital” state, for use in comparative studies at the protein or metabolic level. Such studies require that the constituents of cells be as near the native state as is possible. Therefore, deep frozen tissues, generally, are needed rather than traditionally preserved specimens. Most such collections are housed in the laboratories of individual scientists; however, one has been organized formally as a special unit of MVZ.

Living and natural resources.—The materials maintained in museums and special collections are fractional extracts from nature. Another kind of resource, dealing with the whole organism, is represented by collections of live animals maintained on a long-term basis. A tabulation was made (1974 American Association of Zoological Parks and Aquariums directory) of public collections that kept 100 or more specimens of reptiles and 20 or more amphibians. There were about 50 such institutions, and together they harbored over 16,000 living reptiles and 2,000 amphibians. There were several large collections with over 200 species of reptiles and two with 300 (Columbus, Ohio; Dallas, Texas). Several private, university, commercial or governmental facilities maintaining substantial numbers of reptiles or amphibians are also known to us. Important units are Miami Serpentarium, U. S. Army Medical Research Laboratory Serpentarium, Louisiana State University Amphibian Facility, Indiana University Axolotl Colony and the Amphibian Facility at the University of Michigan. The latter has several thousand amphibians at any one time. These serve both for in-house research and as a source of captive-bred material for researchers at other institutions.

Captive live animals are extracts from yet another kind of resource, that of nature. Field populations are essential for nearly all aspects of herpetological research. Collecting for research and educational purposes presumably has a marked impact on wild populations. However, concrete data to support this presumption are lacking. Astonishingly large numbers of amphibians and reptiles are collected each year. An estimated 20 million preserved and living amphibians were used for educational purposes alone in the United States in 1971–1972, and another two million amphibians are used each year in research laboratories (National Academy of Science, 1974). Most of these have come from domestic sources, but imports are also significant.

In recent years there has been increasing concern for the natural populations which supply these massive numbers of organisms. Unfortunately, we know little about the sizes of wild populations and sustainable yields of most species of amphibians and reptiles, including those that figure prominently in commerce for food, clothing, pets and research materials.
There are now several established facilities that demonstrate progress toward the development of successful breeding programs. With additional support they might become sizeable enough to be able to supply a significant percentage of the high quality amphibians required for research and educational needs in the future.

Several zoological gardens and other organizations are attempting to establish breeding programs for species whose natural habitats have been restricted by man's activities. Such programs may be feasible for certain large species of reptiles, in particular turtles and crocodilians.

The amount of natural environment in North America, and in the world generally, decreases daily. Mechanisms must be found to set aside more natural areas than are now preserved. This is a general problem, with ramifications far beyond the limits of herpetological resources, but one that cannot be ignored.

**Human resources.**—The vast human resource in herpetology includes the professional and para-professional curatorial staffs of collections, researchers, college and university teachers, and graduate and postdoctoral students. Unlike some areas of systematic biology, graduate training centers for herpetology are numerous, and there are many well trained systematic herpetologists. This has contributed to the healthy diversity that characterizes the field. For example, the 28 curators of the 20 largest museum collections received graduate training at 15 different institutions.

It is through the effort of the human resource that the public is made aware of herpetology. Knowledge of amphibians and reptiles and herpetology as a science largely reaches the public in informal educational channels, including newspapers, magazines, books and exhibitions. In their latter role, museums and zoos provide direct means of public contact. Some museums and zoos are progressing from simple taxonomic orientation of their exhibits to more sophisticated illustrations of principles of animal behavior, ecology and evolution.

In addition to public exhibits and animal collections, museums and zoos have housed the majority of notable contributors to the popular and semi-technical literature on reptiles and amphibians. Many amateur and professional biologists and many other members of the public have gained their acquaintance with herpetology through the writings of museum and zoo people. Perhaps the prime example is that still familiar bookstore title “Reptiles of the World,” first published in 1910 by Raymond Ditmars, Curator of Reptiles at New York Zoological Park. A less well-known but redoubtable classic is “The Biology of the Amphibia” by G. K. Noble of the American Museum of Natural History. More recently written are standard identification books for the U. S. herpetofauna, especially the two Peterson Field Guides by Roger Conant and Robert C. Stebbins. About 20,000 of these books are sold each year.

Another kind of public service is provided by the professional herpetological community in the form of advice to public school teachers on instructional use and care of reptile and amphibian materials, to publishers and general writers, to physicians on envenomation problems, to governmental conservation agencies, and diverse other inquirers. As illustrated by many examples in the recent book by Neill (1974), such advice, and the contents of popular and technical publications, exhibits and other media of communication dealing with amphibians and reptiles largely depend on the research products of the professional herpetological community.

**RECOMMENDATIONS**

Results of our two questionnaires addressed to the herpetological public and to collections provide a basis for our recommendations. As expected, there is very strong sentiment, most prominent among the more experienced and senior individuals, that money for basic research should have top priority. While our principal orientation has been to evaluate herpetological resources, we recommend continued and increased federal funding for individual research and for carefully designed team research projects. These should be evaluated, on the proposal basis, by peer review systems, such as those operated by the National Science Foundation.

Our formal recommendations are addressed to resource issues.

**Collections**

Contributions of systematics collections and problems that they face as a group are well documented (Association of Systematics Collections, 1973). Here we focus on special features relating to collections of amphibians and reptiles.

**Archival nature.**—Systematic collections are primary resources for reference as well as research. Materials are constantly flowing in and out and undergoing internal reorganization. Preserved
alcoholic specimens comprise the bulk of most collections. Research in systematics and natural history, and studies concerned with environmental pollution depend heavily upon this resource. Collection data are used for the preparation of distribution maps and faunal lists. Accessory collections of sound tapes and cine-films store aspects of amphibian and reptilian behavior. Specialized libraries have developed in conjunction with collections; these are used by students and visiting researchers, as well as personnel associated with the collection, and are often the source of specialized information desired by the public.

Professional activities.—Curatorial staff use collections in their own research, enhancing the value of the material used, and reporting the results in technical publications. Unlike much research which is of interest only to a restricted audience, such research is important to a wide variety of professionals. Taxonomic keys, faunal lists and similar aids are used by ecologists in the analysis of communities and ecosystems. Systematic studies provide the experimental biologist with the identities and relationships of their experimental subjects, and evolutionary biologists with techniques and new conceptual advances.

Collections are major graduate training centers in herpetology. One of the most productive of these, UMMZ, produced 33 PhD's between 1906 and 1972, 14 of them since 1961. Other large university museums (especially MCZ, MVZ, UK) also have been highly productive, and graduate students are heavy users of collections. Nearly all curators, even in non-university museums, have university affiliations and are involved in graduate training.

Services.—Characteristically museums and their personnel provide public service in many forms. Curators design museum exhibits that allow the public to become familiar with amphibians and reptiles while simultaneously introducing them to basic biological concepts. They regularly provide technical advice to conservation and public service groups, and consult with other institutions and organizations concerning matters in their area of expertise.

Collection management.—To function effectively, collections must be properly managed. Materials in collections must be prepared carefully and stored to assure long-range preservation. Orderly collections should be arranged with each item accompanied by reliable data.

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<td>Technical aid (principally curatorial assistants)</td>
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<td>Curators</td>
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<td>Storage space</td>
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<td>Facilities for visiting workers</td>
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<td>Equipment</td>
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Guidelines designed to aid curators in achieving these goals are to be published elsewhere.

Problems faced by systematic collections in meeting goals.—The results of Questionnaire II provided information concerning the greatest areas of need facing collection managers. Manpower was the principal requirement (Table 1). Storage, visitor’s facilities and special facilities (such as live animal rooms) for collection-related research also received frequent or high priority mention.

Needs for assistance and space are so great that other major requirements cannot even be considered by many collections. The press of daily events associated with the steadily growing collections does not allow time for innovation and development of special facilities. Curators find their time occupied with teaching, public service, direction of graduate students and administration. Curators are expected to be researchers first in most institutions, and they must have technical assistance if they are to maintain their professional status. When curators can rely on technicians for cataloguing and other such technical operations, they will have more time to plan collection management activities.

The great assets of computerization of collection data and formation of data retrieval networks are clear. However, current collections must be brought up to minimum standards, so that accurate information can be placed in such a network. Many collections desire computerization, but technical assistance is a top priority for that too. At the present time the obstacles to a nation-wide herpetological data network are formidable, including absence of hardware at some institutions, severe manpower shortage at others, and lack of conviction among curators.
that such a network is a high priority item in the face of other great needs.

The advent of new and diverse investigations in systematic and evolutionary biology has placed an increasing demand on systematic collections. The analysis of anatomical, physiological, genetic, behavioral and ecological parameters often utilizes novel kinds of material that must be stored for later reference and use. Herpetologists are using laboratory methods with increasing frequency. Voice recording and analysis, perhaps the first laboratory methods to be widely exploited, are now almost routine in studies of frog natural history. Cytological, biochemical and immunological methods are of more recent vintage. The number of papers in systematic herpetology using these techniques has dramatically increased in recent years. Such work previously was published in physiological or biochemical journals; now it often appears as an integral part of systematic studies in the professional journals of herpetology.

Use of advanced laboratory techniques will increase. Herpetologists have yet to take full advantage of the well developed methods of the cytologist and polymer scientist. Some promising techniques in systematic and evolutionary biology, and their applications, include: differential staining of chromosomes which allows far more objective comparisons of karyotypes than were previously possible (Hsu, 1973); in vitro cell hybridizations coupled with high resolution electrophoresis of proteins which together can yield evidence on protein inheritance and chromosome maps of animals difficult or impossible to breed under laboratory conditions (Harris, 1970); and a rapidly expanding battery of relatively simple yet powerful biochemical and immunological methods for obtaining comparative evidence on protein structure which, in turn, can help characterize taxa, yield measures of extent of divergence of phyletic lines and suggest when divergences occurred (Dessauer, 1974).

Maintenance of living cell lines, viable tissues and proteins of herpetological origin presents problems far more complex than those usually encountered in natural history museums. Herpetologists using electrophoretic and immunological methods have already confronted problems concerning storage of such materials; storing cell lines for cytological work involves even more formidable problems. Comparatively little is known about the relative stability of different proteins, and even less about the survival of cell types during long term storage. Many proteins of freeze-dried tissues retain their activity for long periods if the preparation is kept dry and cold; a majority of proteins of frozen tissues seem to remain undenatured indefinitely if stored at ultradep freeze or liquid-N temperatures. Some proteins will remain active for at least moderate periods in tissues preserved under field conditions in aqueous solutions of phenoxyethanol (Nakanishi et al., 1974). Generally, tissues preserved in more standard museum fluids are valueless for molecular studies using current techniques.

In the future, special efforts should be directed toward securing samples of tissues from rare species and from those which are difficult to obtain. Each such animal collected should, in principle, serve as a source of information at many levels of organization, from behavior to protein sequence. To this end field biologists should be taught techniques for collecting tissues in the vital state along with traditional museum procedures.

Recommendations for collections.—The following recommendations concern support for collections so that they may better serve science and society. We make no recommendations as to which collections should receive support. In general, peer review of proposals should be the basis for funding. However, at least initially emphasis should be on larger collections, where services and needs are relatively greatest. Coordinated projects are desirable, and several units might apply jointly. Similarly certain special facilities might best be established for several different kinds of collections housed at a few selected institutions. Special analytical laboratories, frozen collections, and other operations too costly to be feasible for a single department become financially more reasonable if they serve several disciplines. Again, we make no recommendations concerning such special facilities, for we believe that planning for them will be most effective when stimulated by local needs. Without local expertise and interest such facilities cannot be supported. For this reason, intramural but interdisciplinary applications should be encouraged.

Funding should be provided to existing collections with the assurance that institutional support will be maintained at least at approximately the same level as that prevailing at the time of application. Collections should not embark on new programs too costly to be maintained if funding is withdrawn. Collections receiving support must be permanent, but some
pilot projects which may or may not become permanent should be considered. New programs started with federal funds should also have some assurance of continuing support should they prove to be of value.

The first three recommendations are placed in a general priority sequence, in that recommendations 2 and 3 depend to a large degree on recommendation 1. These recommendations have been generated by the Committee as a result of a conscious decision to place stress on museum collections, and not exclusively from needs expressed in our first questionnaire.

RECOMMENDATION 1: Provide Funding for the general support of management activities of systematic collections.

Curators of the 20 principal collections gave increased technical assistance very high priority (Table 1). Technical assistance was the highest priority item for 14 of the 20, and an additional four indicated that their greatest need was at the curatorial level, with technical assistance second. Only two museums had a requirement for other than human assistance as their highest priority. Both cited curatorial or technical help as second priorities.

Service functions can only be performed when collections are in good order. To achieve the expectations outlined in our "Guidelines" (see Collection management, above), the principal requirement is clearly additional manpower.

Several collections are growing at a rate of nearly 10% per year, and others grow at rates of 3–5%. With over two and a half million specimens in only the 20 principal collections, the staggering amount of labor facing curatorial personnel is evident. If a 3% annual growth is assumed to be average, 75,000 specimens are catalogued each year. Faced with such numbers, most curators can only catalogue and enter specimens into collections. All museums have backlogs of uncatalogued materials, approaching 50% in some museums. Keeping collections current in terms of taxonomic revisions, upgrading indices and initiating innovations in management procedures are often impossible due to other pressing matters.

Valuable collections of materials or specimens frequently are amassed at institutions where later, for one reason or another, they are deemed no longer of value to the institution. Also, many owners of private collections recognize that provision should be made for the continuing professional care of their collections, for collections without constant curatorial care deteriorate rapidly. It is vital that collections endangered either by a loss of professional interest at a given institution or potentially endangered by being in private hands be saved. Ideally these should be transferred to a major collection where tradition and institutional policy assure permanent care. We recommend that the herpetological community take the initiative in identifying endangered collections and that the National Science Foundation be responsive to requests for funding transfer of such collections to safe repositories. In many instances, funding will be needed not only for packing and transfer of collections, but also for renovation of space and purchase of storage equipment and supplies. Where very large numbers of specimens are concerned, funding of technical assistance would also be appropriate.

As new techniques for the analysis of genetic, physiological, ecological, behavioral and anatomical parameters of amphibian and reptilian biology have developed, new demands have been placed on collections. Items such as karyotypic and histological slides are compatible with standard museum storage techniques and require only additional time, cabinets and space. Other items require more technical equipment and expertise, and most museums are ill equipped to provide even minimal care necessary for their safe storage. Most of these materials are currently stored in the laboratories of researchers, whose institutions are unable to assure a long term commitment to their safe keeping. These are valuable resource specimens, yet they will be lost to future researchers if past trends are followed. The continual reduction of natural populations emphasizes the need for the immediate preservation of these novel collections, for we have no idea of their future importance in the development of new biological concepts. Incorporation of novel materials should be encouraged by cooperative agreements. In order to avoid complete overlap, different collections should develop different specialties, reflecting the expertise of the curators and technical support staff.

RECOMMENDATION 2: Encourage the use of modern data processing by collections.

The advantages of computer storage and retrieval of specimen related data are manifold and need not be elaborated here as they are well known to the potential user community (Association of Systematics Collections, 1973). We regard it desirable and perhaps even inevitable...
that information in the major collections be computerized. However, with the high priority given to funding technical assistance, we do not think that adopting data processing should be a condition of receiving aid to upgrade a collection.

In any consideration of funding computerization of collection records, several items must receive serious consideration:

1) Does the collection have any effective information retrieval system at the present time? (Might limited funds better be spent in some other fashion?)

2) Is it proposed to make the data entry retrospective? (Recovery of data from only part of the collection may be of little use.)

3) At the minimum, taxonomic and detailed geographic information must be retrievable easily and cheaply. (Ideally, the system should easily do much more than this.)

4) If and when the collection records are wholly computerized, does the grantee institution guarantee continuing support of the computer system? (Is there a possibility of data being irrecoverably locked into the EDP system?)

5) Will the proposed system be compatible with systems at other institutions or for other kinds of vertebrate collections?

Computer files must be kept current by adding the recent taxonomic emendations, correcting collection data, determining new data units to be added and so forth. Computer methods may ease greatly the effort by which these kinds of changes are currently made. However, whether data entry and careful editing will require more effort to be maintained than by traditional procedures is debated by members of the Committee and by others (Shefler, 1974). Certainly increased emphasis will be placed on accuracy in an improved data retrieval system. We make no specific recommendation concerning either hardware or software.

While a nation-wide computer network would have major impact in certain areas, the herpetological community clearly places several items above computerization in its priority lists. Computerization of museum collections ranked fifth out of ten choices, whereas general aid to museums was fourth. The desire for computerization ranked higher than aid to museums among individuals who spend less than 20% of their time with amphibians and reptiles. As time spent increased, general museum aid received higher support than computerization. The same trend was observed when analyzed by years of experience with amphibians and reptiles. Among individuals whose primary employment is in museums, 76 placed general aid to museums among their top five priorities (average priority level about 3), as compared with 54 for computerization (average priority level also about 3). Even systematists, who among all user categories would benefit most in the immediate future from computerization, more frequently place general museum aid in their priority list (157 as compared with 150 for computerization; priority level about 3 for both). Only six respondents whose primary employment is in museums gave top priority to computerization, while 18 gave top priority to general aid for museums.

**RECOMMENDATION 3:** Develop and maintain depositories for viable tissues, and encourage the development of special collections associated with new approaches to research.

We recommend establishment and maintenance of a limited number of regional depositories charged with preserving in the vital state tissue samples of a wide variety of organisms, as well as biological reagents, such as antisera. A standing committee of experts should suggest the best available methods and should establish guidelines for policy in this area. Special efforts should be directed toward having individuals and expeditions deposit in such collections tissue samples from species that are rare or difficult to obtain. As methods of preservation in the vital state are essentially the same for tissues of all groups of organisms, the same facilities could care for specimens collected by biologists of many different disciplines.

The most appropriate sites for such tissue-museums are established natural history museums of universities that already have staff members engaged in cytological, immunological or biochemical studies of a comparative nature. These institutions have a strong research and teaching commitment, and are geographically close to a wide variety of expertise in the physical, chemical and biological sciences. Administrative agreements as to long-term commitment to support of the facility are essential.

“Tissue museums” should be managed by research scientists with special interest and competence in comparative biology and extensive training and experience in macromolecular chemistry. Such positions should carry profes-
sional status in the institution housing the facility. Besides the responsibility for maintaining high curatorial standards, such as careful documentation of source of specimens, the scientist should be using material in the collection in his own research.

Viable tissues are currently of great interest to evolutionary biologists. We believe that museums must stay in the front ranks of modern research approaches and that they should continually be receptive to new approaches in research and to new methods of preservation, new types of collections and novel methods of data storage and recovery.

To aid in the multiple tasks of processing tissues, cataloguing specimens and maintaining vital equipment, some additional full-time employees will be needed. Other technical help would be necessary to perform routine analytical work on the collection. Well equipped laboratories should be available in or near the facility for visiting scientists and for training students in cytological and molecular methods. In addition, individual scientists who need material housed in the collection could apply to the museum for samples or data.

Living and natural resources.—Natural populations are the fundamental resource of herpetology. This resource ranges from small, localized populations of blind cave salamanders of biological interest but no economic value, to vast and widespread populations of sea turtles of considerable economic and nutritional importance to man. The herpetological fauna of the United States is a substantial economic and scientific resource.

There are no feasible alternative sources of supply to harvesting wild populations of most species of reptiles and amphibians: preservation and management of heavily used natural populations is therefore vital. Unfortunately, in this era of rapid technological and environmental change, natural communities and their component populations are being destroyed at an ever-accelerating rate. Apparently little can be done to halt such development and the destruction it has produced, and thoughtful planning is urgently needed to preserve large tracts of relatively undisturbed habitat containing various distinctive biotas.

Response to the Committee's survey showed that natural populations are the immediate source of material for more than two-thirds of the respondents. Not surprisingly, our respondents ranked setting aside and managing natural areas along with individual research as equally deserving of federal funding. High priority for natural areas came not just from expected sources, such as ecologists, but also from such diverse groups as educators, commercial suppliers and anatomists.

Preservation of natural areas is one way to approach the problem of natural resources. It is costly, difficult politically, and conceptually challenging. Partial alternatives for a few species include culturing animals for teaching and research purposes, and maintaining small breeding colonies of endangered species. Culturing animals most extensively used in teaching and research would both improve the quality of animal research and provide certain supply of a few important species (National Academy of Sciences, 1974). Commercial suppliers have encountered serious difficulty in obtaining specimens from some natural populations. As a result amphibians and reptiles are becoming less available for teaching and research just when higher quality and genetic control is needed.

RECOMMENDATION 4: Support a coordinated effort in research and development of basic husbandry projects for amphibians and reptiles. Priority should be given those projects involving species of present or potential importance in education and research, or selected species that are threatened by habitat destruction.

Facilities that can reliably supply species important for educational purposes and for research in the biological and medical sciences should be developed and supported on a continuing basis. Such facilities should develop husbandry and disease control procedures, and select and develop particular species and genetic strains of amphibians and reptiles for culture. They should also train both users and commercial producers in husbandry of these animals.

Many problems must be solved to permit the successful commercial production of these organisms, but a start has been made (National Academy of Sciences, 1974). Studies of nutrition have merely begun, particularly in the devising of artificial diets. More investigations in the area of reproduction are needed, particularly with respect to the roles of nutrition, photoperiod and temperature cycles. Once these and other problems are resolved, the responsibility for the production of commercial quantities of these animals should be shifted to com-
mmercial establishments. However, continued support for selected facilities will be needed for further development of genetic strains and the establishment of relevant research programs to improve the efficiency of husbandry and the effectiveness of disease control.

Many species are endangered as the result of man’s activities. The sea turtles, large tortoises, Komodo dragon, island iguanid lizards, tuatara, most of the 21 crocodilian species and a few kinds of salamanders and frogs are threatened with rapid extinction. A few species, especially among the crocodilians, face nearly certain extermination as viable natural populations within the next decade.

Zoos and other specialized facilities breed and maintain a few species of amphibians and reptiles, including some of the endangered forms. In extreme cases, these institutions could serve as living archives or museums for endangered species, if given encouragement and financial support. Channeling their efforts into breeding programs for rare and endangered forms would fit into conservation themes common in exhibition and education programs of these institutions.

High priority should be accorded the scientific study of the behavior, reproductive biology and disease problems of these species in the wild and captivity. In some cases natural areas might even be restocked with species that have been propagated in captive conditions. This is a stated goal (of existing organizations) in the culture of Galapagos tortoises and some sea turtles.

Support of such programs would lead to improved professional development of herpetological husbandry. Benefits include the realization of the research potential of amphibians and reptiles in a variety of disciplines. Implied in the full development of husbandry technology is the involvement of personnel in many disciplines (pathologists, parasitologists, bacteriologists, veterinarians and nutritionists), as well as appropriately trained herpetologists.

Techniques for maintaining reptiles and amphibians have been developed in various laboratories, zoos and private facilities. Much of this is in the oral tradition, rather than in the literature, partly because the techniques have not been developed under the controlled conditions required for scholarly publication. Avenues for communicating information on these procedures are needed.

RECOMMENDATION 5: Support development of a coordinated plan for the preservation and management of wild populations of reptiles and amphibians.

Commercial suppliers and research scientists have recently expressed great concern over the availability, quality, or both, of amphibians and reptiles taken from wild populations. This supply has deteriorated through expanding urbanization and probably through chemical contamination of ecosystems. Thoughtful immediate action is needed.

Because users of other plant and animal groups have similar requirements, an interdisciplinary approach to saving and managing natural areas is necessary. Conflicts over preserving large tracts of land in their natural state are severe and the dollar expense is staggering. Maximal benefit will be realized if careful evaluations by specialists in all groups of plants and animals are made prior to and following establishment of natural areas. Through such considerations the most versatile areas can be selected. Ideally each preserve should be equipped with a field station and staffed by a trained field ecologist, who would coordinate the use of the area and assist the users through his intimate knowledge of the area and its biota.

Natural populations of economically important species could be managed as renewable natural resources if appropriate plans, based on scientific and economic considerations, can be formulated. Studies of population ecology and pertinent physiological ecology of such species are needed. Before populations can be managed as resources and harvested for sustained yield, imperative information must be available, including such ecological data as rates of reproduction, recruitment, movement, and habitat utilization, and physiological information, such as nutrition, tolerances, environmental factors that affect reproduction, growth rates, and disease. Further, the role of species in ecological food chains and their importance in the biological control of other animals must be understood. In short, we need to know the basic ecology of the populations, especially factors influencing population maintenance and growth.

The American alligator (Alligator mississippiensis), leopard frog (Rana pipiens complex) and bullfrog (Rana catesbeiana) have high economic value—for commercial exploitation as well as
for research and educational use—and merit consideration for initial studies. Recent conservation efforts in Louisiana have demonstrated that with proper management alligators can be preserved and harvested as a renewable resource (Joanen et al., 1971).

**Human resources.**—Excellent human resources are available in the herpetological community, and there are many important tasks that need doing. The problem is to make it possible to apply the pool of talent in the appropriate jobs.

**RECOMMENDATION 6:** Employ with greater efficiency and imagination the rich pool of human expertise needed for proper development, optimal care and intelligent utilization of collections, living and natural resources.

Large numbers of well-trained herpetologists and paraprofessionals will be needed to achieve each of the previous recommendations concerning collections and living resources. Fortunately, the pool of manpower with the requisite skills and interests seems adequate and trained professionals are continually emerging. Unfortunately, many individuals, especially among recent graduates, do not seem to be employed in jobs commensurate with their training. Such “underemployed” scientists should find many positions related to research on, and the management of, resources of museums, breeding centers and natural areas.

Paraprofessional personnel are badly needed to relieve professionals from many routine or technical tasks such as record-keeping, collection maintenance and animal husbandry. Large numbers of individuals express interest in such work; however, funds for their salaries are inadequate.

Training professionals and paraprofessionals presents few major problems. Paraprofessionals usually receive their training on the job; professional herpetologists receive theirs in a wide variety of university settings. Programs of some of the latter should offer the student more exposure to new techniques—for example in molecular and computer methods. As new approaches become incorporated into resource areas, programs in continuing advanced education for long established professionals in herpetology and related fields will be needed.

Organizational policies must be formulated to assure economically stable lifetime careers for competent professionals and paraprofessionals not on academic staffs. At present few institutions have satisfactory procedures for appointment, promotion, recognition and retirement of such personnel. Even fewer have titles for nonacademic personnel that parallel those of full time academic staff members.

**APPENDICES**

As originally submitted, this Report included several appendices. Appendix I presents, in 24 tables, a statistical summary of data from questionnaires. Arrangements are under way to make copies available to interested parties. Appendix II, *Collections of preserved amphibians and reptiles in the United States*, will be published by the Soc. Study Amphibians Reptiles as a Herpetological Circular. Appendix III, *Recommendations for the management of herpetological museum collections*, will appear in Herpetological Review.

**ACKNOWLEDGMENTS**

The Committee gratefully acknowledges the encouragement and financial support provided by the National Science Foundation (Grant GB 40995). We thank the herpetological community for responding to our questionnaires, and officers of the professional herpetological societies for their enlightened attitude in support of our efforts. Personnel at the University of Kansas (especially those associated with the Association of Systematics Collections), University of California, Berkeley, University of Michigan and Brookfield Zoo generously contributed to the success of local meetings. The Museum of Vertebrate Zoology and the American Museum of Natural History freely provided much secretarial time. We especially thank Isobel O’Connor for typing the many drafts of this report, usually under severe time constraints, and Stanley H. Weitzman, Treasurer of the American Society of Ichthyologists and Herpetologists, who administered the grant.

**LITERATURE CITED**


Fish Biology in China

GU SAN-DUN

An award from the Edward C. and Charlotte E. Raney Fund and the help and cooperation of many people enabled me to visit the People’s Republic of China, during July and August, 1974. The purpose of my visit included a desire to establish contacts with biologists there and to find out the state of Chinese ichthyology in order to develop better communication and understanding.

I visited research institutes and communicated with ichthyologists throughout the country (Fig. 1) during my 45 day stay. In Beijin (Peking), I visited Peking University, Qinghua (Chinghua) University and the Institute of Zoology, Academia Sinica (the Chinese Academy of Sciences). Later, in Shanghai, I had the opportunity to see the fish collection and exhibits at the Shanghai Natural History Museum and meet biology teachers and students in Fudan (Futan) University. In a coastal city, Dalian, I met three fishery biologists (Fig. 2) from the Dalian Fishery Institute, and in the suburbs of Peking, Shenyian, Yanan, Xian (Sian) and Hungzhou (Hungchow), I visited several agricultural brigades (the next largest production unit within a commune). I also spent five days living with a family at the Sasiyu (Valley of Rocks) agricultural brigade, Hopei Province, where I observe practical application of scientific research.

I also corresponded with Wu Xien-Wen (Wu Hsien-Wen, Fig. 3), Institute of Hydrobiology, Wu-Han and Zeng Cheng-Kui (Tseng Cheng-Kuei), Institute of Oceanology, Qingdao (Tsingtao). The “Directory of Selected Scientific Institutions in Mainland China,” 1970, published by the Hoover Institution Press, Stanford, was very helpful in preparing for my trip.

Institutions, Research and Collections

China has more than 1,600 research institutes and academies, about 170 of which are affiliated with the Academia Sinica (Tien, H. T. 1974. Eastern Horizon, 13:39–55). There are two national organizations in charge of research on the biology of fishes, the Academia Sinica’s research institutes and the Department of Fisheries system under the Ministry of Agriculture. Research collections in China are housed at institutes throughout the country. There is at least one institute of zoology or fisheries in each of 27 provinces of China (A list may be obtained from the Managing Editor upon request.) A report on the museums of China by C. Ahmanson, 1973, Museum News 52(4):17–25, indicated that each province has at least one museum where scientific and cul-

Footnote 1: Names of persons and places are transliterated from Chinese by following the “Xinhua (Hsinhua) Dictionary,” 1972 edition, Sangwu Press. Xinhua transliteration is the standard romanized spelling of Chinese, which is different from those spelling systems used in English publications. For convenience, the familiar spellings are placed in parentheses when the name first appears, then the more familiar names are used.