Entomological Collections in the United States and Canada

Current Status and Growing Needs

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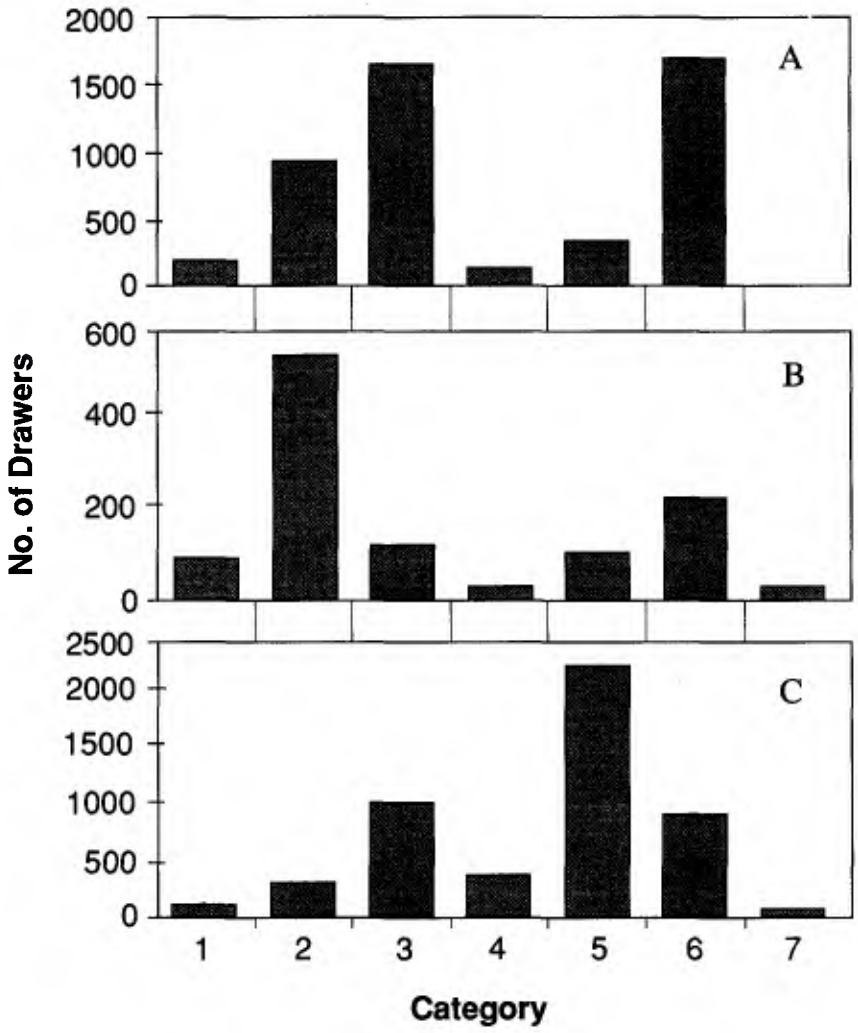
IN October 1988, the Association of Systematics Collections (ASC) held a workshop in Washington, D.C., to discuss collection resources for the 1990s. It brought together seventy people representing institutions of all sizes and types of governance to evaluate progress made in the past ten years and to formulate the directions expected in the next decade (Hoagland & Mabee 1988). The workshop focused on how systematics collections can be managed to maximize productive research and associated activities, and listed the resources needed to make this happen. Preparation for the workshop involved a survey of U.S. and Canadian systematics collections, which included questions on quantity and quality of collections, staffs, budgets, and facilities during the past ten years. The survey questions were designed by ASC to address broad institutional status patterns, as well as narrower disciplinary patterns.

Collections surveyed included those in all ASC member institutions and in other institutions with active entomology programs. Private collections were not included in the survey. Some institutions did not respond to the survey or omitted answers to some questions. Coverage of smaller collections was uneven because the survey was intended primarily to include examples of different kinds of small collections (for the institutional needs portion of the survey and workshop). The trends discussed in this article are based on the data gathered by ASC, supplemented by data from Arnett & Samuelson (1986) and public records. Originally, ASC gathered data separately for entomology and arachnology, but these data subsequently were combined because insects and arachnids usually are administered jointly (however,



Comparison of three Hymenoptera collections based on 1988 inventories: (A) Canadian National Collection (4913 total drawers); (B) Bishop Museum (1309 total drawers); (C) Smithsonian Institution (5152 total drawers). Category refers to curatorial status level (see list 1). These data have been used to implement upgrading of all three collections since 1988.

the Museum for Comparative Zoology is a notable exception) and because the quality of data for arachnology was very poor.

Forty-six institutional collections in the United States and Canada reported combined total holdings in excess of 155 million processed specimens by the end of 1986 (tables 1 and 2). In general, processed specimens are those that are available for study (that is, mounted, labeled, accessioned, and stored to allow retrieval) but not necessarily cataloged or identified to genus or species. The term *backlog,* as used here, refers to specimens that require preparation or processing before they are available for study. Twenty-seven of the collections (59%) were owned by universities, although only two university collections were in the largest ten. The ten largest collections housed 69% of the total processed specimens (around sixty-seven million), and loaned 412,450 specimens (75% of the total number loaned) in 1986.

Hurd et al. (1975) estimated a total of 150 million processed specimens in U.S. and Canadian entomology collections. They considered more institutions than the ASC survey did, but they probably overestimated the total significantly (as seems to have been the trend at the time at many institutions). They reported that about ninety-seven million specimens were housed in the twenty-six institutions with collections of more than one million specimens. The current survey reveals thirty-four collections with more than one million specimens. The 97 million of Hurd et al. (1975) is in line with the 101 million in the ASC data for 1976.

Based on the data in Arnett & Samuelson (1986), R. J. McGinley (personal communication) has estimated a total of 162 million specimens in U.S. and Canadian collections. This is essentially the same as the 156 million estimated in the 1986 ASC data, because probably as many as 10 million specimens are housed in smaller

Table 1. Size of entomological collections (from largest to smallest) from the twenty-six institutions reporting a 1986 collection of one million or more processed specimens

Institution	Collection size (in thousands of processed specimens)		
	1976	1981	1986
National Museum of Natural History	20,000	21,700	25,000
American Museum of Natural History	15,507	15,772	16,204
Canadian National Collection	—	8,300	15,000
Bishop Museum	10,700	12,000	13,250
Field Museum of Natural History	2,765	7,275	8,000
California Academy of Sciences	6,303	6,920	7,601
Museum of Comparative Zoology	6,063	6,650	7,263[a]
Florida State Collection	2,886	3,402	5,436
Cornell University	4,000	4,500	4,750
Los Angeles County Museum	2,642	3,326	4,359
Carnegie Museum of Natural History	2,000	2,200	4,300
University of California at Davis	3,000	3,500	4,000
University of Michigan	3,500	3,600	4,000
Ohio State University	1,500	1,750	3,500[b]
University of California at Berkeley	2,894	3,250	3,500
Philadelphia Academy of Natural Sciences	3,000	3,150	3,250
Illinois Natural History Survey	—	3,065	3,090
University of Kansas	2,300	2,500	2,660
University of Minnesota	2,316	2,408	2,617
McGill University	—	—	1,900
University of Nebraska	1,600	1,650	1,750
Michigan State University	1,250	1,375	1,500
Purdue University	1,300	1,400	1,500
University of California at Riverside	1,161	1,211	1,261
Yale University	870	971	1,172
Washington State University	900	950	1,000

[a] Includes one million arachnids housed in department of invertebrate zoology.
[b] Includes 150,000 mites housed in arachnology laboratory.

collections not included in the ASC survey. Based on the Arnett & Samuelson data McGinley further estimated that 55% of the more than 483 million specimens in world collections are housed in U.S. and Canadian institutions.

Table 2. Totals for entomology collection data (including arachnology), 1976–86

	1976	1981	1986
No. specimens processed	105,400,000	136,310,000	155,568,000
No. specimens unprocessed	27,303,000	38,855,000	46,197,000
No. computer-cataloged specimens	0	20,000	560,000
No. specimens processed/yr	—[a]	4,400,000[b]	4,400,000[b]
No. orphaned collections	36	51	65
No. doctorate-level curators[c]	110.85	110.70	111.97
No. support staff[c,d]	141.90	146.86	154.05
No. grant-funded support staff	33.5	27.85	29.15
No. graduate students in residence at least 1 mo	105	116	153
No. visitors	949	1,223	1,669
No. specimens loaned[e]	551,061	534,454	548,464
Total collection operating budget[b]	$262,115	$299,788	$533,196
National Science Foundation support for collections	$494,000	$605,000	$302,000
Total endowment	$1,019,171	$1,404,238	$2,675,645
Institutions reporting	43	46	46

[a] Survey data too poor to report.
[b] Approximation (survey data poor).
[c] Totals reported in number of full-time equivalent positions, not including U.S. Department of Agriculture Systematic Entomology Laboratory.
[d] Total including all funding sources.
[e] Totals reported are low because some institutions reported only the number of transactions.

Data in table 1 are as reported by the institutions, with slight editing in some cases. Numbers reported range from accurate counts to estimates based on accession records, estimates based on storage units such as drawers, and guesses without a strong foundation. It is hard to draw conclusions without truly comparable data. For future planning and decision making, we need to standardize the gathering of precise and meaningful data on collections. The ASC is investigating means to accomplish such data gathering.

Even though they are not as large as the collections included in table 1, two other collections are worthy of note. These collections are taxonomically specialized and represent major resources within the taxa they cover. The American Entomological Institute specializes in parasitic wasps, and the Allyn Museum of Entomology specializes in butterflies. They held 970,000 and 700,000 processed specimens, respectively, in 1986.

Problems of Maintaining Growing Collections

Processed specimens and backlogs grew at about 3% a year. The ASC data on specimens processed per year are too meager to analyze properly, because responses to the survey question were based in some cases on specimens that were computer-catalogued annually, and in other cases on specimens that were merely processed and accessioned annually. The gain in total processed specimens between 1981 and 1986 was 22,008,000, or about 4,402,000 specimens added to collections annually (but not computer-cataloged).

Backlog numbers are especially variable in what they represent. In some instances they represent materials that are well organized and awaiting specialized study, as at the Field Museum (FMNH); in others they are mixed specimens without particular targeted use, as those at the Florida State Collection of Arthropods (FSCA) and the University of California at Davis. Some backlogs are worthy of immediate attention, while others represent a more-or-less permanent archiving of duplicate or low-priority materials.

Examples of specific backlogs show this variation in type and organization of material. The U.S. National Museum of Natural History (USNM) has mixed lots worldwide, inventoried by lot, which are mostly dry. The Bishop Museum (BPBM) has mixed dry lots from New Guinea and Philippines, as well as backlogs from specific New Guinea research projects, which include canopy samples being processed (fifty trees) and wet soil samples (five hundred lots). The FMNH has ten thousand unsorted wet soil samples, cataloged on data base by locality. The FSCA has thirty thousand wet lots, primarily ultraviolet light and Malaise trap collections.

Numbers of specimens as surveyed by ASC are only crude guides to collection size, not quality or scope. The multiple-level inventory system (list 1) designed by the Smithsonian Entomology Collections Committee (McGinley 1990) allows detailed tabulation of curatorial status of entire collections and is a powerful tool for management of collections and personnel. This system is now in use at USNM, Agriculture Canada's Biosystematics Research Centre (BRC), and BPBM.

The number of collections orphaned and absorbed by other collections per year almost doubled in the ten-year period to sixty-five in 1986. The decline and dis-

List 1. Curatorial level status inventory system

Level 1:	Unprepared or deteriorating material.
Level 2:	Roughly sorted to major groups only.
Level 3:	Sorted to small groups so that the material is accessible to specialists.
Level 4:	Identified but not integrated into the collection (e.g., returned loans).
Level 5:	Identified, but curation is inadequate. Curation needs upgrading (e.g., verification of names, new tray labels, new unit trays with foam bottoms, etc.).
Level 6:	Properly curated to modern standards.
Level 7:	Physical curation complete; species-level inventory (data base) complete.
Level 8:	Physical curation complete; individual specimen label data captured.
Level 9:	Physical curation complete; specimen label data captured; research data (e.g., measurements) captured.

Primarily used for rating drawers in pinned collections but adaptable to other storage units as well. Adapted from McGinley (1989).

continuation of systematics and associated collections programs at universities are major problems. Judging from the minimal institutional support given to some of the collections included in the ASC survey, the trend will continue.

In 1986, very little information from entomological collections had been entered into data bases. Results of the ASC survey indicated that standards for entomological data bases were a major need. Use of computers in entomological collections has evolved substantially since 1986, and the Entomology Collections Network currently is establishing standards for entomological data bases (see Thompson et al. [1990]).

Most collection administrators feel it is practical to use specimen data bases for only special materials, such as types and research projects, but not yet for general collections because of logistic problems caused by number of specimens or poor levels of identification and curation. Many collection institutions are computerizing information on types and other special collections, but some large collections of types remain uncatalogued. Only a couple of institutions (usually small and regional) have attempted databases of their general collections. Several institutions (University of Minnesota, for example) have computerized inventories to the family level only.

Basic taxonomic catalogs and data bases are a vital need (see also Miller [1989]). The only major order of insects for which recent worldwide taxonomic catalogs are available is Diptera. Lack of taxonomic catalogs and data bases is a roadblock to systematics research, as well as to the curation and computerizing of collections.

The importance of material conservation has only begun to be recognized by entomological collections. Fluid (alcoholic) collections are almost inevitably poorly cared for by entomologists. Slide-mounting media can present problems of long-term stability, especially Hoyer's medium, which is popular for mites. Most collections still use archaic fumigation for pests, such as paradichlorobenzene and naphthalene (McGiffin 1985, Zycherman & Schrock 1988). In addition, many collections are not adequately protected from humidity. According to current knowledge of conservation needs, recuration or rehousing of many specimens is required to make up for the "sins of the past." Further advances in knowledge will show the necessity for even more extensive reworking of existing collections to ensure their long-term stability.

Facilities and Equipment

Despite continued addition of specimens, few collections had increases in floor space between 1976 and 1986. Many collections report needs for either compactors or substantial (50–200%) increases in space. Several institutions with large collections have accommodated their current space needs with compacted storage, but they will need more floor space as the compactors fill to capacity.

Most institutions report adequate pest and theft protection. About half report poor protection from fire, temperature, humidity, and water damage. Humidity protection is especially poor. Pest control methods that are more effective against insect pests and less dangerous to human health are needed.

Many institutions (fourteen to twenty of forty-six) report biochemical, electrophoretic, and histological facilities. Most (twenty-eight to thirty-three) report morphometric and computational facilities. Only eight report scanning electron microscopes. The paucity of scanning electron microscopes is surprising, given their growing importance in entomological systematics.

Steady Use of Collections and Related Services

Loan use has remained relatively constant at around 540,000 specimens a year, although the counts are too low (perhaps by 30,000) because several collections reported numbers of transactions instead of specimens. Eleven collections averaged loan activity of more than ten thousand specimens per year during the 1976–86 period (table 3). These collections loaned 84–90% of the total specimens loaned during the period (an average of more than 490,000 per year).

The upward trends in visitor and student use probably are partly attributable to better recording. Many collections now maintain better records of collection use in order to justify institutional or grant support. There seems to be an increase in

Table 3. Loan activity for collections that loaned an average of more than ten thousand specimens per year

Museum	1976	1981	1986	Avg
National Museum of Natural History	89,573	131,130	90,462	103,722
California Academy of Sciences	90,000	60,500	75,000	75,167
Canadian National Collection	—	58,233	81,674	69,954
Field Museum of Natural History	105,570	35,690	19,913	53,724
American Museum of Natural History	59,870	42,072	49,746	50,563
Bishop Museum	42,523	53,429	16,969	37,640
University of California, Berkeley	34,664	15,731	26,998	25,797
Museum of Comparative Zoology	25,176	26,602	24,868	25,549
University of California, Davis	33,500	11,981	12,843	19,441
Los Angeles County Museum	10,613	9,915	33,818	18,115
Carnegie Museum of Natural History	300	15,000	26,046	13,782
Total of above	491,789	468,383	458,337	479,372
All other loan activity	56,449	66,219	86,447	69,705
% Loans from 11 most active collections	89%	88%	84%	87%

Variation in numbers at individual institutions is often caused by fluctuations in National Science Foundation support grants or staffing. For example, high 1976 figures at Field Museum resulted from major sorting of backlog, while low 1986 figures for Bishop Museum were attributable to temporary staff reductions.

researchers visiting major collections instead of just borrowing specimens by mail. Use of collections by students and visitors who are not strictly systematists also increased.

Entomological collections provide diverse services. Most institutions provide preparation of specimens, repository services, training, and sampling. Some provide ecological consulting. Most do not charge fees for routine services to the scientific community.

Collection Staff: Varied Roles, Limited Opportunities

Total numbers of doctorate-level research staff have remained about constant at 111 (not counting the U.S. Department of Agriculture Systematic Entomology Laboratory [USDA-SEL]). Almost all collections have a doctorate-level curator in charge, although several have a masters-level curator. The actual role of these individuals in relation to care and availability of collections and other collection management issues is extremely variable.

Several major collections, such as BRC, FSCA, and Illinois Natural History Survey, have relatively large staffs that have heavy responsibilities for agricultural identification or other services, and their staffing is not directly comparable to that of traditional collections. However, the large staff of USDA-SEL (about twenty-four doctorate-level and eighteen support personnel), located primarily at USNM, are not counted.

Support staff for collection management increased slightly from 142 in 1976 to 154 in 1986. Many small collections, especially university collections, lack adequate support staff. Of forty-four collections reporting personnel, twenty-three had one or less full-time equivalent position in nongrant support staff in 1986. Twelve of these had one or less full-time equivalent position in total curator and support personnel. Definition of collection management personnel is highly variable among institutions, making it difficult to determine their actual roles in the organization, their levels of training or education, their degrees of responsibility, and other factors. Like the research staff, support staff in agriculture organizations often have other responsibilities that are not directly related to the entomological collections.

There is a critical lack of both talented young workers and secure jobs for them. There are painfully few training centers that offer both museum experience and

modern systematics training (see Kosztarab & Schaefer [1990], especially pages 13–17).

Collection administrators report that more collection managers, visiting specialists, and other support staff are needed for regular collection care and special curatorial projects. Adequate identification and arrangement are crucial to use of specimens by outside researchers and to compilation of collection data bases. Insects and arachnids are so numerous in individuals, so taxonomically diverse, and so poorly known, that most collections face major curatorial problems.

Funding

The overall figures for institutional operating budgets are low because financial data from several important institutions such as BRC are unavailable. The increase with time is partially artificial because many collections did not report for 1976 or 1981. Furthermore, the data have not been corrected for inflation. Of thirty-four operating budgets reported, eleven were less than twenty-five hundred dollars annually. Most of the institutions that did not report also had small budgets. Lack of adequate institutional funding even for core programs is a major concern. Many collections, including most of the university collections, lack appropriate institutional support and often have less than one full-time equivalent position in staff and less than two thousand dollars in operating budget. Eventually, institutions should be held accountable for retaining possession of valuable systematic research resources if they fail to provide reasonable support.

Support from the National Science Foundation (NSF) for entomology collections appears to have decreased (table 2), but 1986 was a low year for funding of entomology collections. Total funding during the ten years ranged from $302,000 to $785,000 per year, involving three to seven collections each year. Most large collections have received grants for storage equipment. Few of the smaller collections reported grant support.

Only eight institutions reported endowment funds of more than one hundred thousand dollars and only one surpasses five hundred thousand dollars. Most of the rising trend in endowment value (table 2) is caused by the increase in value of existing funds, not new donations. Some increase also is attributable to better reporting in more recent years.

Meeting the Needs through Coordination

In the ASC survey, most collection administrators placed as highest priority additional funding for curators (meaning researchers, I presume) and collection management staff. Additional space and storage equipment placed as strong seconds. Many collections also noted the need for visiting specialists to help sort, identify, and curate. Other needs frequently listed were computerization, training centers, material conservation, core funding, and coordination of activities.

Many of these concerns can be helped by improved coordination and centralization of resources to make their support and use more efficient. Most collections must develop clearer objectives and manage their programs accordingly (refer to Griffin [1987], for example). The Academy of Natural Sciences of Philadelphia and FMNH are examples of institutions that have achieved productive taxonomic specialization. Regional specialization is exemplified by the California Department of Food and Agriculture, Sacramento.

The community of systematics collections includes institutions whose collections vary in size and scope as a result of their diverse objectives and histories. These diverse collections should work together to enhance the overall effectiveness and financial base of systematic entomology (Miller 1990). Just as there are different types of governance and missions among collection institutions, so there are diverse funding opportunities from city, county, state, national, and international agencies, as well as private sources.

Development of regional or state centers is important. These should serve as foci for curation and identification of specimens and reinforce research and education (Danks 1983, Hardy 1983). Lack of stable funding has been a major problem for regional centers (Danks 1983) and probably will continue to be so.

The major collections provide the bulk of the resources for systematics research and provide numerous services to the smaller collections. Thus, NSF support is most needed for major collections or for other collections that are major resources within particular subdisciplines. Of forty-six collections surveyed, the four largest collections housed 69.5 million specimens (44% of the total) and loaned 238,851 specimens in 1986 (44% of the total). The seven collections housing more than seven million specimens each held a total of 92.3 million specimens (59%), and loaned a total of 358,632 specimens (65%) in 1986.

Growing concerns about maintenance of biological diversity, greater survey efforts on both a national and international scale, and increased transferring of orphaned and private collections to the care of active institutional collections—all of these factors will continue to put more pressure on the space, personnel, and funding resources of systematics collections. The ever-increasing number of specimens provides important resources for research but puts continuing stress on our existing facilities and their traditional methods of operation.

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