

The cladoceran collection of the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

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Abstract.—The cladoceran collection at the Smithsonian Institution National Museum of Natural History is both extensive and diverse. Wet materials (alcohol- and formalin-preserved) comprise over 18,000 littoral and limnetic zooplankton samples and approximately 300 lots of sorted, identified specimens. There are over 20,000 slides, the majority with specimens identified to species and in excellent, useable condition; about three quarters are grouped by taxon, the remainder according to country or specific location. Anomopod taxa (*Chydoridae*, *Daphnia*, and *Bosmina*) predominate in materials donated by D. G. Frey, R. W. Kiser, and E. S. and G. B. Deevey, respectively, but the collection includes representatives of the Onychopoda, Haplopoda, and Ctenopoda as well. The collection is world-wide in scope. Geographically, coastal regions of North America are particularly well represented; there is considerable material from Central and South America, Denmark, South Africa, and Australia. There are presently types of 52 species comprising about one hundred specimens, half on slides and half in alcohol. The comprehensive library given by D. G. Frey facilitates study of cladocerans at the museum.

Following receipt of gifts of sizeable collections of cladoceran specimens and samples to the National Museum of Natural History (NMNH) by R. W. Kiser and D. G. Frey, the cladoceran collection at the Natural History Building in Washington, District of Columbia, was moved to the Museum Support Center (MSC) in Suitland, Maryland. At the MSC, fluid-preserved ("wet") specimens and samples are housed in a controlled-environment storage pod, and slides, books, and papers are housed in a nearby room, the David G. Frey Cladoceran Library.

The NMNH cladoceran collection comprises one of the finest assemblages of cladoceran materials in the world. The British Museum (Natural History) holds more types and perhaps greater diversity in species and sorted specimens. The Canadian Museum of Nature (Ottawa) has a large collection of littoral samples, primarily from Canadian waters. However, the USNM cla-

doceran-containing, unsorted zooplankton collection is unparalleled, both in number and geographic range of samples. The cladoceran holdings of other North American museums are meager in comparison.

Categories of Material Comprising the Cladoceran Collection

The cladoceran materials held by the NMNH are curated by the Department of Invertebrate Zoology. They can be accessed in several ways. A six digit NMNH accession number is assigned all items donated by an individual or otherwise acquired at one time; items given at different times by the same individual will bear different NMNH accession numbers. NMNH catalogue numbers are given to individual lots of materials such as slides, bottles, etc. when they are catalogued by the Department of Invertebrate Zoology. Lastly, some items may be accessed by a number des-

ignated by a previous owner of the materials. A few older items in the collection lack accession and catalogue numbers (Berner 1995) and are not detailed below. All NMNH numbers reported here are accession numbers.

To facilitate description of the cladoceran collection, I group its diverse materials into two categories: sorted specimens identifiable by NMNH accession and catalogue numbers, and larger gifts of multiple items commonly recognized by the donor's name.

Specimens with NMNH Accession and Catalogue Numbers

Type material.—Approximately 100 type specimens, about half on slides and half in alcohol, representing 52 taxa. Many are species described by D. G. Frey from the Americas and elsewhere. Some of his paratypes, retained in his personal collection and included in his major gift (see below), have not yet been catalogued.

Wet material.—(In alcohol.) Approximately 90 vials of identified specimens, representing 40 genera, shelved by genus and species. Most are identified to species, some to genus only. There are catalogue cards for about 70 of them.

One hundred and five catalogued bottles of unidentified cladocerans. There are also at least 12 vials of unidentified cladocerans in one of E. B. Reed's gifts (NMNH 383116), located in the "Copepod holding area" at the NMNH. Reed's material, primarily from Colorado, may complement that in the Shantz and Dodds gifts (see below).

Slide material.—Approximately 365 catalogued slides, representing 50 genera. Many of these slides are of specimens collected in Brazil by H. Kleerekoper, whose samples are among those donated by R. Kiser (see below). These specimens were mounted, identified, and donated individually by Kiser and have accession and catalogue numbers different from the Kiser gift.

Data.—One set of catalogue cards for

(mostly) identified specimens, either handwritten or computer-printed. Cards are arranged by genus and species; those for slides and wet specimens are interspersed. Types are identified by orange cards. The set does not include cards for catalogued bottles of unidentified cladoceran specimens, but does include cards for the vials of unidentified E. B. Reed cladocerans.

David G. Frey Gift, NMNH 403774

Because of the size and complexity of this gift, its components are evaluated separately below. The gift also included three discrete collections that Frey had acquired: the J. Richard collection and the E. A. Birge collection, which Frey obtained from the University of Wisconsin, Madison, and the E. S. and G. B. Deevey freshwater collection. Frey incorporated the Richard and Birge collections into his own, and they are considered as a subset of his gift. The Deevey freshwater materials are considered as a separate acquisition (see below).

The materials donated by Frey reflect his early training (under C. Juday) and life-long interest in limnology, his research on the paleoecology of lakes as revealed by cladoceran remains, and his world-wide studies on the speciation and distribution of chydorid cladocerans in relation to glaciation and continental drift. Frey and his colleagues sampled zooplankton extensively in the areas he studied: eastern North America, northern Europe, southern South America, South Africa, and Australia. Frey also collected indefatigably on his international travels, so most parts of the world are represented to some extent in his collection. Because they are primarily from the littoral zone, his zooplankton samples have a much higher diversity of microcrustaceans and other invertebrates than do limnetic samples. In addition to containing cladocerans, they potentially are a rich source of material for studies of copepods, ostracods, and other littoral organisms, and of the littoral bio-coenosis. Enhancing the sample collection

is Frey's meticulous documentation, by notes and mounted specimens, of the material he studied.

Wet material.—(3–4% formaldehyde solution with a few ml of glycerol added to prevent total drying if evaporation occurs. Some sorted specimens may be in alcohol.) Approximately 9260 bottles of samples and specimens housed in 49 boxes. Per Frey's accession books, 9193 samples have Frey's own F— — numbers on the bottle tops; inside labels bear the same number, sample collection date and number, locality, and name of county, province, or country. Bottles comprising Richard and Birge samples are detailed below.

Two boxes marked "Types" contain bottles with identified specimens; they are not numbered or listed in Frey's accession ledgers. Twenty of the bottles are marked "Paratypes" and 47 have sorted, identified specimens. All have inner labels giving species name and collection data. They have not yet been catalogued by the NMNH and therefore have no identifying numbers.

Field data for the samples are scattered in 92 small notebooks, many labeled with year and place visited. In these, Frey detailed aspects of his trips as well as collection data; often, he later recorded his accession number for each sample in red ink next to its collection data and number.

Frey's samples are recorded (usually by batches in correspondence with dates of collection) in two "Collection Accession" ledgers that list Frey's sample number, locality, date, and collector's name. Samples, specimens, and some slides received from other collectors are similarly recorded. There is no index for finding samples from a particular locality.

Several thousand inventory cards, filed by Frey number, detail contents of samples Frey studied. Chydorid species are listed, other cladocerans are noted by genus, and there are notes on other Branchiopoda, algae, etc. Frey requested that anyone removing specimens from a sample note the species and number of specimens taken on the

back of the corresponding card. If a visitor examined a sample Frey had not yet studied, he requested that the researcher make up an appropriate inventory card. These practices are being continued at the NMNH.

Slide material.—Several hundred slides of identified specimens (mostly chydorids), the large majority mounted in glycerine-jelly or polyvinyl-lactophenol with ringed coverslips, are arranged alphabetically by genus and species in a metal tray cabinet. They are in excellent condition, well-labeled, usually bearing the Frey number of the original sample.

Fourteen large and two small boxes contain Frey's working slides, also in excellent condition, of identified specimens and paratypes of particular taxa on which he published.

Twenty-four boxes house specimens, mostly identified, from diverse locales: Southampton Islands; the Soviet Union (F 1421, a gift from N. N. Smirnov that includes three paratypes); Denmark; Holland; Africa; South America; U.S.A.; Canada; Maine-New Hampshire; Florida & southeastern U.S.A.; and Monroe County, Indiana, ponds. In addition, there are miscellaneous sets of slides in wooden boxes: two boxes of cladocerans from the S. Wright collection (35 slides of poor quality), five boxes from Nova Scotia by G. Doran, and six boxes of various origin and content.

Eleven large and 19 small boxes have slides of lake sediments and cores, representing paleolimnological and taxonomical studies by Frey and his students.

There is no inventory of Frey's slides.

Library.—The library reflects Frey's emphasis on chydorid cladocerans. While strong in all the early cladoceran literature, it lacks many recent papers on non-chydorid cladoceran taxonomy as well as some important contemporary guides with keys. It is usefully organized:

Eleven shelves of bound books, offprints, and photocopies (about 2500 items) of publications relevant to cladoceran taxonomy, evolution, and ecology. These are num-

bered and entered into Frey's "Accession Book for Literature" and are arranged on the shelves alphabetically by author.

Two shelves of theses and dissertations relevant to limnology and cladoceran taxonomy.

Three shelves of books on limnology, paleontology, and taxonomy, most of which have relevance to cladoceran systematics. These do not have Frey accession numbers and are loosely arranged by topic and author.

Numerous unbound offprints of papers not directly related to chydorid systematics; these are housed by author in a small, multidrawer file cabinet.

There are both a literature accession ledger and an index card file of literature.

Papers.—Papers filling several file cabinets were received with the Frey gift, products of his lifetime of research, teaching, and professional activities. Materials pertaining to cladoceran systematics presently kept in the Frey Cladoceran Library are:

Research data for specific ecological, paleolimnological, paleotaxonomic, and taxonomic studies. Generally, a single folder contains all the material related to a single publication: data (counts, measurements, species lists, etc.) from samples that Frey studied, manuscript drafts, and sometimes related correspondence.

Research and correspondence on historic, systematic publications, e.g., publication of the fascimile of Lilljeborg's *Cladocera Sueciae* and of Sars' unpublished 1861 manuscript.

Negatives and prints of scanning electron micrographs associated with the above research and publications.

Plates, maps, and miscellaneous drawings associated with research publications.

A set of computer punch cards with data on Frey's collections. The key to these cards (which are on a shelf of the library) appears to be a large posterboard diagram lying in a map drawer.

Frey's correspondence with other professionals. Many of these are cladocero-

logists and some letters contain taxonomic information.

The J. Richard and E. A. Birge Materials (Gift of D. G. Frey)

The impact of E. A. Birge's early taxonomic studies of North American cladocerans, and the roles he and his associate, C. Juday, played in the development of American limnology are well-documented (Frey 1963, Beckel 1987). Birge was in communication with the French taxonomist, J. Richard, who had studied material collected from foreign countries in the late 1800's by numerous persons. When Richard retired, Birge purchased his collection of samples and slides. D. G. Frey acquired that collection as well as samples, slides, and miscellaneous papers and notebooks belonging to Birge and Juday from the Museum of Zoology (formerly, the Wisconsin Geological and Natural History Survey) at Madison, Wisconsin. Some of the samples in the Birge collection apparently were collected in South America by Harriet B. Merrill, an assistant to Birge (Hartridge 1995), and had been thought lost (Reid 1991). Frey incorporated the Richard and Birge samples into his wet collection, but kept the slides separate. During this survey, papers and notebooks relevant to these materials were found scattered among Frey's papers and were assembled together in marked file cabinet drawers.

Richard and Birge described numerous new cladoceran species. The former did not designate or set aside types and although the latter indicated that types would be deposited for some of the species he described (Birge 1910), they are not to be found in the museum at Madison, Wisconsin (F. Iwen, pers. comm.). Therefore, these materials are of great importance. For instance, during this review the slides from which Birge made the drawings for his description of *Wlassicsia kinistiensis* were found, but none was designated as a type. Also located was a slide of *Ceriodaphnia acanthina*

Ross, 1896 from the type locality and date; as no type exists for this species, Birge's slide might be significant. Furthermore, it is possible that specimens from type localities are in certain of the Richard and Birge samples.

Because of the significance of the Richard and Birge materials to cladoceran taxonomy, they warrant further careful study and documentation.

Wet material.—(In formalin.) According to Frey's accession book, samples from the Richard collection are: F 701–1041 (from Africa, Sumatra, South America & Haiti, the Soviet Union, China, and France).

Samples belonging to the Birge collection are: F 607–676 (from Wisconsin, South and Central America); 1042–1232 (1902–1903, from South America); 1095–1232, 1277–1282, and 1284 (1900–1929, from Wisconsin).

Slides.—Six metal, tabletop file cabinets, with 25 trays per cabinet, not all full of slides. Four cabinets are labeled A–D (perhaps by Frey) and have labeled trays; the remaining two were labeled E and F for this review. No inventory of the slides was found.

Twenty trays, mostly in cabinets A and F, appear to be Richard's slides (as determined by the handwriting and French labels). The remaining slides apparently are Birge's. Their condition ranges from excellent (specimens remounted in polyvinyl lactophenol and relabeled in 1966–1967 by "J.V.B.") to useless: some slides lack coverslips and specimens or have uninformative labels.

Data.—A drawer of index cards, apparently made by Birge, with various data. A subset of the cards relates to the Richard samples.

Field notebooks from South American collections, apparently made by H. B. Merrill.

A bound volume of Birge's correspondence, assembled by the Museum at Madison. His purchase of the Richard collection is documented here.

Frey's analysis of H. B. Merrill's work, the cladocerans found in each of her samples, and correspondence related to a paper he wrote about it. That paper was not found; Frey apparently sent it to M. L. Hartridge, Merrill's niece (cf. Hartridge 1995).

A folder of photocopies, made by Frey, from Birge's (H. Merrill's?) notebooks and Merrill's letters to Birge. The originals apparently were deposited by Frey at the State Historical Society of Wisconsin, in accord with a request by M. L. Hartridge, Merrill's niece (M. L. H. pers. comm.).

These materials have been put together in drawers marked "Birge Collection".

Edward S. and Georgiana B. Deevey Gift

The Deeveys gave their marine collections directly to the NMNH but their freshwater materials to D. G. Frey, who kept them apart from his collection. Although received by the NMNH as part of the Frey gift, the Deevey freshwater materials are being treated as a separate acquisition.

A large amount of this material derives from limnetic plankton tows, and is related to the Deevey studies on *Bosmina* and *Eubosmina*. Florida, Central America, Australia, and New Zealand are particularly well represented. Deevey & Deevey (1971), available in the Frey library, is a valuable reference for locating many of the habitats represented in this material.

Wet material.—(In formalin.) Sixteen boxes, all marked "Deevey", containing glass and plastic vials and bottles of unsorted zooplankton that are mostly labeled only with a date and lake name. A few bottles contain sorted, identified specimens. Locales marked on the boxes are: Wisconsin & Michigan; Costa Rica, etc.; Spain; Denmark, Hungary, Poland, Ireland; Vietnam; Australia & Tasmania; Australia & New Caledonia; New Zealand; Venezuela & Brazil; Nova Scotia, Newfoundland, U.S.A./Canada; Florida (two boxes); Texas, Virginia, Kansas, Vermont, Maine, U.S.A.; Unknown Countries.

Reference to samples containing marine and brackish water cladocerans is in the Deevey notebooks labeled Long Island Sound, Long Island 1950, and Tisbury Great Pond located in the Department of Invertebrate Zoology at the Natural History Building in Washington, District of Columbia.

Slides.—Eight boxes of slides, marked: Rodgers Lake & Queechy Lake, Connecticut (two boxes); Mexico-Guatemala; Mexico, Guatemala, Texas (contains some slides from New York, Ireland, Denmark); Guatemala; Linsley Pond (Connecticut), Mexico, Guatemala, Texas, (includes some slides from the Killarney Lakes, Ireland); New Zealand; Australia (also contains slides from Tasmania, Poland, and Brazil). Many of the slides are of *Bosmina*; some have mixed zooplankton. Their general condition was not assessed.

Data.—Five large, looseleaf notebooks, marked “Deevey” and: Florida Lakes; Rodgers & Queechy Lakes; New Zealand Lakes; New Zealand, Tasmania, Australia; Guatemala Lakes. They contain research data on measurements of *Bosmina* from diverse habitats, drawings, some information on copepods, and other miscellaneous information. No field notebooks with collection data were found.

Alfred A. Doolittle Gift, NMNH 157575

A. A. Doolittle, a teacher at Central High School in Washington, District of Columbia, studied cladocerans as an avocation, collecting them in the eastern United States and especially in and near Sebago Lake, Maine, where he summered. *Chydorus bicornutus*, a North American endemic that he described, later triggered D. G. Frey's studies on the “honeycombed” species of *Chydorus*. Doolittle's material is primarily from Sebago Lake, Maine, and Lake Cooper, Iowa. There are samples from other lakes in those areas, from various north-eastern U.S.A. states, and a few from Mexico.

Wet material.—(In alcohol.) Twenty-four jars, labeled by state, containing vials of unsorted zooplankton samples. (One District of Columbia bottle has two vials of sorted specimens). Vials contain labels with sample dates only; jars contain labels with Doolittle's name and NMNH accession number.

Slides.—One box, mostly of identified cladocerans from lakes in Maine, mainly Sebago Lake. About two thirds appear to be in useable condition. The box is temporarily labeled “Doolittle Collection”. There is no inventory of the slides, and they have not been catalogued.

Data.—Two boxes, one with notebooks and one with index cards. The notebooks contain data on collection sites and meteorological data on Lake Sebago. They are labeled: 1904 Memoranda, 1904 Connecticut Lakes, 1905 Umbagog Lake, 1906 Sebago Lake, 1907 Sebago Lake, 1908 Sebago Lake, 1911 Sebago Lake, 1914 Lake Cooper, 1916 Miscellaneous (this contains collection data through 1921), and Miscellaneous Notes on Freshwater Cladocera.

There are four categories of index cards, only the first two of which can be correlated to data in the collection books:

Locations of collections (presently grouped by state), some having lists of species found and a few with quantitative counts.

Species names, listing locations where they were found.

A small set of references on fish diet.

A miscellaneous set of cards with data concerning material from other collectors and localities.

Rufus W. Kiser Gift, NMNH 356548

R. F. Kiser was a professor at Centralia Junior College, Washington, whose particular interest was the taxonomy of *Daphnia*. He collected extensively throughout the Pacific Northwest, especially Washington and Oregon. His collection includes samples from Alaska to southern California made by Trevor Kincaid, a copepodologist at the

University of Washington. He also received South American material from Herman Kleerekoper, a Dutch limnologist who worked in Brazil for a number of years before moving to Canada (J. Reid, pers. comm.). D. G. Frey became interested in Kiser's collection and persuaded him to donate it to the NMNH (cf. the "Kiser" file among Frey's papers at the NMNH.)

Wet material.—(In alcohol.) Over 8000 vials of unsorted zooplankton samples, stored in about 135 1–2 liter bottles filled with alcohol. All vials contain Kiser's sample number. Most bottles have an interior list of the vials they contain; outside they are identified by Kiser's original bottle number.

Most of the samples arrived at the NMNH stained by Kiser with Fast Green or Acid Fuchsin, dehydrated and in xylene in preparation for mounting specimens on slides. Others, that had been loaned to D. G. Frey, were in formalin. The formalin and xylene were replaced with alcohol at the NMNH.

The bulk of the samples is from west coast states. There are a few samples from New Zealand, Mexico, Brazil (Kleerekoper's samples), British Columbia, and the north-central U.S.A. states. The majority of the samples above 2500 are from synoptic sampling of Oregon lakes, especially Fern Lake.

Slides.—One hundred, seventy-nine boxes of stained, balsam-mounted specimens. Most boxes are organized by genera; *Daphnia* predominate. Six boxes have specimens from specific areas (China, Brazil, South America, New Zealand, and Scotland), one box has slides with University of Michigan Zoological Laboratory labels, one has mixed zooplankton from Oregon, and one has copepods.

Most of the slides are well-labeled and nearly all bear the sample number from which the specimens came. They appear to be in excellent condition. Within the boxes, slides are not ordered by sample number or by species.

Data.—Kiser's typed index labeled "Plankton Collection of Rufus W. Kiser" giving sample number, location (including county and state or country), other pertinent data, and date.

Kiser's typed inventory of the vials contained in each bottle, stating if they were in xylene or formalin.

A typed NMNH list of the location of each sample by sample number and bottle number. This list was made by reference to Kiser's bottle inventory, and may be partially incorrect since some vials were misplaced.

Kiser's sample numbering system started with 100 (cf. his letter of reply to a query from Frey, in the Frey "Kiser" correspondence file). Some slides have numbers less than 100, or are marked ***A (with data not corresponding to Kiser's sample data). These specimens are from collectors other than Kiser, and there appear to be no supporting data for them.

Kiser apparently had 46 bound notebooks recording information on his samples, and an accession file of 3 × 5 in. cards. (See letter of D. G. Frey to R. B. Manning, 28 May, 1983, in Frey's correspondence.) These are not among the materials at the MSC and Kiser may have kept them.

There is no inventory of the slides in the Kiser collection.

S. F. Light Gift, NMNH 177850

S. F. Light was a copepodologist at the University of California, Berkeley, where Mildred S. Wilson was his assistant for a time (Damkaer 1988). This cladoceran material has been separated from his larger zooplankton collection. It has specimens primarily from the western states as well as some from other localities and collectors (e.g., Wisconsin, from C. Juday).

Wet material.—(In alcohol.) Five mason jars and one small bottle, filled with vials of cladoceran specimens sorted by genus and species. In 1983, these sorted cladoc-

eran specimens were found on the shelves of the cladoceran collection but there was no record of them in the files. At that time some of the vials had dried out; they have since been rehydrated. They are not catalogued.

Data.—A list of collection stations and dates and one small box of file cards with SFL on the top; the cards bear sample numbers and a list of cladoceran species in each.

H. L. Shantz Gift

In 1903, H. B. Ward, of the University of Nebraska, investigated lakes in the Pikes Peak, Colorado, and Lake Tahoe, California, regions; E. A. Birge and C. D. Marsh contributed analyses of the cladocerans and copepods, respectively, in his collections (Ward 1904). H. L. Shantz, also of the University of Nebraska, did a limnological study of some of the same lakes in the Pikes Peak area under Ward's direction (Shantz 1907), but he did not analyze the cladocerans in his collections. G. S. Dodds (1924) later published a list of the cladocerans in Shantz's samples. Shantz's specimens were found in 1995 among Dodds' material at the NMNH. These materials are of historic interest because in 1906 several of the Pikes Peak lakes were converted into reservoirs (Shantz 1907) and in 1995 I found that another, the type locale for the rare cladoceran *Macrothrix montana* Birge, has recently been drained.

Wet material.—(In alcohol.) One large, unidentified jar with vials of unsorted zooplankton samples; labels inside vials give lake names and collection dates. Jar is now temporarily labeled.

Data.—None found. Shantz (1907) gives the lake locales and Dodds (1924) lists the cladocerans in the samples.

Gideon S. Dodds Gift, NMNH 061153

G. S. Dodds worked at the University of Colorado. This collection represents an altitudinal study of Branchiopoda in Colorado lakes (Dodds 1917). Comparable mate-

rial may be in the Shantz Gift (see above) and in E. B. Reed's material (see below).

Wet material.—(In alcohol.) Three hundred and one small vials of sorted zooplankton specimens (cladocerans and copepods), each containing a sample number. From two to four vials, all from one locality, are stored together in small bottles, each bearing a catalogue number. Interior labels in the bottles list catalogue and sample numbers, approximate number of specimens, locality and county, date, and other pertinent data. Species names are listed on the reverse side of the interior labels.

This material is housed in one large jar full of vials and in six boxes holding about 30 bottles each, not in strict order according to catalogue number.

Data.—Dodds' list of sample number, location (lake name), date, and county and terrain (mountain or plains).

Other Sources of Cladoceran Materials

The following, while not included in the cladoceran collection, might contain material useful to cladoceran researchers:

The Albatross Expedition collection.—No NMNH accession number. This collection includes freshwater samples made across the United States. The computerized database can be consulted to locate appropriate material.

The M. S. Wilson gifts.—Several NMNH numbers. The catalogue list and materials on the "Copepod holding area" shelves at the Natural History Building in Washington, District of Columbia, should be consulted. Lots under NMNH 319629 might be most useful.

The E. B. Reed gifts.—Several NMNH numbers. The catalogue list and materials on the "Copepod holding area" shelves should be consulted. About 16 lots of unidentified cladocerans under NMNH 383116 have been catalogued. Reed's collections are primarily from Alaska, the Rocky Mountains, and plains lakes near Fort Collins, Colorado.

The C. D. Marsh gift.—NMNH 120079. There are containers marked "Entomostraca" on the "Copepod holding area" shelves that may contain cladocerans.

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