TREATISE ON INVERTEBRATE PALEONTOLOGY

Prepared under the Guidance of the
Joint Committee on Invertebrate Paleontology

Paleontological Society | *Society of Economic Paleontologists and Mineralogists* | *Palaeontographical Society*

Directed and Edited by

RAYMOND C. MOORE

Part D
PROTISTA 3
Protozoa (Chiefly Radiolaria and Tintinnina)

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PARTS

The indicated Parts (excepting the first and last) are to be published at whatever time each is ready. All may be assembled ultimately in bound volumes. The list of contributing authors is subject to change.

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EDITORIAL PREFACE

The aim of the *Treatise on Invertebrate Paleontology,* as originally conceived and consistently pursued, is to present the most comprehensive and authoritative, yet compact statement of knowledge concerning invertebrate fossil groups that can be formulated by collaboration of competent specialists in seeking to organize what has been learned of this subject up to the mid-point of the present century. Such work has value in providing a most useful summary of the collective results of multitudinous investigations and thus should constitute an indispensable text and reference book for all persons who wish to know about remains of invertebrate organisms preserved in rocks of the earth's crust. This applies to neozoologists as well as paleozoologists and to beginners in study of fossils as well as to thoroughly trained, long-experienced professional workers, including teachers, stratigraphical geologists, and individuals engaged in research on fossil invertebrates. The making of a reasonably complete inventory of present knowledge of invertebrate paleontology may be expected to yield needed foundation for future research and it is hoped that the *Treatise* will serve this end.

The *Treatise* is divided into parts which bear index letters, each except the initial and concluding ones being defined to include designated groups of invertebrates. The chief purpose of this arrangement is to provide for independence of the several parts as regards date of publication, because it is judged desirable to print and distribute each segment as soon as possible after it is ready for press. Pages in each part will bear the assigned index letter joined with numbers beginning with 1 and running consecutively to the end of the part. When the parts ultimately are assembled into volumes, no renumbering of pages and figures is required.

The outline of subjects to be treated in connection with each large group of invertebrates includes (1) description of morphological features, with special reference to hard parts, (2) ontogeny, (3) classification, (4) geological distribution, (5) evolutionary trends and phylogeny, and (6) systematic description of genera, subgenera, and higher taxonomic units. In general, paleoecological aspects of study are omitted or little emphasized because comprehensive treatment of this subject is being undertaken in a separate work, prepared under auspices of a committee of the United States National Research Council. A selected list of references is furnished in each part of the *Treatise.*

Features of style in the taxonomic portions of this work have been fixed by the Editor with aid furnished by advice from the Joint Committee on Invertebrate Paleontology representing the societies which have undertaken to sponsor the *Treatise.* It is the Editor's responsibility to consult with authors and co-ordinate their work, seeing that manuscript properly incorporates features of adopted style. Especially he has been called on to formulate policies in respect to many questions of nomenclature and procedure. The subject of family and subfamily names is reviewed briefly in a following section of this preface, and features of *Treatise* style in generic descriptions are explained.

A generous grant of $25,000 has been made by the Geological Society of America for the purpose of preparing *Treatise* illustrations. Administration of expenditures has been in charge of the Editor and most of the work by photographers and artists has been done under his direction at the University of Kansas, but sizable parts of this program have also been carried forward in Washington and London.

FAMILIAL NAMES

Any formally designated assemblage of genera having indicated rank below that of a suborder (or exceptionally, a sub-suborder category such as "division" introduced above superfamily) is recognized as one of the family-group types of taxonomic units (taxa; singular, taxon) (Copenhagen Decisions on Zoological Nomenclature, 1953). These assemblages may include, in order of increasing comprehensiveness, subtribe, tribe, supertribe, subfamily, family, and superfamily; in addition, CAMPBELL in this volume recognizes a taxon called subsuperfamily, which is intermediate between family and superfamily.

Many problems are encountered in the nomenclature of family-group taxa and correct definition of the authorship and date

of original publication of family-group names. This depends partly on acceptance of the co-ordinate status of all family-group taxa as regards nomenclature and partly on adoption of priority of publication as the main determinant for fixation of family-group names. Stability and uniformity of nomenclature are important objectives, and in a work like the *Treatise* it is very desirable to furnish information as completely and compactly as possible on the manner in which each accepted family-group name is derived. Rules adopted as guides in preparing systematic portions of *Treatise* text include the following provisions concerning familial names.

(1) Family and subfamily names are formed by adding the prescribed endings -idae and -inae, respectively, to the stem of the generic name chosen as nomenclatorial type of the assemblage. This accords with stipulations given in Article 4 of the International Rules of Zoological Nomenclature. No restriction is imposed on an author in choosing the type genus of a new family or subfamily, but a subfamily that includes the type genus of the family to which it belongs (nominotypical subfamily) must be named after such genus. The type genus of a family or subfamily need not be the first-published among those included, but once fixed by publication, it cannot be replaced by another genus in the assemblage unless the type genus in question is transferred to a family or subfamily having an earlier chosen different type genus.

(2) Family-group names are co-ordinate, which signifies that a name published with the ending -idae may be changed to -inae or vice versa without change in citation of author and date from those of the original publication. Family-group taxa of other ranks are treated likewise.

(3) The first-published name of any family-group assemblage shall be accepted unless it is unavailable, as in case of names based on junior homonyms or objective synonyms or on invalid emendations of generic names, and unless the name conflicts with requirements stated in paragraph 4.

(4) If a family is divided into subfamilies or a subfamily into tribes, the name of no such subfamily or tribe can antedate the family name. Every family divided into subfamilies must have a nominotypical *(sensu stricto)* subfamily, which has as its type genus the same one which serves as type of the family, and because the name of the family is based on the generic name which (among all included in the assemblage) was first published as type of a familial category, this applies also to the nominotypical subfamily. The same principle applies to subfamilies divided into tribes.

The author and date of the nominotypical subfamily invariably are identical with those of the family (and tribe with subfamily and family), without reference to whether the author of the family or some subsequent author introduced subdivisions. Thus, the family Astrocoeniidae KOBY, 1890, contains the subfamilies Astrocoeniinae KOBY, 1890 (not Astrocoeniinae FELIX, 1898), and Pinacophyllinae VAUGHN & WELLS, 1943; KOBY did not subdivide the family. Just as the nominotypical subgenus of a genus must be ascribed to the author who erected the genus and must bear the same date, so a nominotypical subfamily cannot be attributed to an author other than the one who first selected the genus that serves the family and nominotypical subfamily as type and it cannot bear a date subsequent to that of erecting the family.

(5) Change from the originally published form of family and subfamily names is required (a) if the taxonomic rank assigned to the assemblage is altered, (b) if the stem of the nominotypical generic name is incorrectly distinguished, or (c) if the name of the type genus is changed.

(6) Changes of the sort specified in 5a and 5b do not call for change in citing author and date of family or subfamily assemblages, for these remain as in the original publication. Yet it is desirable to know exactly how an originally published familial or subfamilial name has been modified, and for completeness of information, when and by whom. Such documentation aids understanding of adopted nomenclature and facilitates work of any student concerned with research on a group of invertebrates. It is appropriate for the *Treatise* to supply records of this sort, as illustrated by the following examples. (a) NICHOLSON in 1889 proposed a family of rugose corals called Streptelasmidae, based on the genus *Streptelasma,* whereas the cor-

rect name, first published by WEDEKIND in 1927, is Streptelasmatidae. This seems like a minor sort of emendation but it is needful. The *Treatise* form of citation is "Family Streptelasmatidae NICHOLSON, in NICHOLSON & LYDEKKER, 1889 [as Streptelasmidae; emend. WEDEKIND, 1927]." (b) BASSLER in 1935 defined a subfamily of bryozoans named Exochellinae which in *Treatise* Part G he recognized as an independent family. This is indicated by the entry "Family Exochellidae BASSLER, 1935 [as Exochellinae; emend. BASSLER, 1953]."

(7) A statement given under this number in the Editorial Preface of *Treatise* Part G (Bryozoa) (1953) refers to change of familial names based on change in the name of the type genus, pointing out that the familial name is not replaced by one based on some other genus but is altered to accord with revision of the nominotypical genus. Recommendation approved by the International Zoological Congress at Copenhagen in 1953 calls for restriction of such familial name changes to those which are found to be based on junior homonyms. It is proposed that the new Rules shall provide for retention of familial names having priority over others if the nominotypical genus proves to be an objective junior synonym and likewise if it is judged to be a subjective junior synonym. In the interest of stability of nomenclature, it is appropriate to accept priority of publication as ground for sustaining a familial name based on a junior subjective synonym, for opinions of different workers as to the synonymy of generic names founded on different type species may not agree and opinions of the same worker at different times also may change. This does not pertain to objective synonyms, however, and accordingly *Treatise* authors who conclude that stability of nomenclature is served by adopting familial names (particularly long-used ones) based on senior objective synonyms are encouraged to recognize such names rather than an older familial name based on a junior objective synonym.

An example of alteration of a familial name which is required by discovery that the originally designated nominotypical genus is a junior homonym is replacement of Electrinidae by Electridae as applied to an assemblage of cheilostome bryozoans. Here a junior homonym *(Electrina)* yields to a senior subjective synonym *(Electra)* as name giver to the family. The form of *Treatise* reference is "Family Electridae LAGAAIJ, 1952 [*pro* Electrinidae D'ORBIGNY, 1851, *ex Electrina* D'ORBIGNY, 1851 (*non* BAIRD, 1850) (=*Electra* LAMOUROUX 1816)]." The citation of a widely accepted family name for corals that involves objective synonyms is "Family Heliolitidae LINDSTRÖM, 1876 [*pro* Palaeoporidae M'COY, 1851, *ex Palaeopora* M'COY, 1849 (=*Heliolites* DANA, 1846, obj.)]; *pro* Heliolithidae LINDSTRÖM, 1873, *ex Heliolithes* LINDSTRÖM, 1873 (=*Heliolites* DANA, 1846, obj.)]."

(8) Names not available for family-group assemblages include (a) vernacular designations, such as membranipores (English), Pisokrinoiden (German), and Aulacocératidés or Syringoporiens (French); (b) terms not founded on generic names, as for example "Hastatide STOLLEY, 1919," for which no corresponding generic name exists (derivation presumably based on the "section" of the broad genus *Belemnites* called Hastati, after the species *Hibolites hastatus*); (c) names not originally of suprageneric rank, as terms derived from trivial names of species; (d) names formed from the stem of generic or subgeneric names which are junior homonyms or synonyms; (e) names based on a type other than that having priority of designation among all genera and subgenera included in the assemblage; and (f) names based on invalid emendations of generic or subgeneric names, as for example "Family Zitteloceratidae," based on invalid emendation of *Zittelloceras* HYATT to *Zitteloceras* (even though this genus patently was named for ZITTEL). Present International Rules do not contain some of these stipulations.

STYLE IN GENERIC DESCRIPTIONS

DEFINITION OF NAMES

Most generic names are distinct from all others and are indicated without ambiguity by citing their originally published spelling accompanied by name of the author and date of first publication. If

the same generic name has been applied to 2 or more distinct taxonomic units, however, it is necessary to differentiate such homonyms, and this calls for distinction between junior homonyms and senior homonyms. Because a junior homonym is invalid, it must be replaced by some other name. For example, *Callopora* HALL, 1851, introduced for Paleozoic trepostome bryozoans, is invalid because GRAY in 1848 published the same name for Cretaceous-to-Recent cheilostome bryozoans, and BASSLER in 1911 introduced the new name *Hallopora* to replace HALL's homonym. The *Treatise* style of entry is: "*Hallopora* BASSLER, 1911 [*pro Callopora* HALL, 1851 (*non* GRAY, 1848)]." A senior homonym is valid, and in so far as the *Treatise* is concerned, such names are handled according to whether the junior homonym belongs to the same major taxonomic division (class or phylum) as the senior homonym or to some other; in the former instance, the author and date of the junior homonym are cited as "*Diplophyllum* HALL, 1851 [*non* SOSHKINA, 1939]"), but in the latter no mention of the existence of a junior homonym is made.

CITATION OF TYPE SPECIES

The name of the type species of each genus and subgenus is given next following the generic name with its accompanying author and date, or after entries needed for definition of the name if it is involved in homonymy. The originally published combination of generic and trivial names for this species is cited, accompanied by an asterisk (*), with notation of the author and date of original publication. An exception in this procedure is made, however, if the species was first published in the same paper and by the same author as that containing definition of the genus which it serves as type; in such case, the initial letter of the generic name followed by the trivial name is given without repeating the name of the author and date, for this saves needed space. Examples of these 2 sorts of citations are as follows: "*Diplotrypa* NICHOLSON, 1879 [**Favosites petropolitanus* PANDER, 1830]" and "*Chainodictyon* FOERSTE, 1887 [**C. laxum*]." If the cited type species is a junior synonym of some other species, the name of this latter also is given, as "*Acervularia* SCHWEIGER, 1819 [**A. baltica* (=**Madrepora ananas* LINNÉ, 1758)]."

It is judged desirable to record the manner of establishing the type species, whether by original designation of by subsequent designation, but various modes of original designation are not distinguished. According to convention adopted in the *Treatise,* absence of any indication as to manner of fixing the type species is to be understood as signifying original designation. If the type species has been fixed by subsequent designation, this is indicated by the letters "SD" followed by the name of the author and date of such subsequent designation. An example is "*Hexagonaria* GÜRICH, 1896 [**Cyathophyllum hexagonum* GOLDFUSS, 1826; SD LANG, SMITH, & THOMAS, 1940]."

SYNONYMS

Citation of synonyms is given next following record of the type species and if 2 or more synonyms of differing date are recognized, these are arranged in chronological order. Objective synonyms are indicated by accompanying designation "(obj.)," others being understood to constitute subjective synonyms. Examples showing *Treatise* style in listing synonyms are "*Calapoecia* BILLINGS, 1865 [**C. anticostiensis;* SD LINDSTRÖM, 1833] [=*Columnopora* NICHOLSON, 1874; *Houghtonia* ROMINGER, 1876]" and "*Staurocyclia* HAECKEL, 1882 [**S. cruciata* HKL., 1887] [=*Coccostaurus* HKL., 1882 (obj.); *Phacostaurus* HKL., 1887 (obj.)]." A synonym which is also a homonym is recorded in the following: "*Lyopora* NICHOLSON & ETHERIDGE, 1878 [**Palaeopora? favosa* M'COY, 1850] [=*Liopora* LANG, SMITH, & THOMAS, 1940 (*non* GIRTY, 1915)]."

ABBREVIATIONS

Some authors' names and most stratigraphic and geographic names are abbreviated in order to save space. General principles for guidance in determining what names should be abbreviated are frequency of repetition, length of name, and avoidance of ambiguity. Abbreviations used in this division of the *Treatise* are explained in the following alphabetically arranged list.

Abbreviations of Stratigraphic and Place Names and Words Used in Bibliographical Citations

Accad., Accademia
Am., America
Austral., Australia
Bd., Band
Belg., Belgium
Berrias., Berriasian
Bull., Bulletin
C., Central
Calif., California
Cam., Cambrian
Carb., Carboniferous
Circumtrop., Circumtropical
Comm., Committee
Comp., Comparative
Cosmop., Cosmopolitan
Cret., Cretaceous
Dept., Department
Dev., Devonian
E., East
emend., emended by
Eng., England
Eoc., Eocene
Eur., Europe
fasc., fascicle
fig., figure, -s
Fr., France
Geol., Geological, Geology
géol., géologique
Ger., Germany
illus., illustrated
Imp., Imperial
Inst., Institute
ital., italiana
Jour., Journal
Jur., Jurassic
L., Lower
M., Middle
Medd., Meddeelingen
Mio., Miocene
Mts., Mountains
Mus., Museum
N., North
N.Am., North America
Natl., National
Naturw., Naturwissenschaften
Neocom., Neocomian
N.Y., New York
obj., objective
Oceanogr., Oceanographic
Ord., Ordovician
p., page, -s
Palaeontogr., Palaeontographica
Paleoc., Paleocene
Paleont., Paleontology
Perm., Permian
pl., plate, -s
Plio., Pliocene
Pub., Publication
Rec., Recent
Rept., Report
Riv., Rivista
Roy., Royal
Russ., Russia
S., South
Sci., Science
Scot., Scotland
SD, subsequent designation
ser., serial
Sil., Silurian
Soc., Society, Société
Switz., Switzerland
t., tome
Tech., Technology
Tithon., Tithonian
Trias., Triassic
Trop., Tropical
U., Upper
Univ., Université, University
Va., Virginia
Valang., Valanginian
vol., volume, -s
Zeitschr., Zeitschrift
Zool., Zoology, Zoological

Abbreviations of Authors' Names

C.-Cl., Campell, A. S., & Clark, B. L.
Cl.-C., Clark, B. L., & Campbell, A. S.
Ehr., Ehrenberg, C. G.
Hkl., Haeckel, Ernst
Jörg., Jörgensen, E.
K.-C., Kofoid, C. A., & Campbell, A. S.
Pop., Popofsky, A.
Rued.-W., Ruedemann, Rudolf, & Wilson, T. Y.
Schew., Schewiakoff, W.
Squin., Squinabol, Senofonte
Vinassa, Vinassa de Regny, P. E.

REFERENCES TO LITERATURE

Each part of the *Treatise* is accompanied by a selected list of references to paleontological literature consisting primarily of recent and comprehensive monographs available but also including some older works recognized as outstanding in importance. The purpose of giving these references is to aid users of the *Treatise* in finding detailed descriptions and illustrations of morphological features of fossil groups, discussions of classifications and distribution, and especially citations of more or less voluminous literature. Generally speaking, publications listed in the *Treatise* are not original sources of information concerning taxonomic units of various rank but they tell the student where he may find them; otherwise it is necessary to turn to such aids as the *Zoological Record* or NEAVE's *Nomenclator Zoologicus*. References given in the *Treatise* are arranged alphabetically by authors and accompanied by index numbers which serve the purpose of permitting citation most concisely in various parts of the text; these citations of listed papers are inclosed invariably in parentheses and are distinguishable from dates because the index numbers comprise no more than 3 digits. Ordinarily, index numbers for literature references are given at the end of generic or family diagnoses.

SOURCES OF ILLUSTRATIONS

At the end of figure captions an index number is given to supply record of the author of illustrations used in the *Treatise*, reference being made to an alphabetically arranged list of authors' names which follows. Index numbers printed in lightface roman type denote reproduction of original illustrations in modified form, as in redrawing (in the manner commonly recorded by the examples "after SCHUCHERT"), whereas facsimile copies without any change other than alteration of scale are indicated by numbers in italic type (for example, signifying "from SCHUCHERT").

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