STERKIANA

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ANNOUNCEMENT

STERKIANA is named after Dr. Victor Sterki (1846-1933) of New Philadelphia, Ohio, famed for his work on the Sphaeriidae, Pupillidae, and Valloniidae. It is fitting that this serial should bear his name both because of his association with the Midwest and his lifelong interest in non-marine Mollusca.

The purpose of STERKIANA is to serve malacologists and paleontologists interested in the living and fossil non-marine Mollusca of North and South America by disseminating information in that special field. Since its resources are modest, STERKIANA is not printed by conventional means. Costs are kept at a minimum by utilizing various talents and services available to the Editor. Subscription and reprint prices are based on cost of paper and mailing charges.

STERKIANA accepts articles dealing with non-marine Mollusca of the Americas in English, French, or Spanish, the three official languages of North America. Contributors are requested to avoid descriptions of new species or higher taxa in this serial as the limited distribution of STERKIANA would probably prevent recognition of such taxa as validly published. Papers on distribution, ecology, and revised checklists for particular areas or formations are especially welcome but those on any aspect of non-marine Mollusca will be considered.

STERKIANA will appear twice a year or oftener, as material is available. All correspondence should be addressed to the Editor.

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STERKIANA est une collection de travaux sur les Mollusques extra-marins des deux Amériques, distribuée par un groupe de malacologues du centre des Etats-Unis. STERKIANA publie des travaux en anglais, en français et en espagnol acceptés par le conseil de rédaction. Prière d'adresser toute correspondance au Rédacteur.

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STERKIANA es una coleccion de trabajos sobre los Moluscos extra-marinos vivientes y fosiles de las dos Americas, editada por un grupo de malacólogos de los Estados Unidos centrales. Contenirá en el porvenir trabajos en inglés, francés, y español que serán acceptados por la mesa directiva. La correspondencia deberá ser dirigida al Editor.

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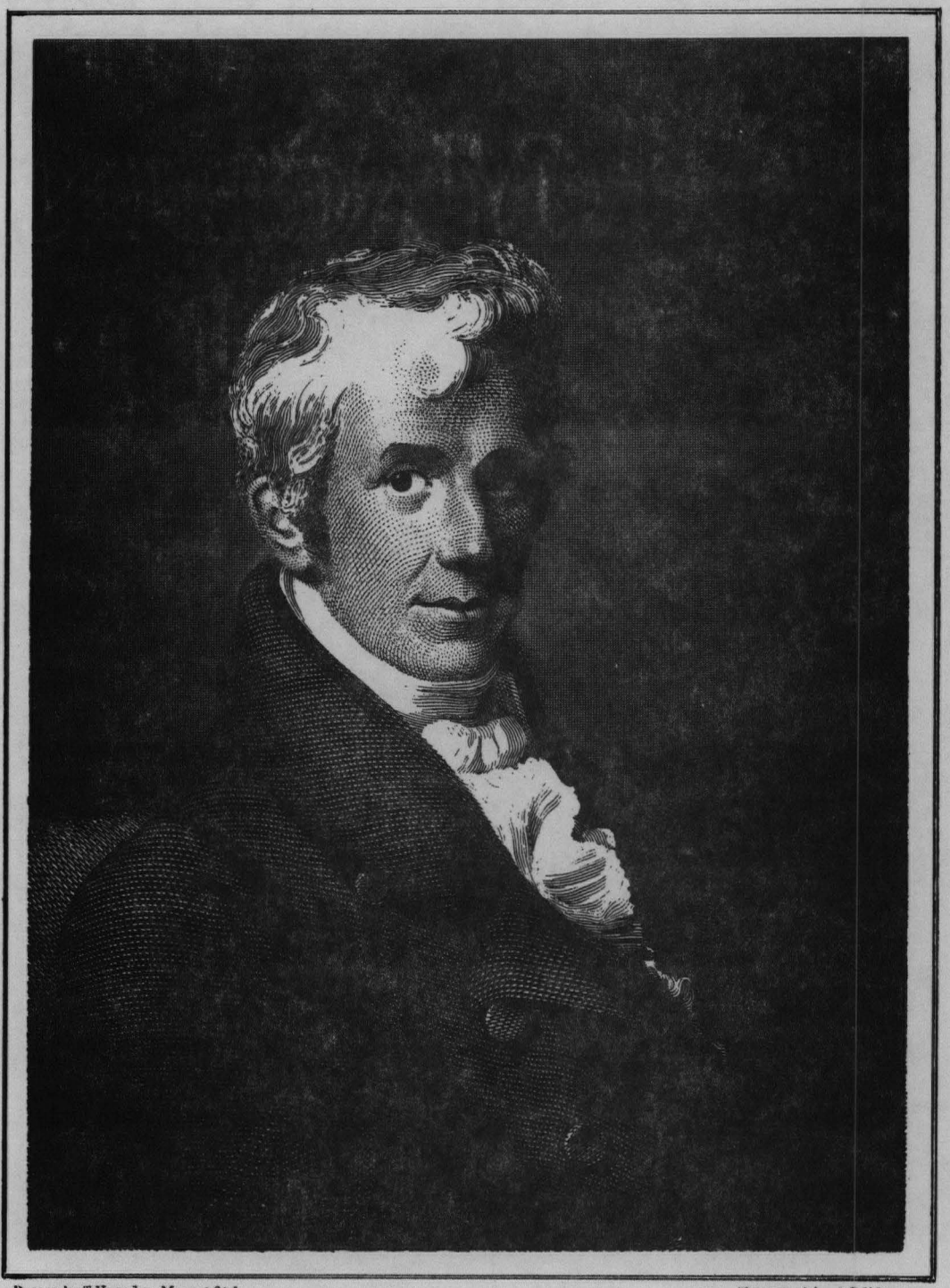

Drawn by T. Heaphy. May. 1816. Engraved by J.C. Edwards.

JAMES SOWERBY, F. L. S: C. S. &c.

Nat: March 21, 1757.—Ob: October 25, 1822.

WHO WERE THE SOWERBYS?

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One of the most loosely used of authors' names for specific and generic names of mollusks, fossil and Recent, is that of 'Sowerby.' The name is so indiscriminately applied to scientific taxa that a worker untrained in the literature of Mollusca may regard the name as referring to one individual. Many times the experienced taxonomists cannot without much labor distinguish which Sowerby should have credit for certain scientific names. Even though he may know that there are several individuals involved he may not be able to determine which Sowerby is the author of a certain specific or generic name. The number of taxa which are ascribed to 'Sowerby' is multitudinous. The members of the Sowerby family have described fossil and living shells from all over the world. There are about 91 species of pelecypods and about 136 species of gastropods from the Recent tropical west American shores the names of which were authored by a 'Sowerby.' These are the species cited by Keen (1958) as valid with many more Sowerby names which fall in synonymy. Carpenter (1857) in the compilations in his Report to the British Association in 1856 recorded 178 mollusk species from the Pacific Coast of the Americas described by a 'Sowerby' in the Proceedings of the Zoological Society of London, 1832-44 and in Reeve's *Conchologia Iconica*. Most of those species were from the collection of Hugh Cuming. One could add a long list of species described by the Sowerbys from other parts of the world. There are at least 32 species of pelecypods and gastropods described by a Sowerby from the Atlantic Coast of North America. Suffice it to say that the number of species of mollusks involved in Sowerby authorship is worthy of taxonomic discretion and more careful bibliographic research than has been carried on in the past.

Rarely is an initial attached to the name 'Sowerby' when indicating the author of a generic or specific name. When referring to the Adamses, of which there were several, it is common practice to state 'H.' or 'A. Adams,' 'H. and A. Adams' or 'C. B. Adams.' But such practice is not true of the Sowerbys of which there were five individuals representing three generations. Each Sowerby has an extensive bibliography of well-known, important, and beautifully illustrated series of publications from 1812 to about 1897. It is important, both to give credit where credit is due, but to make information more readily available and hence

labor saved by indicating by initials which of the Sowerbys should be credited as author of the taxa. This pinpoints the reference. Some writers accompany the name 'Sowerby' with a date. This helps if the bibliography of such a work is refined so that each date refers to specific publications. Frequently this is not done, and the search for the proper reference leaves one in a dilemma. Even a date without an initial as to the Sowerby does not solve a problem because during certain periods genera snd species were described by at least three Sowerbys at the same time in different publications. Writers through the years including the present are not to be blamed for this looseness in connection with these names. The Sowerbys and the writers of their day were not always explicit in indicating the individual.

The importance of differentiating the authorship of Sowerby specific names was recognized by C. Davies Sherborn in the 28 parts of *Index Animalium*. Sherborn distinguished the Sowerbys by initial. The three G. B. Sowerbys are designated I, II, III. *Index Animalium* provides a quick means of identifying the particular Sowerby authorship of specific taxa. The discrimination of the Sowerbys in Sherborn was discovered by the writer after she had compiled the historical data on the family and began to edit the names in the same system of initials and numbers. It was a source of satisfaction to realize that as great a bibliophile as Sherborn recognized the fairness and value of distinct notation for each of the group.

Because of the wide distribution of names of taxa by the Sowerbys it seems a brief outline of this Royal Family of Natural History might be of use and interest.

Instead of one 'Sowerby' as intimated in literature there were five, father Jsmes; James de Carle, son of James; George Brettingham I, son of James and brother of James de Carle; G. B., II, son of G. B., I; and G.B., III, son of G. B., II, grandson of G. B., I, and great-grandson of James. The years of this group represent the perio f from 1757-1921, birth of James and death of G. B., III.

The following includes the genealogical record of the Sowerbys who were involved in the

GENEALOGICAL TABLE

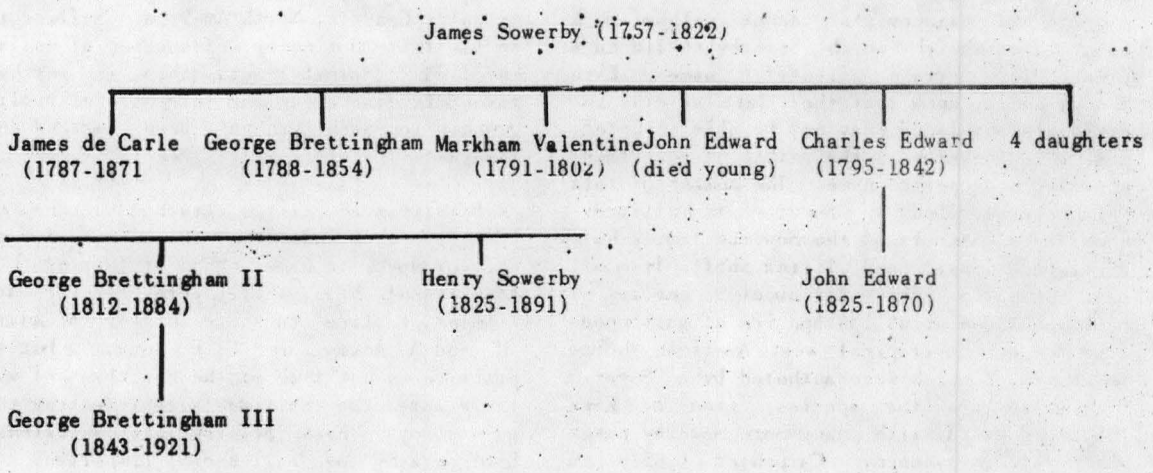

illustration and description of molluscan species. The table was compiled by R. J. Cleevely of the Paleontology Library. British Museum (Natural History) who also sent the photograph of James Sowerby (*Frontispiece*, facing p. 1). The portrait is reproduced through permission of the British Museum (Natural History).

Supposedly portraits were included in a list of exhibits and guide to a Sowerby Exhibit produced by the Royal Botanic Society in December, 1908, but none has been preserved. Students in England who have been interested in the family have not as yet found portraits, other than that of James, of the other members. Other portraits may be discovered.

All of these men were naturalists, artists, conchologists, and publishers. Some were botanists of the first water, and a description of their work in botanical publication is equally important as that of the other sciences. The Sowerbys provided the illustration and publication of such famous works as 'Mineral Conchology of Great Britain' (7 volumes), 'Genera of Recent and Fossil Shells' (2 volumes), 'Catalogue of the Shells contained in the collection of the Earl of Tankerville . . . . 'Thesaurus Conchyliorum' (5 volumes), 'Conchological Illustrations,' and the illustration of the plates of the 20 volumes and continuation of the [15]- 18-20 volumes of Reeve's Conchologia Iconica' and hundreds of articles. The books represent the artistry and extensive publishing business of the family which began with the 'museum' and business of the father, James, continued by sons James de Carle and Charles Edward, and a separate establishment by son G.B. Sowerby, which was furthered by his son and his grandson G. B. Sowerby III. In 1899, the G. B. Sowerby business was united under the name of Sowerby and Fulton and from 1916 became the Hugh Fulton Company. The enterprises moved from various areas of London during the long interval from Mead Place, Lambeth, King Street, Covent Gardens to Regent Street, Great Russel Street, Fulham Road, Station Parade, and Riverside, Kew Gardens.

The Sowerbys have been described as 'admirable delineators of shells,' their conchological drawings were depicted with fidelity and accuracy.'

James Sowerby (1757-1822) was from an old Yorkshire family. He was born in London to John and Arabella Sowerby. His father was a lapidary. Such a profession required mechanical and artistic skills. Consequently James in his youth was brought up in an artistic environment. He was a student of Richard Wright, a marine painter who taught James drawing portrait work and flower painting. From Wright and William Curtis, celebrated botanist, James became interested in botany. James also received training at the Royal Academy. His skill in botanical illustration attracted the attention of botanists and from 1786-1790 he drew and painted great botanical works particularly 36 volumes of 'English Botany' 2592 colored plates. He helped with illustrations for 'Flora Londinensis' which has been described as 'unsurpassed in the history of botanical illustrations.' Three hundred copies of 435 plates were hand-colored by James. From plants he became interested in minerals fossils, and from that work to shells. His best known is the 'Mineral Conchology of Great Britain.' This is a pretentious work of seven volumes. The first four were by James and the last three by his son, James de Carle.

James married Anne, daughter of Robert Brettingham de Carle, of Huguenot descent. The de Carles were also a family of artistic talents. It is from Anne's family that one may connect the names of the others in the conchological quintet.

It was the idea of James Sowerby that there should be a museum in England containing all the forms of animal life of that country. To this end he worked to accumulate such a collection. This he called his 'museum.' From this 'museum' was produced those valuable colored illustrated books on Natural History. The description of the 'museum' which became a family institution through three generations has been described by a descendant, the late Arthur de Carle Sowerby.

"The 'museum' was a family institution, in which every member had his or her place for producing illustrated books on Natural History in quantity. The Museum itself was only incidental to this work--it was comparable with the 'Parlour' which figures in the Publishing, Banking and Local Authority circles of those times (the name is still often retained) a convenient meeting place for customers, enquirers and kindred spirits. It is true that old James had at one time some idea of making it a per-

manent public institution, but he never got far with that: there was never, of course, any charge for admission, and only long after his death was anything sold there except the works, plates, drawings, etc. It consisted chiefly of the specimens from which drawings had been made which were filed for possible publication later.

'These specimens were collected by James and his sons, or sent by correspondents from all over the country--amateur gentlemen naturalists. We have many letters from them. Only in later days were paid collectors employed.

'Filing systems were primitive in those days and the Sowerbys, being handier with the drawing pencil than the descriptive pen, it was their habit to draw anything that took their fancy or interest and put the drawings away in case it might come in handy later. Indeed, when James starts a diary of a journey, say into Cornwall--it soon degenerates into sketches of what he saw. Some of the drawings have a series of notes on them which have been added to over a period of ten years or so.

'After being selected for publication the original was engraved on one copper (sometimes in the later days with a scale drawing intervening). Arrangements were made to provide and print a description, and prints from the copper were run off. When copies were needed for customers the paper cover of the part (all our main works were issued in parts) the letterpress and the plates were assembled from stock, stitched and despatched. Colouring was done by the family, employees who worked in the house, and professional colourers, firms or individuals.

'As the children grew up, they graduated from the 'dirt' as the little strip of ground at the bottom of the specimen in some plates was called, to more responsible work. Patterns were provided by James himself, and of course any work that did not come up to standard was rejected.

'The quantity of work passing through can be roughly guaged by the costs of this colouring. In the early 1800s the colourer's bills were running at some £ 8. The price per plate was about 1¼ *d* to 1½ *d*.

'Anne (James' wife) acted as second in command, and we have some letters from her to James when she was in charge, he being away on scientific excursions.

'A stock was maintained of each publication --cover, letterpress, plain and coloured plates --which was replenished as required. All this is, of course, the despair of bibliographers, who cannot make out how it is they find obviously early plates in obviously late copies. The water-marks do not help much either, as large stocks of paper were held, and not necessarily used in chronological order.' -- The Sowerby Saga ...

James de Carle (1787-1871), son of James, was educated privately, experimented in chemistry, was friend and companion of Faraday, and studied with Davy. He was a mineralogist, artist, using his skill in the depicting of living mollusk shells and of fossils. He finished the last volumes of his father's 'Mineral Conchology of Great Britain.' He continued the drawing of the plates of the 'Genera of Recent and Fossil Shells' begun by his father. He, with a cousin, founded the Royal Botanic Society and Gardens and was secretary for 30 years. After his father's death James de Carle and the fifth son, Charles Edward, carried on the business. The brother, George Brettingham (the First) had left the family circle earlier and set up shop independently.

The brother George Brettingham, I (1788-1854) son of James) also worked and helped to continue 'Genera of Recent and Fossil Shells.' One of his best known works was the catalogue of the shells of the collection of the Earl of Tankerville. He, with others, founded the Zoological Journal which ran for five volumes. He monographed *Ancillaria*, *Ovulum*, and *Pandora*. He started the 'Thesaurus Conchyliorum,' four volumes and 'Conchological Illustrations,' with many other well-known books including the description of the shells in the voyage of Capt. Beechey to the Pacific and Bering Straits, the fossil shells brought from South America by Darwin in his voyage of the Beagle, and other papers from 1812-1849.

G.B. Sowerby, II (1812-1884), called younger, or signed 'Junr.' assisted his father in the family publishing and continued the illustration of 'Conchological Illustrations,' 'Thesaurus Conchyliorum,' 'Conchological Manual' and illustrated Reeve's 20 volumes of Conchologia Iconica' and wrote the last volumes [15-]. 18-20. He died on the same day of the month, July 26, as that of his father G. B., I,

30 years later. G. B. Sowerby, II's works were continued by his son, G. B., III (1843-1921), who carried on that business until it was united with that of Hugh Fulton. G. B., III executed the monograph of *Conus* of the 'Thesaurus Conchyliorum,' 'Illustrated Index of British Shells' and about the last, 'Marine Shells of South Africa. Surprisingly, Sowerby was color blind and the coloring of his sketches was done by his daughter. He died in 1921. The 'Thesaurus Conchyliorum' is signed 'G. B Sowerby, F.L.S.' This is not explicit as the other G. B. Sowerbys were signed in the same manner.

Not only is it difficult to determine in cases of synonymous dates as to which Sowerby wrote an article but it is equally hard to find the true date of publication or distribution. Several authors have spent meticulous search and compilation to determine a true date of the various parts of the Sowerbys' voluminous monographs and papers.

Because the Sowerbys' books were published in parts and sold separately over several years before a volume was completed and because only one date is printed on the cover of the volume, it is necessary for taxonomists to have the dates of the individual parts.

E. R. Sykes in 1906 compiled and published four pages of detailed dates, part by part, page by page, and plate by plate of the seven volumes of the 'Mineral Conchology' from June 1, 1812 through Jan. 1846. R. B. Newton in 1891 also published a detailed listing of dates of the 'Mineral Conchology' but not so complete as that of the later data by Sykes. Newton (1891) also gave a detailed compilation of the dates by number of the 'Genera of Recent and Fossil Shells.'

In 1909, H.O.N. Shaw published eight pages of detailed notes on the dates of parts of the genera covered and plates by each of the Sowerbys' 'Conchological Illustrations' from '1832? to 1839' of the 160 parts. 'Conchological Illustrations' was the work of G. B. Sowerby I and II. The complete matter of dates is a series of complications. Sherborn, in 1909, in an article previous to that of Shaw explained that G. B. Sowerby Sen. [I] and J.E. Gray agreed to bring out a joint project under the title [i. e., Conchological Illustrations] with figures by 'G. B. Sowerby Junr.' and text by Gray. However, during the course of the work, Sowerby I and Gray fell out so that the completion of the 'Conchological Illustrations' was the work of the Sowerbys and consisted of 200 parts from 1832-41. Gray's part remained only as proof sheets.

Although since the publication of the catalogue of the books, manuscripts in the British Museum (Natural History) library where the three Sowerbys were differentiated as 'First, Second and Third of the name,' authors have been trying to bring a measure of definiteness to conchological references of the Sowerbys. However, the old use of 'Sowerby' to differentiate any or all of the five artists lingers.

Details of the genealogy of the Sowerby family from the earliest times in England through the sons of James Sowerby have been described by Arthur de Carle Sowerby, Alice Muriel Sowerby, and Joan Evelyn Stone (1952) in 'The Sowerby Saga ...' Arthur de Carle Sowerby was an eminent oriental scholar.

A chart follows outlining the major molluscan works of the five Sowerbys.

James (1757-1822)

1790 +	Botany
[1802] 1804-17	British Mineralogy
1811-17	Exotic Min. 2 vols.
1812-22	Miner. Conch. Gt. Brit. Vols. 1-4
1820-22	Genera of Recent and Fossil Shells, pls. 1-17

James de Carle (1787-1871)
Son of James

1825-34	Genera of Recent and Fossil Shells, pls. 18-42
1823-46	Min Conch. Gt. Brit., Vols. 5-7
1836	List of Fresh-water Moll. Canada
1838	Fossil Shells of Australia
1850	Desc. Fos. Bracklesham Bay

George Brettingham I (1788-1854)
Son of James

1822-34	Genera of Recent and Fossil Shells, cont'd after James
1825	Cat. Tankerville Shells
1825-26	Zool. Jr. Vols. I, II
1829	Obser. shells of Strutchbury
1830	Mono. of *Ancillaria*, *Ovulum*, and *Pandora*

1832	Conch. Illus. text
1838-39	Mal. and Conch. Mag.
1839	Moll. Animals in Voy.-- Beechey
1843-46	Thesaurus Conchyliorum, Vol. 1
1844	Fossil Sh. St. Jago Darwin Beagle
1845	New Pliocene Moll. Australia

George Brettingham II (1812-1884) Son of G. B. I.

1832-41	Conch. Illust.
1839	Conch. Man.
1842	Conch. Man. 2d ed.
1843-46	Thesaurus Conchyliorum
1852	Conch. Man. 4th ed.
1854	Popular Brit. Conch.
1859	Illus. Index Brit. Sh.
1863	Thes. Conch. Vol. III
1865-78	Contd Conchologia Iconica, Vols. 15-20
1887	Illus. Index Brit. Sh. 2d ed.

George Brettingham III (1843-1921) Son of G. B. II.

1864-87	App. *Conus* Thesaurus Conchyliorum, *Voluta, Melo, Turbo.*
1887	Illust. Index Br. Shells
1892	Marine Shells, S. Africa
1897	Marine Shells, S. Africa App.

REFERENCES

Carpenter, Philip Pearsal
1857. Supplementary report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America. Rept. British Assoc. Adv. Sci. for 1856, 368 pp., pls. 7-9.

Dictionary of National Biography, vol. 1898

Fulton, Hugh
1921. Obituary Notice. George Brettingham Sowerby, F.L.S., Journ. Conch., vol. 16, No. 7, pp. 213, 214
1921. George B. Sowerby. Nautilus, vol. 34, No. 4, pp. 137, 138

Keen, A. Myra
1958. Sea Shells of the tropical West America. Stanford Univ. Press, 624 pp., 606, 12, 1037, 3, 51 figs.

(Original paper presented at the New Orleans meetings of the American Malacological Union, 1964).

Newton, Richard B.
1891. Systematic list of the F. E. Edwards Collection of the British Oligocene and Eocene Mollusca in the British Museum.... 305 pp.

Prestwich, James
1872. James de Carle Sowerby. Quart. Jour Geol. Soc. London, vol. XXVIII, p. XLV

Reynell, A.
1910. Further notes on the dates of issue of the parts of Sowerby's 'Conchological Illustrations'. Proc. Mal. Soc. London, vol. 9, No 3, pp. 212 213

Salisbury, A. E.
1943. H.C. Fulton (1861-1942). Jour. Conch. vol. 22, No. 1, pp. 2, 3
1945. Work and workers on British Mollusca. Jour Conch., vol. 22, No. 6, pp. 136-145 (J. Sowerby p. 145); No. 7, pp. 149-165 (Sowerbys 153, 154)

Shaw, H.O.N.
1909. The dates of issue of Sowerby's 'Conchological Illustration', from the copy preserved in the Radcliffe Library, Oxford. Proc. Mal. Soc. London, vol. 8, No. 6, pp. 333-340

Sherborn, C. Davies
1894. On the dates of Sowerby's 'Genera of Recent and Fossil Shells.'. Ann. Mag Nat. Hist., yth ser , vol 13, pp. 370, 371
1909. On 'The Conchological Illustrations" by George Brettingham Sowerby, Jun., London, 1832-41, and the 'Descriptive Catalogue of Shell' by John Edward Gray, 1832 Proc. Mal. Soc. London, vol. 8, No. 8 pp. 331-332.

Sowerby, Arthur de Carle, Sowerby, Alice M., and Stone, Joan E.
1952. The Sowerby Saga..., Pt. I, II, 48 pp., Pt. III. Washington, D.C. mimeographed.

Sykes, E. R.
1906. On the dates of publication of Sowerby's 'Mineral Conchology' and 'Genera of Recent and Fossil Shells'. Proc. Mal. Soc. London, vol. 7, No. 3, pp. 191-194.

Woodward, B. B
1922. George Brettingham Sowerby, F.L.S. Third of the name. 1843-1921. Proc. Mal. Soc. London, vol. 15, pts. II, III, pp. 65, 66

Woodward, Horace B.
1907. The history of the Geological Society of London. Geol. Soc., 336 pp., 28 pls, Sowerbys, James and James de Carle pp. 83, 84

Zittel, Karl Alfred von
1901. History of geology and palaeontology to the end of the nineteenth century. London English trans., 562 pp., 13 portraits. Sowerby, James and James de Carle, pp. 48 131 132 365, 434.

UNIONID RECORDS FROM KANSAS, ARKANSAS AND LOUISIANA

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In this era of dam building, many beautiful streams are ear-marked for the sacrificial block of so-called progress. In many instances, if not all, the faunas involved, other than the large, economically important fishes, are not being studied and recorded for future reference. The Marmaton River in Kansas and the Kings River in Arkansas are two such streams. The White, of course, already staggers under multiple dams, although there are brief stretches of that stream which still vaguely resemble the former wild condition. Although this paper does not pose as a detailed study of any fauna, it does list a few local unionid assemblages which may be of interest to workers carrying out post-impoundment requiems. In the species list which follows, the number collected precedes a set of parentheses, and the number in each parenthesis refers to the collecting locality. These localities are:

1. Marmaton River, 3 miles west of Fort Scott, Bourbon Co., Kansas; 23 September, 1962.

2. Strip-pit, seasonally effluent to Cow Creek, 3 miles south, 2 miles west of Pittsburg, Crawford Co., Kansas; 18 November 1962.

3. Spring River, 14 miles south, 2 miles east of Pittsburg, Cherokee Co., Kansas; 3 November 1963.

4. Wildcat Creek 1 mile west of Manhattan, Riley Co., Kansas; 11 August 1964.

5. Kings River, 1 mile north of Marble, Arkansas; 20 April 1963.

6. White River, 10 miles east of Fayetteville, Arkansas; 18 April 1963.

7. Strip-pit, 8.1 miles west of Monroe, Highway 80, Louisiana; 2 June 1963.

8. Strip-pit, west city limits of Minden, Highway 80, Louisiana; 2 June 1963.

SPECIES LIST

Fusconaia flava (Rafinesque)
2(1)

Amblema (Crenodonta) peruviana (Lamarck)
16(1)

Quadrula quadrula Rafinesque
6(1)

Tritogonia verrucosa (Say)
1(1). 1(5)

Pleurobema cordatum (Rafinesque)
4(1) 1(6)

Elliptio dilatatus (Rafinesque)
1(1), 7(5), 1(6)

Uniomerus tetralasmus (Say):
2(1), 1(2), 1(8).

Lasmigona costata (Rafinesque)
25(5). 1(6).

Lasmigona complanata (Barnes)
2(1), 1(4).

Anodonta grandis Say
1(2), 2(4).

Strophitus rugosus (Swainson)
1(1), 3(5), 1(6).

Cyprogenia aberti (Conrad)
1(3). This species has not been reported in southern Kansas since 1906, and this is the only record for the southeastern part of the state.

Actinonaias carinata (Barnes)
7(5), 2(6).

Leptodea fragilis (Rafinesque)
1(1); 2(6).

Proptera alata (Say)
5(1).

Proptera purpurata (Lamarck)
4(6).

Proptera capax (Green)
1(7).

Ligumia subrostrata (Say)
1(2) 1(8).

Lampsilis anodontoides (Lea)
4(6).

Lampsilis luteclus (Lamarck)
1(1). 23(5).

Lampsilis ventricosa (Barnes)
2(1), 2(5), 2(6).

Manuscript received and accepted for publication, June 10, 1966

STUDIES ON THE MOLLUSCAN GENUS *CAMPELOMA* RAFINESQUE, 1819

BARBARA ESTEL ANDERSON

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Campeloma is a genus of freshwater, ovoviviparous gastropod widely distributed throughout most of the eastern half of North America. Being commonly found in most lakes and streams of this area, the shells were noted by such early naturalists as Constantine S. Rafinesque (1819: 423), Thomas Say (1821: 173), Richard E. Call (1894: 133-137); 1898: 420-429), Bryant Walker (1893: 135-140) and others. These men, recognizing many different and apparently distinct shell types in this group, described a number of species based on observed shell characteristics.

Recent authors, Goodrich *et al.* (1939: 23-25; 1944: 257-326) have stated that, since these shell characteristics are influenced by the environment, earlier authors may have observed and used shell differences which do not actually reflect genetic differences. Thus not all of the nominal species established by these men may exist in nature.

The stage of ontogeny least affected by the action of the environment is apparently that of the uterine young. Baker (1928: 57) used embryonic shell characteristics as an aid to species differentiation. He believed these were some of the most reliable characteristics available. The study of the shell, gross soft parts, and serial sections of the uterine young of the many forms of this genus may shed much light on the problem of environmental influence in the development of this snail.

An additional problem in species determination not known to these early authors is that of parthenogenesis Mattox (1936: 77; 1937: 455; 1938: 244-245) concluded that *Campeloma rufum* Haldeman (1841) reproduces by thelytokical parthenogenesis. Van der Schalie (1965: 1-15) however demonstrated that not only are males of *C. ponderosum coarctatum* (Lea 1844) common, but that mating evidently takes place since sperm was found in the bursa copulatrix and seminal receptacles of some females.

Parthenogenetic reproduction results in each individual being reproductively isolated. Therefore crossbreeding and associated genetic recombination does not occur in parthenogenetic forms. A different approach is thus necessary in differentiating parthenogenetic species.

Unfortunately there is no uniform approach to the problem of parthenogenetic 'species.' Two authors who discuss this problem are Mayr (1963) and Dobzhansky (1937). Mayr (1963: 411) states

> 'Complete parthenogenesis poses a taxonomic problem. The orthodox species criterion of interbreeding cannot be applied, because each clone is reproductively isolated not only from the parental species but also from every sister clone. How to treat clones and parthenogenetic species taxonomically must be decided for each. Where no essential morphological or biolo-

gical differences exist, such clones should be combined into collective species. Where a parthenogenetic line has originated from a bisexual species by an irreversible chromosomal event (for instance, polyploidy), it is usually advisable to consider it a separate (sibling) species, even though the morphological difference is slight.'

Along the same line Dobzhansky (1937: 321) says

'The binominal system of nomenclature, which is applied universally to all living being, has forced systematists to describe 'species' in the sexual as well as in the asexual organisms. Two centuries have rooted this habit so firmly that any thorough reform will meet with a determined opposition. Nevertheless, systematists themselves have come to the conclusion that sexual species and 'asexual species' must be distinguished.' (Du Rietz 1930). In the opinion of the writer, all that is saved by this method is the word 'species.' A realization of the fundamental difference between the two kinds of 'species' can make the species concept methodologically more valuable than it has been.'

Since *Campeloma* contains sexual as well as asexual forms it would seemingly be better to follow Mayr (1936: 411) rather than Dobzhansky (1937: 321) in this genus.

Due to the confusion that existed (and still exists) concerning the classification of the many forms of this snail, the generic name under which these forms belong remained in doubt until Richard E. Call (1885) clarified the status of *Campeloma* Rafinesque (1819).

THE GENERIC NAME

The first record of a species later to be assigned to *Campeloma* was that of *decisum* Say, 1817. Say placed it initially in the genus *Lymnaea* Linnaeus, 1799. Two years later Rafinesque (1819: 432) established the genus *Campeloma* from a reversed specimen to which he gave the trivial name *crassula*. *Campeloma crassulum* became the type, *ipso facto*, and was so recognized by Call (1883: 604).

During the nineteenth and early twentieth centuries many species were described which were later assigned to this genus. Because of adverse feelings towards Rafinesque in the scientific world of that day (Call 1883: 604), his work was largely ignored. Authors used various other generic names for the species then being described. Those most commonly used were *Lymnaea* Linnaeus, 1799; *Paludina* Lamarck, 1816; *Vivipara* Montfort, 1810; and *Melantho* Bowdich, 1822. By 1885 both *Paludina* and *Melantho* were in widespread use.

In 1885 Call revived the generic name *Campeloma* and revised its species. His arguments against the use of the other generic names I summarize as follows:

Melantho Bowdich, 1822, was characterized by: 'Peristome incomplete, not effusive; very thick; white. Subglobular. Marine.' (Bowdich 1822, after Call 1885: 150).

Since these snails *(Campeloma)* are exclusively freshwater, the use of this generic name *(Melantho)* was and is difficult to understand.

Paludina, although a freshwater genus, is European Call cites no authority for this statement. Hence *Paludina* is inappropriate for these American shells. *Lymnaea* and *Viviparus* were excluded by Call as clearly pertaining to non-campelomid groups of freshwater snails.

The original description of the genus *Campeloma* Rafinesque (1819: 423) is as follows:

'Test ovale. Ouverture ovale, base tronquée lèvres réfléchies, flexueuses, unies en pointe postérieurement. Point d'ombilic. Animal inconnu. ....'

Call (1885: 151) translates the above as follows:

'Shell oval. Aperture oval, truncated at base; lip reflected, united in a point behind. Umbilicus wanting. Animal unknown. ....'

Call (1885: 153) expands this with

'Shell ovate or sub-ovate, thick and solid; spire more or less produced and often eroded at the apex; volutions rounded or convex; aperture ovate; peristome simple, continuous; inner lip often thick above, outer lip broadly retreating in outline along and above the middle, prominent farther down, and again slightly sinuous around the base of the aperture; axis not distinctly perforated; surface

smooth, or only showing lines of growth, with sometimes minute revolving striae and covered with an olivaceous epidermis (Meek).'

Call gave no citation for the above quotation other than the name Meek in parentheses. It apparently came from the work of Fielding Bradford Meek (1876: 585). Meek seemingly meant this as a redescription of the genus. Call (1885) thus settled the question of the proper generic name for this snail and by 1900 *Campeloma* was in use by most authors.

THE TYPE SPECIES

On the question of the use of the specific name of the type species, however, Call (1883; 1885) was in error. Call (1885: 151) recognized the rule of priority in stating that *Campeloma* 'had precedence of *Melantho* by three years, and thus would replace that name, ...' Still he failed to apply the same rule in the case of *crassulum* Rafinesque (1819: 423) over *ponderosum* Say (1821: 173).

Rafinesque's original description of *crassulum* is

> 'J'en ai une seule espèce trouvée dans l'Ohio. *C. crassula.* 4 tours de spire contraires, sommet aigu, test épais, ouverture plus de la moitié de la longueur totale.'

Say's original description of *ponderosum* is

> 'Paludina *ponderosa*, Say.--Shell somewhat ventricose, much thickened, olivaceous or blackish; spire not much elongated much shorter than the aperture, eroded at tip, but not truncated; whorls five, slightly wrinkled across; suture profoundly impressed; aperture subovate, more than half the length of the shell; labium with much calcareous deposit, and thickened into a callosity at the superior angle; within tinged with blue
>
> Inhabits Ohio River.'

Comparing the two descriptions and taking into account that:

(1) the type locality of each is the Ohio River, and that

(2) the name *crassulum* from the Latin *crassus* means thick, dense, (i. e. *pondercus*) Call (1883: 604) concluded that *C. crassulum* and *C. ponderosum* referred to the same species. But in his statement

> 'The assumption that the French naturalist [Rafinesque] had before him a *reversed* specimen of Say's *Paludina ponderosa* is strengthened by his specific name *crassula*, bestowed in allusion to its texture.'

Call (1883: 604) implies that Say's *ponderosum* is the correct name, ignoring the fact that the description of *crassulum* preceded that of *ponderosum* by two years. Again in 1885 (P. 150-152) Call reasserted that *C. crassulum* and *C. ponderosum* were synonymous and concluded, incorrectly, that *C. ponderosum* was the correct name.

There seems little doubt that Call was correct in stating that the two names were synonymous. Binney *et al.* (1865: 36-40) gave as part of the synonymy for *Melantho ponderosum* Say

> *Paludina ponderosa* Say, 1821 J A.N.S. II, 173, ...
> *Ampullaria crassa* Deshayes. Encycl. Meth. II, 32 (1830). Paludina crassa Say of Deshayes, *l c.*

Since Binney referred to Say's *ponderosum* he was speaking of the same species as Call (1883, 1885). The use of *crassa* as a species name by Deshayes would indicate that he was also impressed by the thickness of the shell of this species. Say (1821: 173) in his description of *ponderosum* states that this species is '... much more incrassated and heavy' than *decisum*.'

A reasonable conclusion seems to be that the Ohio River form commonly referred to as *Campeloma ponderosum* has, by priority, the proper name *Campeloma crassulum*. Whether or not the more southern forms of *C. ponderosum* should be included under *C. crassulum* requires further study. Moreover the entire classification of the various forms of *Campeloma* is in need of revision since the relationship between these various forms is not at all clear.

PROBLEM

In any attempt to determine the validity of the many described species of *Campeloma* one of the first major steps must be the determination

of the boundary between the parthenogenetic strains a nd the sexually reproducing strains. Mattox (1938) studied *C. rufum* Haldeman (1841) thoroughly and concluded that this northern form is parthenogenetic. He studied specimens from Illinois, Wisconsin, and from Kentucky about 25 miles south of Cincinnati, Ohio in a tributary of the Ohio River. Van Cleave *et al.* (1937) also decided an Illinois form of *C. rufum* was parthenogenetic. Medcof (1940) found a parthenogenetic form related to *C. d tsum* in the Speed River of Ontario, Canada. However, van der Schalie (1965) found testicular as well as ovarian tissue in a southern form *C. ponderosum coarctatum* Lea from the Birdsong Creek area of the Tennessee River. The findings of these men and the many works on geographic distribution indicate that northern forms will be found to be parthenogenetic, perhaps exclusively so, and the southern forms dioecious There is the possibility that both forms will be found in the boundary region.

If such a boundary exists, its precise location might be determined by a cytological examination of the gonad tissue of all sizes of *Campeloma* snails from each population, especially those from the Kentucky Tennessee area which, at the moment, seems to be the boundary region.

Special attention should be paid to the presence or absence of testicular tissue whether or not ovarian tissue is found Once the boundary has been determined, then each of the two groups so determined can be further examined for species differentiation.

Adult shells in either group have been and continue to be subjected to environmental influences. Goodrich *et al.* (1933: 23 25) used the species name *decisa* for all *Campeloma* found on the Upper Peninsula of Michigan They believed that all differences in adult shells were due to different environmental influences. They suggested that these differences may be due to the folkwing:

1. Brightness or dullness of shell—exterior environment
2. Retention of apical whorl—absence of erosive agencies
3. Reddishness of shells—process of disintegration
4. Obesity—longer active season
5. Angular body whorl—trematode infection.

If Goodrich's suggested explanations are correct, then variations in external morphology are not enough to indicate genetic differences In addition, studies on geographic location, habitat, soft-body morphology of the adult, and embryology including a thorough examination of uterine young should be made for all forms under consideration A method of obtaining large numbers of these uterine young quickly and easily would be a distinct aid in this work.

Since the external morphology of the adult is extremely variable, a clearer picture of environmental effects can be obtained by comparing the respective uterine young from adults exhibiting these variations Another approach would be the raising of different groups of uterine young under identical controlled conditions. Still another approach would be to place tagged uterine young into new locations, e. g river forms into lakes or northern forms into the south, and observe their development. Comparisons could be made between the shell characteristics, gonad tissue, and uterine young of these tagged specimens and local specimens. Comparisons of the internal anatomy of the young from various natural populations, chiefly by means of serial sectioning the whole embryo would give a further check on differences and similarities between populations.

Using these several approaches it should be possible to end much of the confusion resulting over a century of (perhaps) indiscriminate species establishment and from the added problem of the existence of at least one parthenogenetic strain in this genus

It was the purpose of this investigation to make a pilot study of a local population of *Campeloma* from the Olentangy River, at Columbus, Ohio. From the descriptions in Baker (1928: 68) and Call (1885: 158) these shells appear to be *C. rufum* (Haldeman 1841). I was unable to obtain the original description of *rufum* The library could not locate a copy of Haldeman's Monograph of the Freshwater Mollusca, Part III. The description is on page 3 of the wrapper For the purposes of this paper I have assumed that this form is *Campeloma rufum*

The anatomy of both the adult gonad tissue and the uterine young from this local population were to be studied. The gonad tissue examination was to provide photomicrographs of

ovarian tissue and to see if the snails examined showed any evidence of testicular tissue. The uterine young were sectioned to provide photomicrographs for comparison with the uterine young of other populations. During these investigations it was necessary to find a method for obtaining large numbers of uterine young. A technique was also devised for sectioning these embryonic snails while still in the shell.

METHODS AND MATERIALS

Three collections of *Campeloma* were made in the Olentangy River near the Ohio State University below a small dam above the Fifth Avenue bridge. The snails were generally found in gravel or sand at the base of the Water-Willow *(Justicia americana)* or immediately downstream from rocks and logs. This habitat is consistent with the observations of Boubjerg (1952: 176). He studied the movements of *Campeloma decisum* in Dickerson Creek, Michigan. His summary on the movements of this snail is as follows:

> '1. Unusually high population density of the snail *Campeloma decisum* was noted at two points in a small Michigan stream.
>
> 2. The concomitance of the aggregations with the presence of rapids directly upstream prompted investigation of rheotactic response.
>
> 3. Under controlled and natural conditions, release-recapture experiments with marked snails indicated a positive upstream movement.
>
> 4. Experiments designed to simulate natural reactions to a physical barrier in flowing water resulted in duplications of the aggregation phenomenon observed in the stream.
>
> 5. It was concluded that the aggregations of snails noted could be related to the two responses: upstream dispersal and relative inability to traverse even a very slight block to the upstream movement, this inability perhaps being associated with the burrowing habit of this species.'

The first collection was made on August 4, 1964. The snails were very abundant and about 200 were taken in one hour. Since little information was available on laboratory maintenance or culture of this genus, they were placed in aquaria with river water until better arrangements could be made. Before aerators could be introduced the temperature of the room in which the aquaria were placed rose to about 90° F. The snails began to die, filling the water with mucus. The cause of death may have been excessive heat, lack of O_2, or a build-up of CO_2. (In subsequent aquaria air pumps were used at once to supply O_2 and release CO_2.

Approximately 75 percent of this collection was fixed in time to preserve soft parts. Some 80 percent of those preserved contained many well-developed uterine young. Since hermaphroditism has not been found in this genus by any author, these were assumed to be females.

A second set from the same location, collected on August 25, 1964, was maintained in aquaria using tap water, river mud, and aerators. These snails were kept alive and under observation until December, 1964, when it was necessary to dismantle the laboratory setup. The snails were given to the people in charge of laboratory supplies. During this time, the method for removal of the uterine young was developed.

The third collection was made on May 21, 1965, from the same location. This was in order to obtain material for histological examinations. Fewer snails were found and these were farther downstream. Water levels were up from the previous August, and Spring floods may have washed many of the snails downstream. The aquaria arrangements were the same, except that Water-Willows were placed in the mud of the aquaria. Since the snails were found at the base of these plants which are abundant in the habitat, it was thought that a favorable relationship may exist between the snails and the Water-Willow. No such relationship was observed in the aquaria. The Water-Willow died within a few weeks and were discarded.

My attempts at relaxing *Campeloma* by the usual methods such as boiling, nembutal, menthol crystals in water (van der Schalie, 1953; McCraw, 1958; J. A. van Eeden, 1958), always resulted in the snails contracting into and remaining contracted within the shell. The quite effective method of Lever *et al.* (1964) using nembutal, nitrogen, and M.S. 222 (metabenzoic acid ethylester methansulphonate) was not tried

because I was unable to obtain any M.S. 222 from the University Laboratory Supply. They were not able to find a company which could supply this chemical.

The method of Michelson (1959: 157-8) for the recovering of bacteriologically sterile embryos from *Viviparus japonicus* von Martens (an ovoviviparous snail introduced into North America from Japan prior to 1900) was attempted. His method, following thorough sterilization of equipment and snail shell (which is not necessary for my purpose) is as follows:

> 'Using the handle of a scalpel or similar instrument, the shell was cracked by firmly striking the arc of the body whorl. In gravid females the uterus usually was distended and occupied the entire exposed area.'

At this point there is additional information concerning sterilization of the uterine wall which was not necessary for my purpose. The method continues:

> 'the uterus wall was lifted by means of a mosquito hemostat, and a horizontal incision (approximately one cm. in length) was made using a fine-pointed scissors. Watch-maker forceps were introduced into the uterus to remove the eggs, ...'

The rest of his work is concerned with culturing the embryos under sterile conditions. The technique which follows was suggested by Michelson's method but has the additional objective of obtaining adult soft parts as well as uterine young.

A snail is taken from the aquarium, dried and shell height measured. It is placed, aperture down, on the laboratory table (formica in this case) and rapped firmly with a wooden mallet. Care must be taken to crack the shell rather than crush it. After several cracks are made, the pieces of shell can be picked away with small jeweler's forceps. It is generally possible to remove the entire animal intact. Several specimens had the blood still circulating and I once removed a snail in which the heart continued beating for several minutes. A snail removed in this manner has only the foot and head contracted. The tentacles respond to touch. The main body mass is relaxed and in the natural coiled position.

Next the animal is placed, foot down, in a small dissecting dish. It is then oriented under a dissecting microscope so that the head faces the worker. An incision is made along the snail's right dorsal surface to the snail's right of the vaginal opening, cutting through the edge of the mantle. The incision is continued distally along the columnar surface to the proximal margin of the digestive gland. The flap thus formed is laid to the viewer's right and pinned down, making any cuts in the mantle edge necessary to flatten the flap. The uterus is now on the outer margin of the flap with the ureter and rectum toward the columnar muscle. Mattox (1938) has an excellent drawing of this stage on page 259, plate 1, figure 5. The uterus can now be opened by placing the fine point of a pair of scissors in the vaginal opening and cutting along the now dorsal surface to the proximal end of the digestive gland. Spreading the cut surfaces of the uterus exposes its entire contents.

All well-developed young present in the May, 1965, specimens were removed from the uterus and placed in 50 percent glacial acetic acid for 24 hours to soften the shell prior to sectioning. They were then fixed for 24 hours in 70 percent ethyl alcohol. The digestive gland (with ovary) was removed from the adult and fixed in 70 percent ethyl alcohol for 24 hours.

Both the uterine young and the digestive glands were embedded in paraffin and sectioned serially. Delafield's Hematoxylin stain and Eosin-Orange G counter stain were used following the procedure in Humason (1962: 129-132). Steps 5-7, 11, 12, 16, 18, 19 were eliminated and both stain and counter stain were timed at two minutes each.

Of the snails examined, none under 2 cm. in height contained uterine young. This agrees with Mattox (1938: 252) in that *C. rufum* 'does not become gravid until it reaches a shell height of about 20 mm, ...' Those snails under 2 cm. in height were discarded after examination. The largest taken (and thus the largest examined) were 4 cm. in height. The digestive glands were separated according to height of shell into three categories: 2-3 cm., 3-3.5 cm., 3.5-4 cm. This was done in order to examine separately the ovarian tissue of the three groups of snails found upon examination. These groups were as follows: (1) The

snails from 2 cm. to 3 cm. in height had few (if any) well-developed uterine young. They contained mostly early stage larvae. (2) The snails from 3 cm. to 3.5 cm. in shell height contained the largest numbers of well-developed young. (3) The snails from 3.5 cm. to 4 cm. in shell height contained few or no uterine young.

RESULTS

The techniques used provide a reliable method of obtaining both uterine young and gonad tissue for comparative studies. The young, if large and well-formed (see Mattox (1935) for a discussion on the abnormalities possible) were generally alive when I removed them from the uterus. Each embryonic sac had to be ruptured to insure survival (Michelson, 1959: 159). Uterine young obtained in this manner can be easily observed crawling about if placed in a petri-dish full of tap water. I found them to be much less disturbed by movements of the dish or themselves than were the adults.

Because of the small size of a young snail I found it impossible to remove the animal from its shell in one piece. The shell is mainly $CaCO_3$ and is too hard to be sectioned. The 24 hour bath in 50 percent glacial acetic acid softened the shell sufficiently for the microtome blade to penetrate. I was then able to obtain serial sections of entire uterine young including the shell. I could find no publication containing photomicrographs of cross-sections of uterine young. The only drawing I found was that of Mattox (1938: 261, pl. 2, fig. 11).

Using the section best illustrating the various structures visible in these slides of the uterine young, I took photomicrographs (fig. 1) at 10 X 10 magnification. Kodak Panchromatic-X 4"X 5" cut sheet film was employed using an exposure time of 1/5 second.

In figure 1 the blood (a) appears as a gray stain within the heart (b) and blood vessels (c). It was possible to trace the large cephalic blood vessel (c) as it branched into the foot (not visible here). The various chambers of the heart (b) were visible in several sections.

The gill in figure 1 is seen as a series of parallel folds (e) of columnar epithelium containing closely packed nuclei. In the medial tips of these folds appears a yellow colloidal material. This may mark the area corresponding to the hypobranchial gland of the marine snail *Busycon canaliculatum*. Brown (1960: 338) referring to *B. canaliculatum* states: ' Along the median side of the gill lies a modified glandular area of the mantle called the hypobranchial gland. This gland secretes mucus rapidly and copiously and thus protects the gills by removing dirt and other foreign particles.' The uterus (g) of figure 1, lying within the digestive gland (h), is lined with a columnar epithelium. In the uterine young this part of the reproductive system is much better developed than the ovary. I was unable to identify the ovary in any of these slides of the uterine young. Mattox (1938: 261, pl. 2, fig. 1) indicated a structure he believed to be the ovary.

The ovary of even a large (4 cm.) adult is small and difficult to locate. It consists of a long slender blind tubule with lateral branches. It is actually a continuation of the oviduct, egg-shell gland, and uterus. Mattox (1938: 259, pl. 1, fig. 6) has the only adequate illustration of the ovary and this is a drawing. I have seen no photomicrographs which clearly show the ovarian tissue of these snails.

In the three categories of adult digestive glands examined (i. e. shell height of 2-3 cm., 3-3.5 cm., 3.5-4 cm.) the ovarian tissue showed few detectable differences. The best example of a cross-section of the ovary of a 4 cm. adult was selected and photomicrographed (fig. 2) at 10 X 10 magnification. The film was 4 X 5-inch cut sheets of Kodak Panchromatic-X with exposure time of 1/2 second. I attempted to photograph the same ovary at 43 X 10 magnification but the tissue stain presented too much contrast. Therefore the area of the ovary on the 10 X 10 photomicrograph was enlarged (fig. 3).

In figure 2 the ovary (a) is embedded in the distal whorls of the digestive gland just within the columnar surface (b). In some sections more than one loop of this tubule are visible. The ovarian tubule was always found to be hollow in cross-section. In this manner it may be distinguished from the near-by tubules of the digestive gland (c) which have a

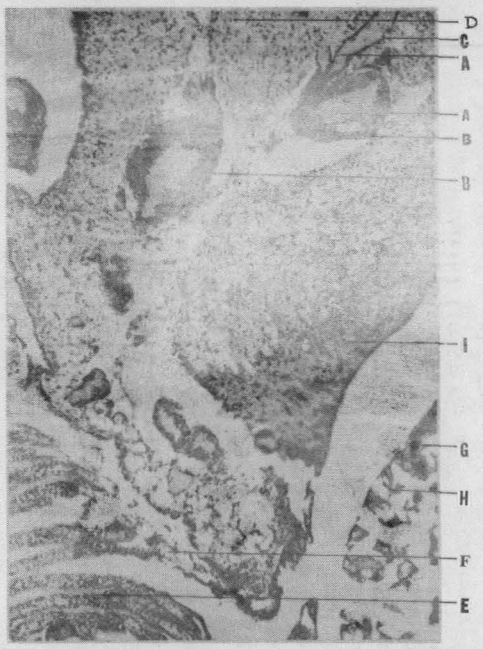

FIG. 1. CROSS-SECTION OF UTERINE YOUNG

A. Blood
B. Heart
C. Blood vessel
D. Proximal edge of foot
E. Gill
F. Hypobranchial gland (?)
G. Uterus
H. Digestive gland
I. Columnar muscle

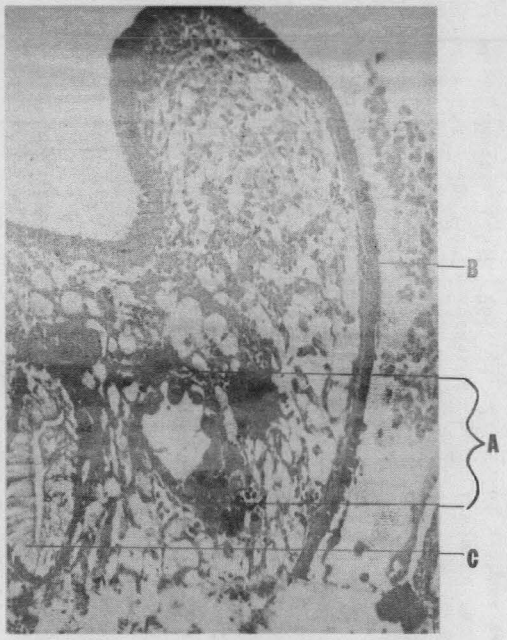

FIG. 2. CROSS-SECTION OF OVARY WITHIN DIGESTIVE GLAND

A. Ovary
B. Columnar surface
C. Tubule of digestive gland

FIG. 3. CROSS-SECTION OF OVARY

A. Fibrous layer
B. Oogonia and nurse cells
C. Oocyte

deep membranous epithelial lining. In figure 3 the ovary is seen to be surrounded by a fibrous layer (a) supporting the oogonia and nurse cells (b). The oocytes (c) are large and project into the lumen.

No evidence of testicular tissue was found in any of the snails examined. According to van der Schalie (1965: 6) this tissue should be easy to recognize. He describes the testicular tissue of *Campeloma ponderosum coarctatum* thus: 'The testis is large and massive; its numerous acini form a thick layer surrounding the liver or digestive gland. Sperm leaving the testis pass to the prostate which is a thickly coiled structure lying along the top of the last whorl. In cleared specimens the vas deferens appears as a long and loosely coiled tube connecting the prostate with the verge or penis terminating in the enlarged right tentacle. The size relationship between the testis and the digestive gland is striking in that the testis covers the greatly reduced liver in the upper whorl and a half; the same relationship is shown in one of the serial cross sections. An enlarged section of the testis .... shows many acini with active spermatogenesis. The numbers of sperm produced are prodigious, and .... there are all stages in spermatogenesis.'

Mattox (1936: 77; 1937: 455; 1938: 244) has investigated *Campeloma rufum* from many angles to determine if true parthenogenesis is present. He found no evidence of testicular tissue at any stage of development, thus ruling out protandry, seasonal males, etc. Therefore I made no investigation for testicular tissue in any animal other than those used to obtain uterine young. This would seem to rule out hermaphroditism.

Testicular tissue is easily found and identified. Van der Schalie (1965) has photographed this tissue. Ovarian tissue can be found and identified using the methods given in this paper. Therefore, it should be possible to continue the examination of the various age groups of the many populations of *Campeloma* throughout its range. By these means the boundaries of the parthenogenetic strains and the relationships between the various strains can be determined. Thus the systematics of *Campeloma* may some day become clear.

SUMMARY

Snails of the genus *Campeloma* were collected for a pilot study. A local population from the Olentangy River at Columbus, Ohio was utilized. Previously unpublished methods were used to obtain the uterine young and to section them. These methods involved cracking the shell in order to remove the adult body in one piece and in the natural coiled position. Acetic acid was used to soften the embryonic shell so that the entire embryo could be sectioned.

Observations of the living young in tap water revealed them to be much less affected by movements of themselves or their container than were the adults. Photomicrographs of the embryonic tissue showed clearly the various chambers of the heart, blood vessels, gill, and uterus. Photomicrographs of the adult digestive glands illustrated the location of the ovary, showing the surrounding fibrous layer, nurse cells, and ova, the latter clearly projecting into the lumen of the ovarian tubule.

All evidence indicated that this was a parthenogenetically reproducing population. The techniques provide a method for comparing the reproduction and embryonic young of additional populations of *Campeloma*.

LITERATURE CITED

BAKER, F. C. (1928) The freshwater Mollusca of Wisconsin, Part I: Gastropoda. -- Wisconsin Geol. and Nat. Hist. Surv., Bull. 70, Part I.

BINNEY, W. G. (1858) Complete writings of Thomas Say on the Conchology of the United States.-- H. Baillière, New York.

BINNEY, W.G. & BLAND, Thos. (1865) Land and Freshwater Shells: Part III. -- Smiths. Misc. Coll., No. 144, 120 pp., 232 figs.

BOUBJERG, Richard V. (1942) Ecological aspects of dispersal of the snail *Campeloma decisum*. -- Ecology, 33: 169-176.

BROWN, Frank A., Jr. (1960) Selected Invertebrate Types. -- John Wiley and Sons, Inc., New York.

CALL, Richard E. (1883) Note on the Genus *Campeloma* of Rafinesque. -- Amer. Nat., XVII: 603-608.

----- (1885) On the Genus *Campeloma*, Rafi-

nesque, with a revision of the species, Recent and fossil.--Bull. Washburn College Lab. Nat. Hist., v. 1, no. 1, p. 149-165.

----- (1888) On the gross anatomy of *Campeloma*. -- Amer. Nst., 22: 491-497.

----- (1894) On the geographic and hypsometric distribution of North American Viviparidae.--Am. J. Sci. XLVIII whole number. CXLVIII no. XVII: 132-141.

----- (1898) A descriptive illustrated Catalogue of the Mollusca of Indiana. -- State of Indiana.

CHAMBERLAIN, Norman A (1958) Life history of *Campeloma decisum*. -- Nautilus, 72: 22-28.

DOBZHANSKY, Theodosius (1937) Genetics and the origin of species.--Columbia Univ. Press, New York, 364 pp.

GOODRICH, Calvin and VAN DER SCHALIE, Henry (1939) Aquatic mollusks of the Upper Peninsula of Michigan. -- Univ. Mich., Mus. Zool., Misc. Publ. 43: 7-45.

----- and ----- (1944) A revision of the Mollusca of Indiana. -- Am. Midl. Nat., 32, no. 2: 257-326.

HALDEMAN, Stephen S. (1841) Monograph of Freshwater Mollusca, Part III.

HUMANSON, Gretchen (1962) Animal Tissue Technique. -- W. H. Freeman and Co., San Francisco.

LEVER, J., JAGER, J.C., and WESTERVELD, A. (1964) A new anaesthetization technique for freshwater snails. -- Malacologia, June 1964: 331-334.

MATTOX, Norman (1935) Abnormalities in the uterine young of *Campeloma rufum*, a freshwater snail. -- Am. Midl. Nat., 16(2): 144-153.

----- (1936) Sex organs and reproduction in *Campeloma rufum*, a freshwater snail. -- Anat. Rec. 67, Abstract 108: 77.

----- (1937) Oogenesis of *Campeloma rufum*, a parthenogenetic snail. -- Zeitschr. f. Zellforschung, Bd. 27: 455-464.

----- (1938) Morphology of *Campeloma rufum*, a parthenogenetic snail. -- Jour. Morph., 62 (2): 243-257.

MAYR, ERNST (1963) Animal Species and Evolution. -- Belknap Press, Harvard Univ. Cambridge, Mass., 797 pp.

McCRAW, B.M. (1958) Relaxation of snails before fixation. -- Nature, 181: 575.

MEDCOF, J. C. (1940) On the life cycle and other aspects of the snail *Campeloma* in the Speed River.--Canad. Jour. Res., 18(D5): 165-172.

MEEK, F. B. (1876) A report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country. -- U. S Geol. Surv. Territories, Rept. IX.

MICHELSON, Edward H. (1959) A technique for securing and maintaining bacteriologically sterile prosobranch snails. -- Trans. Am. Micr. Soc. LXXVIII, no. 3: 256-261.

RAFINESQUE, Constantine S. (1819) Prodrome de 70 nouveaux genres d'animaux découverts dans l'intérieur des Etats Unis d'Amérique durant l'année 1818. -- Jour. Physique, Chimie, Hist. Nat., Bruxelles, t. LXXXVIII.

SAY, Thomas (1817) (in Nicholson, William) Conchology. -- Nicholson's Encycl., Am. ed., ed. 1, v. 4, no pagination.

----- (1821) Description of univalve shells of the United States. -- Jour. Acad. Nat. Sci. Phila., II: 164 ----

VAN CLEAVE, H.J. and ALTRINGER, D.A (1937) Studies on the life cycle of *Campeloma rufum*. Am. Nat. 71(733): 167-184.

van der SCHALIE, Henry (1953) Nembutal as a relaxing agent for mollusks. -- Am. Midl. Nat. 50: 511-512.

----- (1965) Observations on the sex of *Campeloma* (Gastropoda: Viviparidae).--Occ. Papers Mus. Zool. Univ. Mich., 641: 1-15.

van EEDEN, J. A. (1958) Two useful techniques in freshwater malacology.--Proc. Malac. Soc. London, 33: 64-65.

WALKER, Bryant (1893) The shell-bearing Mollusca of Michigan. -- Nautilus, 6: 135-140.

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ECOLOGY OF *CORBICULA MANILENSIS* PHILIPPI IN THE OHIO RIVER AT LOUISVILLE, KENTUCKY[1]

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ABSTRACT

A population of the Asiatic Clam, *Corbicula manilensis* Philippi, in the Ohio River at Louisville, Kentucky was studied from July, 1963 through July, 1964. Spawning activity in late summer and fall increased the population to its yearly maximum in winter, but the population density was greatly diminished by high mortality in March, 1964. The die-off affected all age classes and seemed to be brought about by increased suspended sediment loads that accompanied spring floods. Spawning began to increase the number of clams in late summer. Qualitative observations in 1965 and 1966 showed the spring mortalities to be annual occurrences in the Ohio River.

The first Ohio River record of the Asiatic Clam, *Corbicula manilensis* Philippi, was obtained in 1957 at Paducah, Kentucky (Sinclair and Isom, 1961); later records have extended its range upstream beyond Cincinnati, Ohio (Keup *et al.*, 1963). It is present in the Tennessee, Cumberland (Sinclair and Isom, 1961), Green (Bates, 1962), Wabash (Fechtner, 1966) and Kanawha rivers (Thomas and Mackenthun, 1964). In eastern North America the species is known also to inhabit the Alabama and Mississippi rivers, and streams in Louisiana, Mississippi, and Florida (Heard, 1966).

Upon its discovery in North America, this clam was erroneously identified as *Corbicula fluminea* (Müller) and was subsequently referred to by this name in the literature. Sinclair and Isom (1963) found, however, that it is monoecious and incubates its eggs in marsupia that are modifications of inner gill lamellae. These characters led them to reidentify it as *Corbicula manilensis*. The group to which *C. fluminea* belongs is dioecious and non-incubatory. The species name was misspelled, *manillensis*, until the error was noted by Baker (1966).

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1. Some portions from a thesis submitted as partial fulfillment of requirements for a Master of Science degree in the Department of Biology, University of Louisville.

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The present paper is concerned with the dynamics of a *C. manilensis* population in a small segment of the Ohio River (River Mile 600.5-600.6) at Louisville, Kentucky, from July, 1963 through July, 1964 and less detailed observations made through July, 1965. The study area includes a broad shoal on the Kentucky bank that slopes abruptly to the main channel of the river (Figure 1). Wood and stone retaining walls border the shoreline and wooden boat slips occupy much of the area just offshore. Most of the bottom for 40 or 50 m out into the channel is composed of loosely packed silt and some fine sand, but at 50 to 70 m from shore a transitional area of sand and silt occurs. From there to mid-channel the bottom consists of firmly packed sand, granules, and pebbles. A narrow zone of very fine sand and silt also lies adjacent to the bank. Organic detritus, consisting mainly of small plant fragments, has accumulated on the shoal, while the main channel holds lesser quantities of this material. During summer and fall, several species of aquatic plants formed a zone of submerged vegetation across the littoral area, and were most abundant among the boat docks. Most of the plant growth occurred at depths of 0.5 to 2 m. Several pieces of submerged driftwood and dead tree branches rested on the bottom near shore or were lodged among the dock pilings. Pleasure craft, ranging in size from small outboard motor boats to cabin cruisers, use the harbor from early summer to late fall, but they have no discernible effects on the bottom or its inhabitants.

Six other mollusks, *Campeloma crassula* Raf., *Amnicola integra* (Say), *Somatogyrus subglobosus* (Say), *Pleurocera canaliculatum undulatum* (Say), *Physa integra* Hald., and *Pisidium casertanum* (Poli), also were abundant in this section of the river, and ten additional species were found infrequently.

MATERIALS AND METHODS

All quantitative collections were made with a 15 cm^2 Ekman dredge. Swmples were taken semi-monthly, from 11 to 16 representative sites at 0.5, 1, 4, and 10 m depths, except when springtime floods hampered access to the area. Because of flooding, only 22 collections could be made. Samples were washed in a wire screen that retained all objects of 0.8 mm diameter or larger, and the cleaned samples were preserved in isopropyl alcohol. The mollusks were later removed, sorted, and counted in the laboratory. Measurements were taken from dried specimens with a millimeter rule, vernier calipers, or a stereoscopic microscope equipped with an ocular micrometer. When it became apparent in the early spring of 1964 that the population was being diminished by environmental forces, the number of quantitative samples was reduced and supplementary observations were made with a hand sieve net. The clams taken in these qualitative samples were returned to the stream.

The discharge values supplied by the U. S. Geological Survey were recorded at a rating station at River Mile 607. Turbidity data provided by the Louisville Water Company were based on analyses of raw river water taken from their main intake pipe. The mollusk samples were collected about 50 m upstream from the pumping station.

RESULTS

The density of *C. manilensis* in this area fluctuated greatly during 1963 and 1964. The clams occurred infrequently throughout midsummer, 1963, but spawning activity added steadily to their numbers during late summer and fall. Intensified spawning in the winter months resulted in a preponderance of juveniles that raised the population to its yearly maximum. The highest density during this period was 273/m^2 on December 8 1963. Between mid February and late March a high rate of mortality rapidly decreased the population (Table 1) In samples taken on February 15 and March 2, over 50 percent of the specimens were either empty shells from recently deceased animals or valves that still contained decomposing soft parts. From April to July only six live specimens were taken in the quantitative collections. However, samples gathered with a hand net indicated that the species became common again in September, 1964.

The clams inhabited the soft substratum near shore and were slightly more abundant at moderate depths. Only the larger individuals were normally common in the deeper main channel but juveniles were prominent in deep water during mid winter. Specimens were occasionally

TABLE 1. The number of clams per square meter at various depths from July, 1963 to July, 1964

DEPTH	July	Aug.	Sep.	Oct.	Nov	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July
10 m.	-	-	0	15	7	72	237	22	-	-	0	0	0
4	4	3	98	22	94	176	196	200	37	0	2	4	2
1	4	28	109	104	128	246	444	250	133	0	0	0	0
0.5	2	43	47	57	126	181	153	114	63	0	0	2	0

The clams inhabited the soft substratum near shore and were slightly more abundant at moderate depths. Only the larger individuals were normally common in the deeper main channel but juveniles were prominent in deep water during mid winter. Specimens were occasionally found in areas next to the bank that were somewhat protected from waves, but only rarely near sections of the retaining walls exposed to wave action. They also tended to avoid the more compact plant beds that occurred in a few spots, but apparently lived among vegetation when the plants were not growing closely together.

The population in this segment of the river was made up largely of young clams in their first year; i.e., specimens less than 12 mm in length (Figure 2). The smallest juveniles found during the spawning season at Louisville were 0.9 mm long. Spawning commenced in early August, and the young began a period of growth that lasted until winter. The largest first-year clams measured 10 to 12 mm at the start of winter, and those beginning their second winter had reached lengths of 16 to 20 mm. Sinclair and Isom (1963) reported that *Corbicula* in the Tennessee River reached sexual maturity at about 6.5 mm lengths, and that this size was reached during the first year of growth. In the present study, only seven clams were collected with shells longer than 20 mm (presumably in their third year of growth). These sizes agree with previously reported growth information on *Corbicula* (Ingram, *et al*, 1964 and Keup, *et al.*, 1963). After February any growth trends were obliterated by a late winter kill, and the few surviving clams measured anywhere from 3 to 15 mm. Both young and adult specimens perished during the decline, but the older animals apparently died off first.

Late larval stages and juveniles of the Asiatic Clam have a byssal gland, but it seems that only a few individuals ever use the byssus threads to attach themselves temporarily to a firm surface. Close examination of submerged surfaces throughout the study revealed attached specimens only in December, 1963, when several young *C. manilensis* were collected from a sunken scrap of iron pipe. Another clam was discovered similarly attached to a submerged piece of driftwood. Sinclair and Isom (1963) found very few specimens attached by means of byssus threads.

DISCUSSION

It seemed probable that the high mortality in the population of *Corbicula manilensis* at Louisville during the spring of 1964 was caused by an increased suspended sediment load that accompanied high discharges in late winter and spring (Table 2). While this clam is apparently sensitive to highly turbid water, Sinclair and Isom (1963) found the species to be tolerant of many extreme chemical and physical conditions. Horning and Keup (1964) noted a decline at Cincinnati, Ohio, that took place some time between the winter of 1962 and fall of 1963. They speculated that the mortality

was brought about by abnormally low temperatures during the 1962-63 winter. Sinclair and Isom (1963) reported mortalities of *Corbicula* in the Tennessee and Cumberland rivers during mid April, 1961. It is less likely that temperature was responsible for the 1964 decline at Louisville, inasmuch as the lowest bottom temperatures were recorded in late December (1.4° C on December 24, 1963) and early January. The depletion of *C. manilensis* between late winter and spring is an annual occurrence in the Ohio River, since spring floods of varying intensities occur annually between March and May. Qualitative samples taken between March and July, 1965 showed the same rapid decline followed by a population increase, and workers at the Potamological Institute report that numerous dead clams and shells were washed ashore just before the spring floods in 1966. This annual destruction would explain why the population was composed predominantly of clams in their first year of growth, with some second year individuals, and few if any shells in the third year class. A population with a similar age structure was found in the Ohio River at Cincinnati in 1962 (Keup, *et al.*, 1963). Apparently a few sexually mature Asiatic Clams can easily replenish a population in one spawning season. Newly cleaned cement irrigation canals in Arizona were repopulated by *Corbicula* in less than 16 months *(Ingram,* et al., *1964).* A high rate of increase is the main attribute enabling this bivalve to maintain itself in the Ohio River.

Heard (1964) noted that the Asiatic Clam is usually abundant below power dams, and he suggested that these aggregations were due to the

TABLE 2. Some physical conditions in the Ohio River at Louisville, Ky. from July, 1963 to July, 1964

	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July
Bottom Temperature (°C)	29	27	26	22	16	4	2	3	5	8	19	25	27
Discharge (1000 cfs)	18	19	15	7	16	28	94	89	393	248	62	33	18
Turbidity (ppm)	6	4	4	3	3	5	77	72	410	178	27	16	5

(TEXT CONTINUED PAGE 24)

EXPLANATION OF FIGURES 1 AND 2, PAGE 23

FIGURE 1. Kentucky bank of the Ohio River within mile 600.5, Louisville, Kentucky, showing area investigated, dock structures, and bottom contours (1963-64). Values of submerged contours are in meters. Shoreline is at bottom of figure.

FIGURE 2. Length frequency of *Corbicula manilensis* in the Ohio River at Louisville, Kentucky from September, 1963 to March, 1964. The values in parentheses are sample sizes.

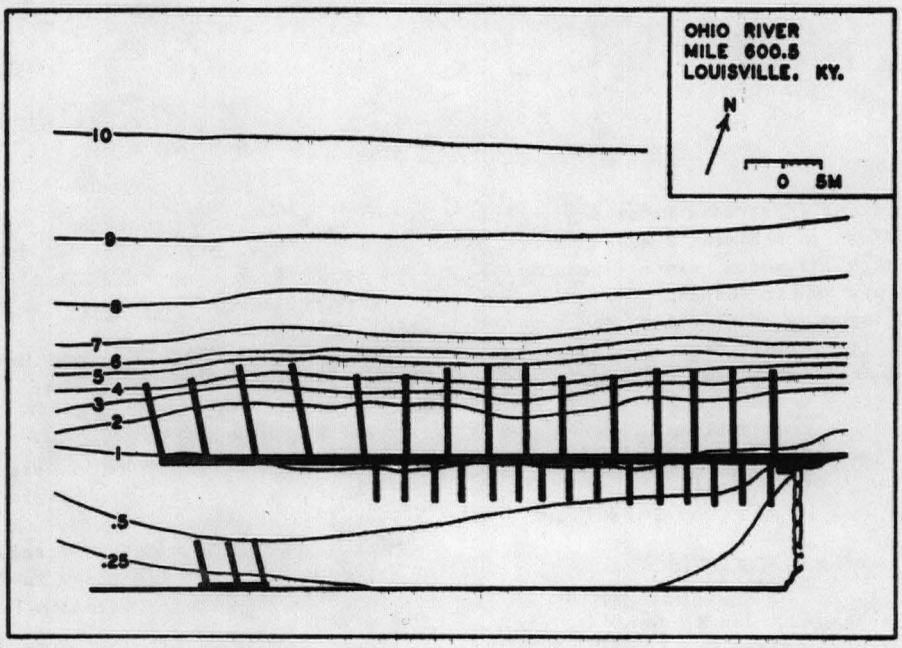

FIGURE 1

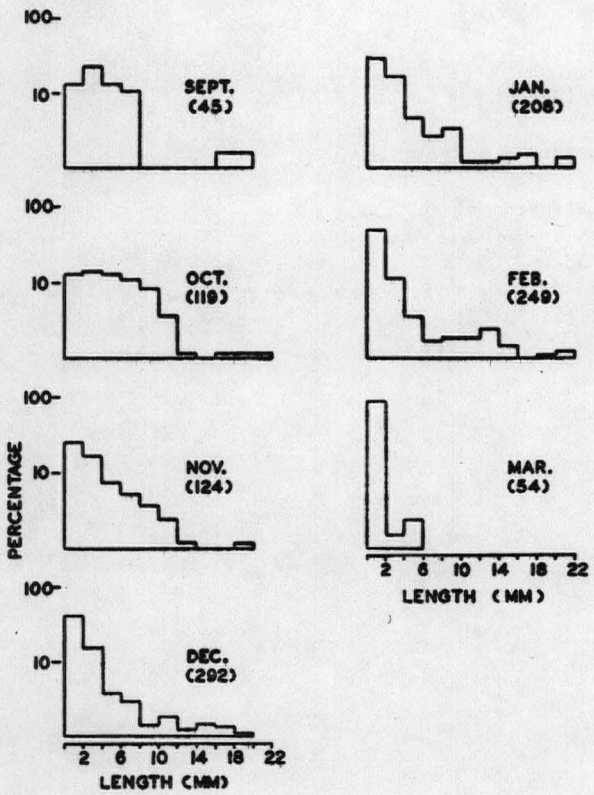

FIGURE 2

absence of silting in streams below dam spillways. A reduction in sediment load is probably a factor in such instances, since impoundments allow silt and other suspended materials to settle out of incoming water. Also, the cleared waters will frequently develop flourishing plankton communities while impounded (Neel, 1963). The streams below such reservoirs often (depending on dam construction) receive clear plankton-charged water that would be favorable for the existence of *Corbicula*.

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LITERATURE CITED

BAKER, H. B. (1966) *Corbicula manilensis*. -- Nautilus 79 (4): 144.

BATES, J. M. (1962) Extension of the range of *Corbicula fluminea* within the Ohio drainage. -- Nautilus 76 (1): 35-36.

FECHTNER, F. R. (1966) *Corbicula* from the Mississippi River. -- Nautilus 79 (4): 138-139.

HEARD, W. H. (1964) *Corbicula fluminea* in Florida. -- Nautilus 77 (3): 105-107.

HORNING, W. B. and KEUP, L. (1964) Decline of Asiatic Clam in Ohio River. -- Nautilus 78 (1): 29.

INGRAM, W. M., KEUP, L., and HENDERSON, C. (1964) Asiatic Clam at Parker, Arizona. -- Nautilus 77 (4): 121-124.

KEUP, L., HORNING, W. B., and INGRAM, W.M. (1963) Extension of range of Asiatic Clam to Cincinnati reach of the Ohio River. -- Nautilus 77 (1): 18-21.

NEEL, J. K. (1963) Impact of reservoirs. -- *IN* Frey, D. G. (ed.), Limnology in North America, p. 575-593. Univ. Wisconsin Press, Madison, Wis.

SINCLAIR, R.M. and ISOM, B.G. (1961) A preliminary report on the introduced Asiatic Clam *Corbicula* in Tennessee. -- Stream Pollution Control Board, Tenn. Dept. Publ. Health, 31 p.

THOMAS, N.A. & MACKENTHUN, K.M. (1964) Asiatic Clam infestation at Charleston, West Virginia. -- Nautilus 78 (1): 28.

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Binney, p. 43

Younger specimens are proportionally more globose than the one figured, and the spire is often not truncated, but consisting of 5 whirls, the apex being perfect. Fig. 80 is drawn from a specimen found in the Susquehanna, more elongated in shape, and truncated at the apex alone. In New England and Canada the shell is less elongated, with more pyramidal spire.

Say figured another shell as *Paludina decisa* in the American Conchology, and gave two figures of it, from one of which my figure 84 is copied. At this time he repeated the description from the Encyclopedia, and added the following remarks and references. Fig. 84.

This species is common in various parts of the Union. Dillwyn informs us that Müller and others have incorrectly quoted Lister's figure for their *Helix angularis*. *Petiver*, Gaz., pl. pl. 106, fig. 18. *(Say.)*

The figure copied above does not agree with that given in Nicholson's Encyclopedia. I should rather refer it to *Melantho ponderosa* (page 37). Fig. 86. Fig. 85.

To the typical form of *M. decisa* the following synonyms may without doubt be referred.

Figure 85 is a fac-simile of *Helix dissimilis*, Wood, of which no description nor locality is given. It is evidently intended for this species, though the true name *decisa* is

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applied by Wood to a figure of *subcarinata*. I also give a fac-simile (fig. 86) of Lister's figure.

Paludina heterostropha of Kirtland's Ohio Report is referred by Gould (Boston Proc. I, 32) to *Mel. ponderosa*. Judging from the figure given of it by Tappan, I would rather refer it to *decisa*. It is so considered by Reeve. This figure is copied in my fig. 87, while the description furnished Tappan by Dr. Kirtland is as follows:--

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Paludina heterostropha, Kirtland, *l.c.*--Sinistral; aperture more than half the length of the shell. Shell subglobose, ovate; spire depressed, apex generally truncate; whirls 5; aperture ovate, with its superior extremity curved towards the body whirl, within bluish-white; epidermis greenish horn color, usually coated with ferruginous clay. Length ¾ inch. Fig. 87.

This shell frequently occurs in Mill and Yellow Creeks, tributaries of the Mahoning River. I formerly considered it a mere variety of *P. decisa*, Say; but on further examination found it to be specifically distinct. It never attains more than half the length of that species; its spire is never depressed, and it is always heterostrophal. *(Tappan.)*

To the copy of the description of *Paludina decapitata*, of Mr. Anthony, given below, I am able to add Fig. 88, drawn from the type, which he kindly loaned me for the purpose I do not consider this a well-established species. The single specimen on which it is founded is evidently an undeveloped specimen in a very imperfect state. The spire is eroded, the shell presents the appearance of belonging to a small ill-favored individual of *M. decisa*. However, the only information we have regarding it, given below, may serve to identify it, should it appear in future.

Paludina decapitata, Anthony.--Shell globular, thin, of a light green color; spire truncate, but never elevated under any circumstances, composed of about four very flat whirls; aperture broad, ovate, one-half the length of the shell, within dusky white; columella regularly but not deeply rounded, with a slight deposit of callus, and having a very small linear umbilicus at base. Fig. 88.

Tennessee. My Cabinet.

A single specimen only is before me, and therefore I claim it as a new species with some hesitation; it seems to me, however, too unlike any of the ordinary forms in this genus to warrant its being included with any of them; it is the most globose of any species hitherto published, if we except the small, round forms which were long since removed, and very properly too, to

Amnicola; the spire is entirely wanting, but traces of the sutures show the number of whirls; and its present appearance forbids the idea of its ever having had an elevated spire. *(Anthony.)*

The fac-simile which I have given of Haldeman's figure, drawn from the original specimen of *Paludina genicula,* Conrad (Fig. 89) would lead one to consider that species identical with *Viv. decisa.* I do not, therefore, hesitate to unite them; my opinions are founded on an examination of a series of shells from the locality which furnished Mr. Conrad's specimen, which show a gradual series from the rounded whirls of the *decisa* to the angular form of *genicula,* though none of the shells were as well marked as that figured. From other localities, also, I have received specimens of *decisa* whose six whirls were quite as angular and scalariform. I suppose Higgins refers to some such in quoting *Pal. genicula* from the Ohio and Scioto Canal (Cat. 6). In Küster's Paludina (Chemn. ed. 2), Cedar Creek is also given as a locality for *genicula.* Mr. Conrad's description is as follows. Fig. 90 is a fac-simile of his. It is considered identical with *decisa* by Reeve.

Fig. 89.

Paludina genicula.--Shell suboval, spire slightly elevated; volutions 4, scalariform, shoulders angulated; apex eroded, aperture rather more than half the length of the shell; epidermis green olive; within bluish.

Fig. 90.

A species which is readily distinguished from those nearest allied to it by the angulated whirls. I found a single specimen in Flint River, Ga. *(Conrad.)*

Lymnula ventricosa, Rafinesque, of whose description and figure (fig. 91) a copy is here given, is evidently this species. His figure, though very rough, is quite characteristic.

Fig. 92.

Fig. 91.

Lymnula ventricosa.--Whirls 4, last one very large; form obtuse-oval; aperture bluntly oval, &c. *(Rafinesque.)*

From the same MS., 'Conchilogia Ohioensis,' which was presented to the Smithsonian Inst. by Prof.

Haldeman, I find rough figures (fig. 92) of *M. decisa* under the name of *Ambloxis, Amblostoma,* or *Lymnulus major,* Rafinesque, or *Lymnaea reburnea,* Rafinesque. All these names are given, and I find it impossible to decide which was the one finally fixed upon, or to decipher more of the description than the following:--

I put *Melania ovularis,* Mke., in the synonymy on the authority of Küster (Chemn. ed. nov.), who so quotes it. I have seen no authentic specimen, but cannot doubt its identity with *M. decisa.*

Melania ovularis, Menke, (l c.)--Shell ovate-conoid, truncate, substriate, shining, greenish, reddish-brown when old, truncated at apex; aperture ovate, columella subcallous above; aperture rounded before.

Length 1 inch; breadth 7 lines.

Hab.--Near Cincinnati, in the Ohio River. Bescke. *(Menke.)*

Paludina limosa, Valenciennes, is considered a synonym of *M. decisa* by Haldeman and Küster. I have seen no authentic specimen. It is also considered a synonym by Reeve, *l. c.*

Paludina limosa, Valenciennes (l.c.)--Shell ovate-conic, thin subdiaphanous, green; whirls 5, longitudinally striate; labrum acute.

Paludina limosa, Say, Journ. Phil. I, 125.

This *Paludina* is less globose and longer than that of our climate. The height at the last whirl is a little less than of the others. Its breadth is greater than its length, and its surface is covered with somewhat strong longitudinal striae. The form of the aperture is also more oval. Its vertical diameter is the longest.

The lip is sharp, continued to the columella, which is not appressed.

The shell is not very thick; there are, however, some individuals which are eroded like some of the bivalve shells.

The apex is destroyed as the animal grows, and a flat circular partition is formed, hav-

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ing the axis of the shell in its centre, in about the same manner as *Bulimus decollatus*.

I saw one individual whose three apical whirls were destroyed so as to give a broken appearance to the shell.

Length rather more than one inch. *(Valenciennes.)*

The following also is cited as a synonym of *M. decisa* by Reeve. Judging from the description I should so consider it.

Paludina cornea, Valenciennes (l.c.)--In the Delaware and many other rivers of the United States there is found a horn-colored *Paludina*, which at first sight resembles the *Pal. limosa*, but which a more careful examina-

(PAGE 47)

tion proves to be sufficiently distinct to form a new species. On account of its color I call it

Paludina cornea.--Shell ovate-conic, thin, opaque, greenish horn color; whirls 5, subrounded; sutures deeply impressed.

This species has an obtuse apex; the last whirl is one-third longer than the others; each of them has a kind of flattening (aplatissement) which forms a balustrade (rampe) around the spire, whose sutures are deeply impressed. The striae of growth are vertical and fine. The aperture is oval. Horn colored, with a greenish tinge; the interior of the mouth and lip is white.

The largest individual was 11 lines in length. *(Valenciennes.)*

Figure 93 represents a deformed specimen of *Melantho decisa*, from the Susquehanna. It is introduced here for the purpose of showing how abnormal an individual of a species may be.

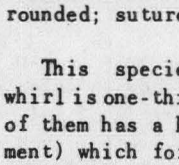

Fig. 93.

Another abnormal form of *Melantho decisa*, in which the whirls are more numerous and tapering, which is often met with in any large

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number of specimens, has been described as a distinct species as *Paludina milesii*. The original description is given below, as well as a figure of one of the original specimens, presented by Prof. Miles.

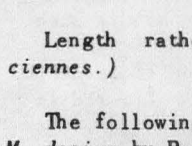

Fig. 94.

Paludina milesii.--Shell smooth, subpyramidal, subsolid, imperforate; spire lengthened; sutures deeply impressed; whirls 6, subinflated; aperture somewhat small, subovate; labrum acute, somewhat sinuose; columella somewhat thickened both above and below.

Branch Lake, Antrim Co., Michigan. M. Miles. *(Lea.)*

No. 8921-4 of the collection were presented by Dr. James Lewis under the unpublished name of *Paludina obesa*, Lewis. Fig. 95 represents one of them. This form is a well marked variety, found near Mohawk, N.Y., in Ohio, and Michigan. It is readily distinguished by its very ventricose, rounded form and dark olive green color. Its name is preoccupied.

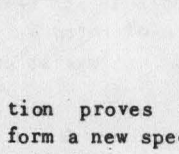

Fig. 95.

It is customary, in collections, to separate the more elongated forms of *Melantho decisa* under the name of *M. integra*. It becomes necessary, therefore, to ascertain what shell Mr. Say had before him in drawing up the description of *Palu-*

(PAGE 48)

dina integra. I have, therefore, copied below his description, and given a figure (96) of his typical specimen still preserved in the collection of the Philadelphia Academy.

Paludina integra, Say.--Shell olivaceous, pale, conic; whirls six, wrinkled across; spire rather elongated, entire at the apex; suture profoundly indented; aperture subovate, less than half of the length of the shell.

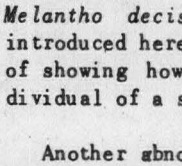

Fig. 96.

Inhabits the waters of the Missouri. Length ¼ inch.

Very much resembles *P. decisa;* the spire, however, is more elongated, and ne-

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ver truncated at the apex, but always acute. *(Say.)*

The dimensions given above are probably a typographical error.

The large number of specimens which I have had the opportunity of examining have exhibited so many and so slight degrees of difference between *M. decisa* and *M. integra*, that I am persuaded of their specific identity. I am supported in this view by the recent monograph of Mr. Reeve, but opposed in it by most of the American collectors. I have given below a description and figure of what is usually acknowledged to be *Paludina integra*. The difference of form of the sexes is shown also, Fig. 98 being male, Fig. 97 being female.

Melantho decisa, var. *integra*.--Shell imperforate, elongate-ovate, quite thick, smooth, surface hardly broken by lines or wrinkles of growth, marked with delicate revolving striae; greenish, with darker streaks, marking the edge of former peristomes, uniformly chalky white under the epidermis; spire elongated-conic, apex perfect, acute; whirls 5, convex, the last equalling two-thirds the shell's length, imperforate; aperture oval, narrowed above, oblique, more than half the length of the body whirl, milky white within; peristome externally of a darker color, simple, acute, somewhat sinuous, its terminations joined by a thin, transparent callus on the parietal wall of the aperture,

Fig. 97, Fig. 98.

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more heavily thickened and white above and below. Length of axis 24, greatest breadth of body whirl 15; length of aperture 15, breadth 11 mill.

Operculum as in *M. decisa*.

In general terms it may be said that the form known as *M. integra* differs from *M. decisa* by being more elongated, having a perfect apex, a smaller aperture, more prominent revolving striae, and a whiter aperture. These characters are only comparative. The two forms are not distinguished by any

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decided, constant, specific characters. Fig. 99 represents young shells, which are more globose, comparatively, than the more mature ones.

Fig. 99.

Two curiously deformed specimens of *M. integra* in the collection are figured in Figs. 100 and 101.

Fig. 100

Fig. 101.

Reeve places *Paludina ponderosa* in the synonymy of *Pal. decisa*. On page 37 will be found an enumeration of the constant specific characters of *Melantho ponderosa*.

Paludina microstoma, Kirtland is added to the synonymy on authority of Mr. Anthony, who tells me Prof. Kirtland described it before meeting with the description of *integra*. On seeing Mr. Anthony's cabinet he was at once convinced of their identity.

Paludina microstoma, l. c.--An undescribed species of *Paludina*, found frequently associated with the *P. decisa*, and distinguished by its elongated spire and small mouth. *(Kirtland)*

Fig. 102.

Paludina rufa, Haldeman is said by him (l. c.) to be distinguished by a reddish color and entire apex, but may be a variety of *Pal. decisa*. The reddish or pinkish tint within the aperture (sometimes divided into bands) appears to distinguish this form of the species, which occurs in the Southern as well as Northern States. Prof. Haldeman's original specimen of *Pal. rufa*, together with all those from which

(PAGE 50)

the plates of his Monograph were drawn, are deposited by him in the collection of the Academy at Philadelphia. Fig. 102 is a fac-simile of the figure referred to by Haldeman under this name. No. 8905 of the collection represents it. This variety is represented by eight of the lots catalogued below in the museum register. One of them has the spire truncated, the surface very much eroded, a more globose form, and more sinuous peritreme than usual (see Fig. 103). The whole shell under the epidermis appears of a rosy hue.

Fig. 103.

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Paludina subsolida, Anthony. appears to me also a synonym of this species. My opinion is founded on an examination of Mr. Anthony's specimen, kindly lent me for figuring (Fig. 104.) It is wlso considered by Reeve. No. 9311 was presented to the collection under this name by Mr. Anthony. His description here follows.

Paludina subsolida, Anthony.--Shell ovate, imperforate, very thick; color light green, verging to brown in old specimens; spire much elevated, composed of 6-7 inflated whirls sutures very distinct; aperture broad-ovate, about one third the length of the shell, within white; lip curved forward and forming a very conspicuous, subacute tip near its base; columella well rounded, a thick callous deposit covering the umbilicus. Length 2 inches, breadth 1¼ inches.

Fig. 104.

Illinois. My cabinet; cabinet of Hugh Cuming, London.

This is the most ponderous species in the genus, far exceeding *P. ponderosa,* Say, in that respect; compared with that species it is not only much more solid and heavy, but its spire is proportionally more elongate, whirls more convex, while the body whirl is less ventricose, and the aperture is uncommonly small for a *Paludina* of its size; the body whirl is disposed to be angulated near its middle; all the whirls are more or less shouldered and the lines of growth are very conspicuous; the body whirl is obscurely striate concentrically, and its surface thereby modified so as to present a faintly sculptured appearance, and the striae being somewhat finely undulated the appearance under a microscope is very pleasing. *(Anthony.)*

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Paludina heros, DeKay, of one of the earlier Zoological Reports of New York is said by that author to be a large form of *Pal. integra.* (N. Y. Moll. p. 85.)

Fig. 105 represents the lingual dentition of *M. integra.* Lingual membrane composed of forty-eight rows of teeth, arranged in the form common to the group

Fig. 105.

Binney, p. 51

3, 1, 3. Central tooth broad, short, and hooked, a small shoulder each side near its base; first lateral broad and hooked; second and third lateral long, claw-shaped; anterior part of membrane broad, narrowing toward the middle, and again widening at its posterior portion. First twelve or fourteen rows translucent brown in color, the rest colorless.

The animal of this species is given in Fig. 68, p. 35.

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

8876	3	.....	W.G. Binney. Cabinet series.
8877	1	.....	Dr. J. Lewis "
8878	4	.....	W.G. Binney "
8879	6	Burlington, N.J.	"
8880	1	Blue River, K.T.	Dr. J.G. Cooper.
8881	3	Massachusetts.	W. Stimpson. .....
8882	4	Nimahaw River, K.T.	Dr. J.G. Cooper.
8883	4	New York - Erie Canal.	Dr. J. Lewis.
8884	7	Grand Rapids, M.	"
8885	3	N. Illinois.	R. Kennicott. .....
8886	4	Erie Canal, N. Y.	Dr. J. Lewis .....
8887	3	" "	"
8888	2	"	"
8889	2	"	"
8890	7	Quasqueton, Iowa.	E.C.B.
8891	3	Jerseyville, Ill.	
8892	1	Big Sioux.	Dr. F. V. Hayden.
8893	2	Milwaukee, Wis.	I. A. Lapham.
8894	6	Sangemon River, Ill.	D.H. Roberts.
8895	4	Mohawk, N.Y.	Dr. J. Lewis.
8896	7	Illinois.	W. G. Binney.
8897	7	Miss. River.	
8898	1	Maryland.	A. N. S.
8899	2	Maine.	"
8900	2	Greenwich, N.Y.	Dr. Ingalls.
8901	6	Texas or Alabama.	W. G. Binney.
8902	2	Big Prairie Creek, Ala.	Dr. Showalter.
8903	3	New York.	Dr. Lewis. Revolving bands.
8904	5	Batavia, Ill.	W. G. Binney.
8905	3	Grand Rapids, Mich.	Dr. Lewis. *(Pal. rufa,* Hald.)
8906	7	E. Georgia.	Dr. Jones.
8907	1	Vermont.	Acad. N. Sc.
8908	8	Buffalo, N Y.	Nasons.
8909	7	Alabama.	
8910	10	Burlington, N. J.	W. G. Binney.
8911	1	Alabama.	
8912	9	Hiram, O.	
8913	1	Elyria, N. Y.	

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8914 10 ....
8915 10 Athens, Ga. ..... *(Pal. rufa.)*
8916 2 Aztalan, Wis. S. F. Baird
8917 3 Schuyler's Lake, N.Y. Dr. J. Lewis
8918 4 Racine, Wis. S.F. Baird .....
8919 3 Texas. W. G. Binney. .....

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8920 507 Mohawk, N.Y. Dr. J. Lewis. *(P. rufa)*
8921 6 Grand Rapids, Mich. Dr. J. Lewis. *P. obesa*, Lewis.
8922 2 Columbus, O. Dr. J. Lewis. *P. obesa*
8923 1 Ohic. " "
8924 2 " " "
9018 1 New York. "
9021 1 Delaware River. W. G. Binney.
9029 1 Coosa River. "
9027 30+ Grattan, Mich. Dr. J. Lewis.
9028 7 Reed's Lake, Mich. "
9029 200+ Grand River, Mich. "
9030 250+ Michigan. "
9031 300+ Brest, Mich. "
9032 50+ .... "
9033 100+ Mohawk, N.Y. "
9034 20+ Grattan, Mich. "
9035 900+ .... "
9036 20+ Mohawk, N.Y. "
9037 100+ " "
9038 50+ " "
9039 7 Erie Canal, N. Y. "
9040 11 " "
9041 9 " "
9042 12 Mohawk River. "
9043 13 " "
9044 4 Erie Canal. "
9045 10 Mohawk River. "
9046 12+ Erie Canal. "
9047 9 Mohawk River. "
9048 6 Canal, Mohawk. "
9049 6 " " "
9050 10 Grand Rapids, Mich. "
9051 7 Grattan, Mich. "
9052 11 Grand Rapids, Mich. "
9053 7 Erie Canal. "
9054 3 ..... "
9055 100+ Mohawk, N. Y. "
9151 20+ .... "
9155 2 Owasco Lake. Mrs. H. W. Parker.
9153 3 Cayuga Lake. "
9157 ..... "
9197 7 Lynn, Mass. Dr. Prescott.
9198 1 Schuylkill. Gen. Totten.
9199 3 South Carolina. "

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5 Santee Canal. Ravenel.
9330 .. ..
9334 9 Arkansas. .....
9311 1 ..... L. Agassiz.

Melantho coarctata, Lea.--Shell imperforate, ovately turreted, thick, the surface decussated by revolving striae and lines of growth light greenish horn color, with darker longitudinal streaks marking the margins of former peristomes, white under the epidermis; spire elongated, apex entire; whirls 6, regularly increasing, slightly convex, the last one equalling more than one-half the shell's length, imperforate, sometimes compressed and obtusely carinated; aperture

Fig. 106. Fig. 107.

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scarcely oblique, ovate, longer than wide, more than half the length of the body whirl, within white: peristome simple, acute, sinuose, its margins not on the same plane, its terminations connected by a heavy shining callus upon the parietal wall. Length of the axis 22, greatest breadth of body whirl 15; length of aperture 15, breadth 9 mill.

Paludina coarctata, Lea, Tr. Am. Phil. Soc., Proc. II, 243 (1842).--Reeve, Con. Icon. 46 *a* (Feb. 1863).
Paludina lima, Anthony, Proc. Acad. N. S. Phil. 1860 p. 70.--Reeve, Con. Icon. 46 *b* (Feb. 1863).
Paludina exilis, Anthony, Proc. Acad. N. S. Phil. 1860 p. 71.
Paludina compressa Lewis in *Sched.* (Unpublished.)

It has been found in South Carolina, Alabama, Mississippi, and Arkansas.

The striae of growth, very much decussated by revolving deep cut lines, distinguish all the forms mentioned in the synonymy, and constitute one of the chief characteristics of the species. In form it seems capable of some considerable variation, being, at times, very slender and elongate, at others much more ovate, with more globose whirls.

I give below a copy of Lea's description,

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and a drawing of his original specimen (Fig. 108).

Having before me the original specimens of *Pal. lima* and *exilis,* kindly loaned me by Mr. Anthony, and one determined by Mr. Lea to be his *Pal. coarctata,* I cannot hesitate in uniting them under one specific name, which, of course, will be the earliest published. No. 8867 of the Smithsonian collection is also a specimen of the same, though presented by Dr. J. Lewis, under the unpublished name of *Pal. compressa,* Lewis.

Mr. Lea has enabled me to figure his original specimen (Fig. 108). I am able also to add figures of the shells from which Mr. Anthony drew his description of *Pal. lima* (Fig. 110) and *exilis* (Fig. 109). The latter shell is rather more slender than the other forms, one specimen being only thirteen mills. wide, though thirty-one long.

Reeve places *P. exilis* in the synonymy of *P. coarctata,* but considers *P. lima* distinct.

Paludina coarctata, Lea.--Shell smooth, ovate, compressed, thick, imperforate, olive color; spire drawn out; sutures much impressed; whirls flattened; aperture rather small, ovate, white.

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Fig. 108. Alabama. E. Foreman, M. D. Cabinet of Dr. Foreman. Diam. .50, length .98 inch.

This species, of which a single specimen only was received, differs from all of the genus which has come under my notice. It is remarkable for its compressed form, the body whirl being quite flattened. The apex is eroded, which prevents the number of whirls being ascertained: there appear to be five. The aperture is less round than usual in this genus, and may be rather more than half the length of the shell. *(Lea.)*

Fig. 109. *Paludina exilis,* Anthony *(l. c.)*.--Shell turreted, smooth, rather thick; color light apple-green; spire elevated, composed of about seven volutions; sutures well marked; aperture small, broad-ovate, livid within; body whirl distinctly angulated, subumbilicate, and with very distinct lines of growth; columella well rounded and curved with a callous deposit, connecting perfectly with the outer lip. thus forming a continuous rim.

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Length, 1¼ inch; breadth, ¾ inch.

Hab.--Mississippi. My Cab. H. Cuming, London; A. N. S. Philadelphia; State collection, Albany, N. Y.; Smithsonian collection.

Obs.--One of the most slender of our American species; *Paludina subsolida,* nob., is more ponderous, more globose, and has a larger aperture; no other species approaches it in general appearance; the whirls of this species taper more rapidly to an acute apex than in most of the species; compared with *P. integra,* Say, it is more slender, more solid, and the aperture is much smaller. *(Anthony.)*

Fig. 110. *Paludina lima,* Anthony *(l. c.)*.--Shell ovate, rather thin, dark green; spire obtusely elevated and composed of six convex whirls, which are strongly striate or subcarinate; sutures very distinct, and the upper part of each whirl being flattened renders it more conspicuous; aperture broad-ovate, about half the length of the shell, livid within; columella slightly rounded and callous deposit small; umbilicus none.

Length, 1¼ inch; breadth, ¾ inch

Hab.--South Carolina. My Cab.; Cab. H. Cuming, London; A.N.S., Philadelphia; Smithsonian collection, Washington, D.C.

Obs.--In general form not unlike our western *P. integra,* Say, from which it differs, however, by its revolving, raised striae and by its carinae, which are also well developed; the lines of growth are very strong, and decussating with the striae give the surface a beau-

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tifully rough appearance, which suggests its specific name. It is really one of our handsomest species, and so unlike all others that no American species can readily be mistaken for it. In most specimens the body whirl is

very strongly carinate about the middle, and the outer lip is considerably produced as in *P. subsolida*, nob. *(Anthony.)*

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

8865 13 Natchez, Miss. Lieut. Wailes. ....
8866 6 " " Cabinet series.
8867 2 Jackson, Miss. Dr. Lewis. *V. compressa*, Lewis.
9331 9 Big Prairie Creek, Ala. Dr. Showalter. .....

LIOPLAX, Troschel.

Foot very large, rather thin, elongated, greatly produced beyond the snout, truncated before, and becoming slightly narrower behind towards its rounded extremity. Colors as in *Melantho*. Head very small. Snout very short. Lingual teeth smooth at their apices or cusps. Tentacles broader and rather shorter than in *Melantho*. Right tentacle in the male very short, only one-third the length of the left,

Fig. 111.

Fig. 112.

and broader than the snout. Lingual dentition as in *Melantho*. Right cervical lappet narrow, not plicated, but extending beneath the right tentacle and snout, nearly to the base of the left tentacle. Left cervical lappet very small. Branchiae as in *Melantho*. *(Stimpson.)* *Operculum* with a spiral nucleus.

Fig. 113.

Shell thin, ovate-turreted, imperforate, spire produced, whirls rounded, carinated, covered with a thin epidermis; peristome thin, continuous.

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Lioplax cyclostomatiformis, Lea.---Shell subcylindrical, rather thick, pale horn color, smooth, imperforate; spire exserted, at the apex rose colored and obtuse; sutures very small, nearly round, within salmon colored. Coosa River, Alabama. Dr. Brumby. My cabinet, and cabinets of Dr. Griffith, Dr. Jay, L. W. Sloat, and Dr. Foreman. Diam. .32, length .82 of an inch.

Fig. 114.

This is a very remarkable species, assuming very much the form of an exserted *Cyclostoma*. A single, somewhat worn specimen only, was received. The aperture is rather more than one-third the length of the shell. Its subcylindrical form is very remarkable.

Since the above description was written, Dr. Jay and Dr. Foreman have placed in my hands specimens from the same locality. The epidermis is perfect, and they are of a greenish horn color. The interior of the aperture is bluish, while the apex is slightly salmon colored. *(Lea.)*

Paludina cyclostomatiformis, Lea, Tr. Am. Phil. Soc. IX, pt. i, p. 23 (1844); Obs. IV, 23: Proc. II, 83, (1841).---Reeve, Con. Icon. 43 (Feb. 1863).

Paludina contorta, Shuttleworth, of Küster in Chemn. ed. 2, p. 20, pl. iv. f. 7-9 (1852).

Paludina elliotti, Lea, Proc. Acad. Nat. Sc. Phila. 1858 p. 166.

The specific name of this species must not be confounded with that of *Pal. cyclostomaeformis* of D'Orbigny (Mag. de Zool. 1837, cl. v, pl. ixxix, f. 1).

The outline of the back of the shell reminds one of the Cuban *Megalomastoma*. The three upper whirls are sometimes of a very light flesh color, contrasting with the dark green of the remainder. The peristome is sometimes continuous, being appressed to the body whirl, and forming a rimate umbilicus. On some specimens I have detected minute revolving lines.

Pal. elliotti is a finer, better developed form of the species than that described as *cyclostomatiformis*, and has more acutely carinated upper whirls. A careful examination of Mr. Lea's types leads me to consider them identical. With his original description of the latter I have given Fig. 114 from his type, while below will be found the description of *Pal. elliotti* and a figure (115) of a specimen presented me under this name by Mr. Lea and now in the Smithsonian collection (No. 9015).

I have placed *Paludina contorta* in the syn-

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onymy of this species after a careful examination of a specimen received from Mr. Bland

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from Mr. Shuttleworth. The original description given below, and the copy of the figures (Fig. 116) confirm my opinion of its identity with Mr. Lea's shell.

Since the publication of this paper in the form of proof, Mr. Gill has criticized my opinion of the identity of *Pal. elliotti* with *P. cyclostomatiformis*. His opinion was not based on an examination of specimens, and has since been changed on seeing the Smithsonian series.

Paludina elliotii, Lea *(l.c.)*.--Shell subcarinate, pyramidal, rather thick, greenish-olive, smooth, very narrowly umbilicated; spire elevated, subacute, flesh-colored at the apex; sutures excavated; whirls 7, rounded, obtusely carinated above, rather small; aperture subrotund small, white within. Fig. 115.

Othcalooga Creek, Ga. Bishop Elliott. *(Lea.)*

Paludina contorta, Shuttleworth *(l. c.)*.--Shell non-rimate, cylindrically conic, subovate, shining, greenish with olive lines; apex eroded; whirls 6, strongly convex, divided by a deep suture, the middle ones carinated in the middle; aperture oblong, white; peristome straight, acute, curved above. Fig. 116.

Shell smooth, cylindrical-conic turreted with a truncated apex; shining, green, with olive brown lines and striae; sutures deep, whirls 6, ventricose, moderately increasing above, rapidly so towards the base, the middle ones clearly carinate in their centre, with brown angular curving striae and lines at the middle keel; last whirl shorter than the penultimate, and near the upper portion of the aperture separated so as to form a deep groove of the suture. Aperture longitudinally rounded, inner lip appressed; peristome straight, acute, twisted above (fig. 9), curving again below its centre, beautifully rounded below and regularly blending with the columella. Height 8"', breadth 5" '.

Alabama (Pugel), coll. Charpentier. (Küster).

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Reeve, *l. c.*, adopts the same view of *Pal. elliotti* and *contorta* as I have done.

No. 9147 of the collection is almost ecarinate, and nearer Mr. Lea's type of *cyclostomatiformis* than *elliotti*.

It is singular that the only two known species of *Lioplax* should share the peculiarity of having a strongly carinated form with perfect apex, as well as a form with rounded whirls and truncated apex.

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Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

8868 1 Coosa River, Ala. W. G. Binney. .....
8869 1 Alabama. A.N.S. Phila. Cabinet series.
9015 1 Georgia. I. Lea. Figured in Fig. 115.
9149 1 Coosa River. Ala. Dr. E. R. Showalter.

Lioplax subcarinata, Say.--Shell with three whirls, which are rounded, and subcarinated, reticulated with striae and wrinkles, sometimes without the striae; suture deeply impressed; apex truncated and re-entering; aperture more than half of the length of the shell, oval; elevated lines or subcarinae on the body two, three, and sometimes none. Length half of an inch, breadth four-tenths. Fig.117

Inhabits with the preceding species. (Delaware River.)

Animal viviparous, with a chestnut, coriaceous operculum, white spotted with orange; head pale orange, not extending beyond the shell; tentacula darker, short, subulate; eyes situated at their base, elevated, black and conspicuous; base of the animal much advanced, broad, truncate, purplish before, tail rounded behind. *(Say.)*

Limnaea subcarinata, Say, olim. Nich. Enc. ed. 2, 1818, pl. ii, f. 6.

Paludina subcarinata, Say, Nich. Enc. ed. 3, 1819 pl. i, f. 7; ed. Binney, p. 47, pl. lxix, f. 7.--Haldeman, Mon., p. 8 pl. ii (1840).--De Kay, N.Y. Moll., p. 87 (1843).--Chenu, Conch. Ill., pl. i, f. 6-8.--Philippi, Conch. II, 7, pl. ii, f. 7

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(1846).--Küster, in Chemn. ed. 2, p. 29, pl. vi, fig. 10-14.--Reeve, Con. Icon. 44 (Feb. 1863).--Not of Potiez et Michaud.

Paludina sulculosa, Menke Syn. Meth., p. 134 (1830).

Paludina bicarinata, Potiez et Michaud, Gal. des Moll., I. 249, pl. xxv, f. 17, 18.

Helix decisa, Wood, Cat. Suppl. p. 21, pl. vii, f. 17 (1828); Hanley's ed. 226, f. 17 (1856).

Helix subcarinata, Eaton, Zool. Text-book, 195 (1826).

Lioplax subcarinata, Troschel, Gebiss der Schn. 100 (1857).

There are in the mature perfect shell 3 more whirls than the number given by Mr. Say. It is a very variable shell. The whirls are sometimes truncated at the apex, very much rounded and hardly marked by the carinae (Fig. 118), which in other localities are much developed, continuing to the sharp, well-defined apical whirls, on which is no trace of erosion (Fig. 119). Sometimes there is a prominent revolving

Fig. 118.

Fig. 119.

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elevated ridge below the carina on the body whirl. The revolving striae are sometimes very strongly marked.

Fig. 120.

The operculum, which in the young shell is subspiral, in its later growth is concentric as in the other species of *Viviparidae*.

Fig. 121.

I have received specimens from Ohio, Indiana, Kentucky, Pennsylvania, and New Jersey.

Paludina sulculosa, Menke, *l.c.*, appears to me to be this species. I have seen no authentic specimen. His description is as follows:-

Paludina sulculosa.--Shell ovate-conoid, apex deroded; imperforate, thin, decussately striated, transversely lightly sulcated; green; whirls 4, angulated on the spire; suture deep; aperture ovate; lip simple. Length 4½, breadth 3 lines.

Ohio River at Cincinnati. Bescke. *(Menke)*

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Paludina bicarinata, Potiez and Michaud, is certainly this species as shown by their description and the copy of the outline of their figure given below.

Paludina bicarinata, Pot. et Mich. (l c.) not Say.--Shell oval, ventricose, brown or greenish, covered with numerous transverse ridges, two of which are more developed on the last whirl, the other whirls having but one medial carina; spire comprised of three or four convex whirls, of which the first are usually truncate; aperture ovoid; peristome simple. Length 12-15, breadth of last whirl 10-12 mill.

Fig. 122.

Mr. Say and Ch. des Moulins have both given the same name to two different shells belonging to this genus, consequently it becomes necessary, in order to avoid confusion, to change that of Des Moulins, being posterior to Mr. Say's. Moreover, M. des Moulins' shell having three carinae, will be better designated by the name *tricarinata,* adopted in this catalogue.

Delaware River, N. America. *Potiez et Michaud.)*

I give also an outline of Wood's figure (Fig 123) of *decisa,* of which no description is given, though it is specified as 'tawny Delaware.' It is evidently *Lioplax subcarinata*

Fig. 123

In addition to the above fac-similes I have given one of Say's figures in Nicholson's Encyclopedia (Fig. 117).

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The lingual dentition of *Lioplax subcarinata* is thus figured by Troschel (Fig. 124). There are seven teeth in each row, with recurved, simple, acute apices, the central broad at the base, narrower above, the laterals narrower. For the animal see p. 55.

Fig 124,

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

8870 50+ Raritan River. W. G. Binney.
8871 5 ..... W. Stimpson. Cabinet series.
8872 20 Burlington, N. J W. G. Binney.

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8873 9 Ohio. W. Stimpson.
8874 2 Licking River, Ky. W. G. Binney.
8875 8 Laporte, Ind.
9013 1 .... Figured in Fig. 119.
9056 30+ Laporte, Ind. Dr. Lewis.
9057 20+ Bank Lick, Ky. "

DOUBTFUL, SPURIOUS, AND EXTRA-LIMITAL SPECIES OF VIVIPARIDAE.

This completes the list of known North American *Viviparidae*. There now follow notices of doubtful species and those which have been erroneously referred to the genus.

In the Trans. Lit. and Hist. Soc. Quebec, I, 196, occur the two following descriptions by Mrs. Shepard:--

Paludina .....,--Shell white; epidermis olive; spire the length of the aperture; last whirl inflated. Island of Orleans.

Paludina --------.--Shell pale buff; spire longer than the aperture; top obtuse. Found with the foregoing on the beach at the island; the whirls are not so much inflated as those of this genus generally are, but I think it would not range under any other; it has bluish bands of gray round the top of the whirls.

Paludina alleghanensis, Green.--Shell conical; spire elevated and rather obtuse; whirls four, rounded and nearly smooth the ultimate whirl the largest; mouth oval, slightly angular near the upper part of the peristome, where it adheres to the body whirl; umbilicus none: epidermis dark brown color. Length two-tenths of an inch. Fine specimens of the shell are in the cabinet of Mr. W. Hyde. Mountains of Pennsylvania. *(Green.)*

Paludina alleghanensis, Green, in Doughty's Cabinet of Nat. Hist., II, p. 291 (1832).

The above is Green's description. I have not been able to obtain any information about the species. From the size and shape of the shell I should incline to believe it to be an *Amnicola*.

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Paludina solida, Say, is mentioned by name only by Cristofori & Jan, Conch. Terr. et Fluv. p. 7, (1832).

Paludina canaliculata, Gould, is mentioned by name only in the Preliminary Report on Mass. Shells, p. 107, and by Wheatley, Cat. 29.

Paludina unicolor, Lam., from South Carolina, mentioned by name only by Wheatley, in his Cat. of U. S. Shells, p. 30. I have never known of any such species having been found there.

Vivipara bengalensis, Lam. *(Pal. elongata*, Swainson.--*Pal. multilineata*, Say, N. H. D. II, 245, 1829 Binney's ed., p. 146.--*Pal. vitula*, Rafinesque (Bengal.) Atl. Journ., V, 169), said to have been found in St. John's River, Fla. Mr. Say's words are as follows: 'Capt. Leconte presented me with a shell which, he informed me, he found in the River St. John, Florida. I described it nearly four years since under the name of *multilineata;* but, recently, being about to publish it, on a more attentive examination and comparison with a specimen of the *elongata* from Calcutta, given to me by Mr. Hyde of Philadelphia, I have concluded that it varies from that specimen only in having the umbilicus a little smaller.'

See also *Ampullaria rotundata*, p. 6.

I have seen some specimens said to have come from Florida which might be referred to this species, but at present cannot consider its existence there sufficiently established to admit in the list of American *Vivipara*. Haldeman (Mon., p. 24. Fig. 125. pl. vii, f. 3, 4), thus describes and figures it, considering it probable that it was accidentally introduced into Florida together with *Ampullaria rotundata*, Say. They are both Calcutta shells:--

'Shell lengthened, conic, and polished; composed of six or seven convex whirls, the surface of which is covered with minute transverse wrinkles, and numerous narrow spiral bands; apex pointed; suture deep; lines of accretion very fine; aperture regularly rounded, produced posteriorly. Color bright green, often passing into brownish; the spiral bands are fuscous,

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and the inside white.' See also Haldeman, Mon. 24, pl. vii, f. 3, 4 (1841).

Paludina minuta, Say of Küster, Chemn. ed. ii, p. 52, pl. x, f. 15-16, is *Cingula minuta*, Totten. Mr. Say never described any such species. I have not given Küster's description as he quotes Totten's description, leaving no doubt of its identity.

Paludina hyalina, Lea, Tr. Am. Phil. Soc. VI, 17, pl. xxiii, f. 81, (1839), (not of Morelet), is a distorted *Planorbis exacutus*, q. v. (Land and Fr.-Wat. Sh. II.L

Paludina turrita, Menke, Syn. Meth. p. 40, is mentioned by name only, *Cyclostoma marginatum*, Say, being mentioned doubtfully as a synonym.

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Paludina aculeus, Küster, Chemn. ed. ii, p. 73, pl. xiii, f. 8-9, is there said to be *Cingula aculeus*.

Paludina scalaris, Jay, Cat. 3d ed. 112, pl. i, f. 8, 9 (1839) =*Physa scalaris*, q. v. (Land and Fresh-Water Shells, II.) The name is also used in Zeit. für Mal. II, 164, 1845, by Dunker.

Paludina porata, Say, is mentioned by name only in Menke's Syn. Meth. p. 42 (1830) with *P. katschkana*, Parr. and *P. fluminensis*, Ziegler, as its synonyms.

Paludina castanea, Valenciennes, Humboldt and Bonpland, Rec. d'Obs. II, 256, is not specified as American. The description was drawn from a specimen in the Paris Museum, locality unknown.

Paludina viridis of Virginia is quoted without description by Sowerby (Tank. Coll. p. 43), *Helix viridata*, Budgin MS. being given as a synonym.

Paludina maxima, Ravenel, Cat. 12 (1834), is unknown to me. No description was ever published.

Paludina decipiens is mentioned by name only in Lamark's Animaux sans Vertebres, by Gould's

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translation (p. 70, Genera of Shells) I have no information concerning it.

Finding *Pleurocera* of Rafinesque quoted in the synonymy of *Vivipara* by Adams. Gen. Rec. Moll., I was inclined to place the following species in *Vivipara*, but now omit them. See Rafinesque's Complete Writings, 1864, pp. 65 and 67.

Pleurocera acuta, Enum. and Acc., p. 3.
Pleurocera rugosa, " p. 3.
Pleurocera gonula, " p. 2.
Pleurocera verrucosa, Ann. of Nat., No. I. p. 11 (1820).

The genus *Pleurocera* is considered by Haldeman (Mon. of *Leptoxis* and Encycl. Icon., Baird's ed.) to be the same as *Io*, Lew, which last name not having priority of publication would be considered a synonym of *Pleurocera* The following description of Rafinesque is translated from the Journal de Physique, &c. of Brussels, LXXXVIII, p. 423. The fac-simile Fig. 125 is from a MS work of the same author, 'Conchologia Ohioensis,' presented by Prof. Haldeman to the Smithsonian Institution.

Pleurocera, l. c.--Shell spiral, oval or pyramidal, numerous rounded whirls; aperture oblong oblique, base prolonged twisted, narrowed above; outer lip thin, interior lip appressed to the columella, which is smooth and twisted without umbilicus. Animal with a membranaceous operculum, proboscis-like head, inserted on the back; tentacles two, lateral, subulate, sharp, eyes at their exterior base. Family of *Turbinacea*. Species numerous, of which I have already twelve, all fluviatile, from rivers and creeks. *(Rafinesque)*

Fig. 126.

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Omphemis plaioxis and *lacustris* of Rafinesque are mentioned by name only (Journ de Phys. LXXXVIII, p. 424. The generic description is as follows:--

Shell oval; aperture rounded, lips detached, columella separated from the lower lip by a small oblong umbilicus; spire slightly oblique; animal with a membranaceous operculum, two flattened lateral

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tentacles, eyes at their exterior base. Family Turbinacea. Two species, *O. lacustris* and *plaioxis*, which is fluviatile. *(Rafinesque.)*

I take this opportunity of giving a fac-simile of a figure of the animal of *Leptoxis* as well as Rafinesque's description, translated from the work referred to, p. 424. The figure (127) is copied from the same MS. as that quoted on the last page, written in the well-known hand of Rafinesque.

Fig. 127.

Leptoxis, l. c., differs from *Lymnula* by its oval, ventricose shell of two or three whirls; aperture oval, almost as large as the whole shell; eyes exterior. Four species, fluviatile, &c. *(Rafinesque.)*

To the genus *Somatogyrus* (q.v.) must be referred the following:--

Paludina altilis, Ravenel, undescr. Cat.S. C. 12 (1834).
Paludina pallida, Lea.
Paludina subglobosa, Say.
Paludina fontinalis, Phil.
Paludina isogona, DeKay.

To the genus *Amnicola* (q. v.) must be referred the following:--

Paludina sayana Küster, Chemn. ed. 2, p. 48, pl. ix, f. 30-32.
Paludina emarginata, Küster, *l.c.* p. 50, pl. x, f. 3, 4.
Paludina cincinnatiensis, Küster.
Paludina porata, Küster. *l.c.* and of Philippi.
Paludina lustrica, Küster, *l.c.*
Paludina granosa, Say, of Kirtland's Ohio Report, p 174 (1838), and Sill. Am. Journ. [1] XXXI, 36, (1836); probably *Amnicola granum*, Say.
Paludina grana, Say.
Paludina limosa, Say.
Paludina obtusa, Lea (not of Troschel).

To the genus *Pomatiopsis* (q.v.) must be referred the following:-

Paludina lapidaria Küster, *l.c.*
Paludina nicklíniana, Lea.

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To the genus *Fluminicola* (q.v.) must be referred--

Paludina nuttalliana, Lea.
Paludina nuclea, Lea.
Paludina virens, Lea.
Paludina seminalis, Hinds.

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To the genus *Leptoxis* are to be referred the following species:--

Paludina dissimilis, Say (Binney's ed. p. 48); DeKay N. Y. Moll. 86 (1843), and Potiez & Michaud, Gal. des Moll. I have not considered it necessary to repeat Mr. Say's description, the species being well known and universally acknowledged to be a *Leptoxis*.

Paludina crenata, Say, is mentioned as a species of *Leptoxis* by Dr. Brot in his admirable 'Matériaux pour servir à l'étude de la famille des Mélaniens, p. 24. Mr. Say described no such species. Prof. Haldeman describes a *Leptoxis* under this name in the Monograph referred to by Dr. Brot. See also *Somatogyrus*.

Fig. 128. *Paludina humerosa*, Anthony, *l.c.* Shell ovate, thick, bright green, imperforate; spire rather obtusely elevated, composed of about 5--6 convex whirls; upper whirls smooth, body whirl and preceding one strongly striate and granulate or subgranulate; sutures very distinct; aperture ovate, nearly one-half the length of the shell, livid within.

Length about half an inch.

Alabama. My cabinet.

A single specimen only is before me, but it is sufficiently distinct; its granulated surface and the broad shouldering of the whirls are its chief characteristics; compared with *P. genicula*, Con., it is more slender, darker in color, and its granulated surface is of itself a sufficient distinction. *(Anthony.)*

Paludina humerosa, Anthony, Proc. Acad. Nat. Sc. Phila 1860, p. 71.

Binney, pl 64 *Binney, p. 65*

From an examination of Mr. Anthony's type I have no doubt of this being a nodulous species of *Leptoxis*, on which the nodules are slightly developed. Fig. 128 is drawn from it.

To the genus *Melania* are to be referred--

Paludina virginica, Say, Nich. Enc. 3d ed. (1819).

Paludina rudis, Ravenel (Cat. of Cabinet, p. 12, 1834). No description was given by Dr. Ravenel, who informs me that he found the species at Danville, on the Dan River, and subsequently sent some specimens to Mr. Lea, who described them as *Melania inflata*.

Paludina nitida, Ravenel (Cat. of Cabinet, p. 12, 1834). No description was published. Dr. Ravenel informs me that on submitting specimens to Mr. Lea he pronounced them an undescribed species of *Melania*. They were found in the Dan River, at Danville.

To the genus *Bithynia* (q. v.) has been referred the following:--

Paludina tentaculata, Lin.

To the genus *Lithasia* is to be referred--

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Paludina incrassata, Lea.--Shell smooth, elliptical, rather thin, imperforate, dark horn color; sutures somewhat impressed; whirls somewhat convex; columella thickened above; aperture rather round, small, within bluish. Fig. 129.

Alabama. E. Foreman, M. D. Cabinet of Dr. Foreman. Diam. .52, length ... inch.

Rather more than the first whirl only of the specimen before me is perfect, and I would not have proposed it for a new species, but that this part differs from any which has come under my notice. The callus on the superior part of the columella is very like that we find in the genus *Anculosa*. The aperture is smaller than usual in this genus. The upper whirls being decollate, neither their number nor the form of the spire can be given. *(Lea.)*

Paludina incrassata, Lea, Tr. Am. Phil. Soc. IX, 30 (1844); Obs. IV, 30; Proc. II, 243 (1842).

The figure given above (Fig 129) is taken from Mr. Lea's original specimen. I have not seen others.

Paludina thermalis, Linn., is quoted by Philippi from the United States, *Turbo minutus*, Say, being given as synonym (Arch. f. Nat. 1844, 28).

FOSSIL SPECIES OF VIVIPARIDAE

Dr. Meek furnishes the following list of fossil American Viviparae, most of which were first described as *Paludinae*:--

Vivipara vetusta, Meek & Hayden Phila. Proc. 1860 43; 1856, 121.
Vivipara leaii, " " " *1860, 184; 1856, 121.*
Vivipara retusa " " " 1860, 185; 1856 122.
Vivipara conradi, " " " *1860, 185; 1856, 122.*
Paludina peculiaris " " " 1856 122.
Vivipara trochiformis " " " 1860, 185; 1856, 122.
Vivipara leidyi, " " " " 1856, 123.
Vivipara raynoldsana, " " 1861, 446.
Vivipara nebrascensis (Paludina multilineata, Meek & Hayden, Phila. Proc. 1856, 120); 1860, 430.
Vivipara glabra, H. C. Lea, teste Conrad, Proc. Phila. A.N.S. 1862 567.

FAMILY RISSOIDAE

Lingual teeth 3, 1, 3; the rows being more transverse and less arcuated than in the *Littorinidae*. Rhachidian tooth broader than long, and armed with basal denticles (so called

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by Troschel) on each side; which may be either

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on the basal margin, or on the anterior surface of the tooth above the base; cusp recurved and denticulated. Intermediate tooth

(Fig. 130)

more or less hatchet-shaped, having a handle-like process (peduncle) projecting outwardly from the base of the broad body which is denticulated at the upper margin. Lateral teeth generally slender and armed with numerous minute denticles at their superior margins. Shell small, spiral, turreted or depressed, often more or less umbilicated; aperture more or less rounded, never truly channelled in front; peritreme continuous. Tentacles elongated, with the eyes at their outer bases. Verge (male organ) exserted, situated on the back at a considerable distance behind the right tentacle. Gills both pallial; the right or principal one usually rather short and broad, and composed of few laminae, which are much broader than high. Foot oblong, truncate before, rounded or pointed behind. Operculigerous lobe well developed. Operculum horny or partly shelly, spiral or concentric.

Station in fresh, brackish, or sea water, rarely on land. Distribution mundane.--[Stimpson.]

Dr. Stimpson subdivides the *Rissoidae* into the following subfamilies:--

BYTHINIINAE, with an ovate shell, a concentric operculum which is calcareous within, and with cervical lobes. They are comparatively large. Fresh water. Genus *Bythinia*, Gray.

RISSOININAE, with an ovate or turreted shell, and a thick, corneous, subspiral operculum provided with an internal process (articulated). Size small. Marine. Genus *Rissoina*, D'Orb. (See Stimpson's paper, p. 39.)

RISSOINAE, with an ovate or elongated shell, and a subspiral operculum not provided with a process. Foot without lateral

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sinuses. Rhachidian tooth of the lingual ribbon with the basal teeth on the inferior margin. Size small. Marine. Genera *Rissoa*, Frem., *Cingula*, Flem., *Alvania*, Risso, *Onoba*, H. & A. Ad., *Setia*, H. & A. Ad., *Ceratia*, H. & A. Ad.

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SKENEINAE, with a depressed, almost discoidal shell, and a corneous paucispiral operculum. Minute. Marine. Genus *Skenea*, Flem.

HYDROBIINAE. with shell and operculum and foot like those of the *Rissoinae*, but with the rhachidian tooth of the lingual ribbon having the basal teeth on the anterior surface, behind the lateral margins. Size variable; some are minute, some as large as *Bythiniae*. Living in fresh or brackish water. *Genera Hydrobia*, Hartm., *Littorinella*, Braun, *Amnicola*, Gould & Hald., *Bythinella*, Moq.-Tand., *Stenothyra*, Benson, *Tricula*, Benson, *Pyrgula*, Christ. & Jan., *Paludestrina*, D'Orb., *Tryonia*, Stm., *Potamopyrgus*, Stm., *Lithoglyphus*, Muhlfeldt, *Fluminicola*, Stm., *Gillia*, Stm., *Somatogyrus*, Gill, *Cochliopa*, Stm.

POMATIOPSINAE, with the shell and operculum as in the *Rissoinae*. Foot with lateral sinuses. Size small. Amphibious. Genus *Pomatiopsis*, Tryon.

The land and freshwwter species only are included by me in the following pages. The figures are all somewhat enlarged.

BYTHINELLA, Moq.-Tand.

Lingual dentition of *B. thermalis*, according to Troschel: Rhachidian tooth moderately long, with the infero-lateral angles much produced. Intermediate tooth with the body longer than

(Fig 131)

broad. Formula of the denticles: $\frac{9}{1+1+6}$ 18 + 0. Tentacles tapering, but blunt at tip. Foot rather narrow, rounded behind.

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Verge (in *B. ferrusina*) bifid. Shell elongate-ovate, usually somewhat pupiform, imperforate, or simply rimate; apex obtuse. Aperture oval or rounded; peritreme continuous, slightly

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thickened. Operculum corneous, with the nucleus moderately large, not very close to the basal margin.

Station, fresh water.

Distribution, Europe and North America. *(Stimpson.)*

Bythinella attenuata, Hald.--Shell unusually long, slender, with 6 or 7 obliquely revolving, very convex whirls, separated by a deep suture; labium in contact with the body whirl, leaving scarcely any perforation.

Fig. 132.

Color pale-green beneath an extraneous coating of black. Taken from a spring in Montgomery County, Virginia, connected with Roanoke River.

I am not confident that this is not the adult of *nicliniana*, as there is a very close resemblance between that shell and the young of this species, when it has but four volutions. In the latter, the aperture appears to be rather contracted. *(Haldeman.)*

Amnicola attenuata, Haldeman, Mon. pt. 4, p. 3 of wrapper (1842); Ib. Mon. p. 22. pl. i, f 13 (1844?); Ib. Journ Acad. N. Sc. Phila. VIII, 200 (1842); Ib. Proc. I, 78 (1841).
Amnicola elongata, Haldeman, *l.c.* in plate.

It is also said to inhabit New York. *Amnicola elongata*, Jay, of the Smithsonian Check Lists, is probably this species. No synonymy or reference is given by Dr. Jay (Cat., p. 278).

Bythinella nickliniana, Lea.--Shell turreted, green. smooth, apex obtuse; whirls 4, convex; aperture ovate.

Fig 133.

Hot Springs, Va. Diam. two-twentieths; length three-twentieths inch.

This shell, with several other species, was brought by Mr. Nicklin from the Hot Springs of Virginia, and kindly placed in my cabinet. It lives in a rivulet, whose channel is supplied by the waters of a hot and a cold spring The *Physa aurea* inhabits the same stream. It is

Fig. 134.

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the smallest species I know in our country, except the *granosa* of Say. It is rather larger, and very much resembles the *viridis* Lam. Its habitat, however, is very different, as the *viridis* lives in cold fountains. *(Lea.)*

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Paludina nickliniana, Lea, Tr. Am. Phil. Soc VI, 92, pl. xxiii. f 109 (1839; Obs. II, 92.
Amnicola nickliniana, Haldeman, Mon p. 21, pl. i, f. 12 (1844?).

Mr. Lea's figure (Fig. 133) not being as correct a representation as desirable of the species, I add another (Fig. 134), copied from Haldeman.

The lingual dentition is figured on page 131.

Cat. No.;	No. of Sp.;	Locality.; From whom received. Remarks.
8972	100+	Fishing Creek, Clinton Co , Pa. Teste Lea.
9931	3	" .... Cabinet series.

Bythinella tenuipes, Couper.--Animal with the head proboscidiform, sub-bifid, sub-cylindrical; foot strap-shaped, anterior portion extending laterally, and emarginate before; tentacles setaceous; eyes at the external base of the tentacles; color, except the head and eyes, mottled white.

Shell 'small, one and a half lines long, subumbilicated, oblong-ovate, turreted, thin. smooth, lines of growth very slightly marked; color light brown; volutions five, suture slightly impressed; aperture ovate, oblong, angulated above, rounded at base; labrum simple, sharp.

Fig 135.

'Found in the rice-field ditches at Hopeton, Georgia; movement active, made by the joint action of the head and foot, the head advancing before the foot; floats on the surface of the water in an inverted position.' *(Couper in Haldeman.)*

Amnicola tenuipes, Couper, in Haldeman's Mon. 23, pl i, f 14 - 15 (1844?); No. 7, p. 4 of wrapper (1844).

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Bithynella binneyi, Tryon.--Shell minute, elongated, consisting of 4 to 5 very convex whirls; apex somewhat obtuse; aperture ovate or nearly suborbicular, both lips rounded; umbilicus very small. Color light horn. Length 3, diam. 1.6; length of aperture 1.25, breadth 1 mill.

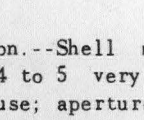
Fig. 136.

Bolinas, California. Rev. J. Powell. My cabinet and cabinet of Mr. Powell. Some specimens of this very small and exceedingly fragile species were sent to me; they exhibit, however, all the stages of growth from the very young to adult form. None of them retained the operculum. It is much smaller than any other species of *Pomatiopsis,* and is not likely to be confounded with any of them. It approaches nearest in form to two European species of *Bythinia, B. acuta* and *B. viridis;* the former however, has a more lengthened, acute spire, and the latter is a more robust and ventricose shell. *(Tryon.)*

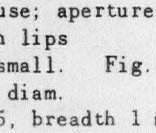
Fig. 137.

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Pomatiopsis binneyi, Tryon, Proc. Phila. Acad. 1863, 148 pl. i, f. 10.

Mr. Tryon's description is given above, as well as a fac-simile of his figure (Fig. 136). I have also given another figure of his original specimen.

Bythinella obtusa, Lea.--Shell subcylindrical, rather thin, dark green, smooth, slightly perforate; spire short; at the beaks very obtuse; sutures impressed; whirls four, convex; aperture small, nearly round.

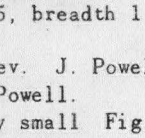
Fig. 138.

Ohio. Diam. .07, length .10 inch.

This is among the smallest of the genus, and may at once be distinguished by its obtuse apex, which has the appearance almost of being truncate. The whirls do not decrease regularly from the lower one to the apex, the greatest diameter being apparently across the second whirl. In form, therefore, it has the aspect of a *Pupa.* It answers partly to the description of *Paludina alleghaniensis,* Green, but seems to differ in the truncate appearance

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of the apex, and in its size Two specimens were found in a box, with some other small species, kindly sent me by Dr. Kirtland. It is rather less than *Pal. nicklinlana,* but differs from it in being less tapering to the apex. It closely resembles *P. viridis,* Lam., but is rather larger, and more obtuse. There were no opercula to examine in these specimens; aperture rather more than one-third the length of the shell. *(Lea.)*

Paludina obtusa, Lea, Tr. Am. Phil. Soc. IX, 13 (1844); Obs. IV, 13; Proc. II, 34 (1841).
Amnicola obtusa, Haldeman, Mon p. 24 (1844?).

TRYONIA. Stimpson.

Shell perforate, elongated, turreted, subulate, acute at summit and rather pointed at base; surface longitudinally ribbed or plicated not spinous; whirls numerous, shouldered. Aperture small, oblique, rhombo-ovate; and somewhat pointed, sinuated and effuse at base; outer lip thin and sharp, projecting below; inner lip appressed to the whirl above, peritreme however continuous. Operculum and lingual dentition unknown.

Station, fresh water.

Distribution, Southern California. *(Stimpson.)*

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Tryonia clathrata, Stimpson.--Whirls eight. Longitudinal ribs variable in number, usually about twelve to each whirl. Surface otherwise smooth, or marked with delicate incremental striae. There is no trace of revolving striae or lines. Length 0.2 inch.

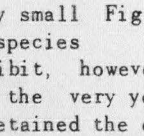
Fig. 139.

The specimens described are in a semi-fossilized condition, mostly white, though not chalky, but with an ivory-like hardness. Some of them are translucdnt, looking as if silicified. From the circumstances under which they were found, however, it is probable that the species existed within a very recent period, if not indeed now living.

Large numbers of specimens were found, in company with other dead fresh-water shells of

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the genera *Physa, Planorbis, Amnicola, Cyclas,* etc., in the basin of the Colorado Desert, Southern California, by Mr. Wm. P. Blake, on one of the Pacific Railroad Surveys. The basin is the bed of an ancient lake, now dry. The specimens collected by him are in the museum of the Smithsonian Institution. *(Stimpson.)*

Tryonia clathrata, Stimpson, Am. Journ Conch. I, 54, pl. viii, f. 1, 1865.

The figure I have given is not a fac-simile of that of Stimpson.

Tryonia protea, Gould.---Shell elongate, slender, variable; whirls seven to eight, rounded, divided by a deep suture, simple or variously ornamented, and barred with revolving ridges and longitudinal folds; aperture ovate; lip continuous, simple, scarcely touching the penultimate whirl. Length of the largest specimen three-tenths, breadth one-tenth inch. Fig. 140.

From the Colorado Desert (Gran Jornada), Dr. T. H. Webb, W. P. Blake.

Peculiar from its large size and slender form, though differing greatly in its relative proportions. It differs from all others, in being variously sculptured with revolving ridges and longitudinal folds, like most *Melaniae.* It varies greatly also in the relative proportions of length and breadth. It is as slender as *Amnicola attenuata,* Hald., and much larger. This appears to be the same shell as that subsequently described by Mr. Conrad, under the name of *Melania exigua. (Gould.)*

Amnicola protea, Gould, Proc. Bost. S. N.H. V, 129 (March, 1855); P. R. R. Rep. V, 332, pl. xi. fig. 6-9 (1857); Prelim. Rep. App. 24 (1855); Otia, 217.
Melania exigua, Conrad, Proc. A.N.S. Phila. VII, 269 (Feb. 1855).

Two of Dr. Gould's figures are copied in my figure (140). With them may be compared Fig. 141, which is drawn from a specimen presented by Prof. Haldeman (No. 9143), and pronounced by Mr. Conrad to be his *Melania exigua,* it having been one of

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the original specimens collected by Dr. Le Conte. Mr. Conrad's description, given below, bears an earlier date than that of Dr. Gould, but was not actually published at that time. I have, therefore, retained Dr. Gould's name. The two descriptions evidently refer to the same species.

Melania exigua.--Turreted; volutions 8 disposed to be angulated and somewhat scalariform above, cancellated, longitudinal lines wanting on the lower half of the body whirl; columella reflected; aperture elliptical. Length one-fifth of an inch. Colorado Desert, California. *(Dr. Le Conte.)* Fig. 141. Fig. 142.

The specimens are numerous and of a chalky whiteness, showing that they are all dead shells. Said to have been found one hundred and twenty miles distant from any stream passed on the route. I am indebted to Dr. Caspar Parkinson and Mr. Mactier for specimens. *(Conrad.)*

Fig. 142 is drawn from one of Dr. Gould's original specimens.

Cat. No.	No. of Sp.	From whom received.; Locality.	Remarks.
9143	4	Colorado Des.	Prof. Haldeman. *M. exigua* teste Conr.
9356	4	"	Mr. Mactier. *M. exigua* teste Conr.

COCHLIOPA, Stimpson.

Lingual dentition of the typical species: Rhachidian tooth short and broad; middle lobe of the basal margin very broad; basal teeth rather large. Intermediate tooth with a long peduncle, and square body having a cavity in the centre. Lateral teeth with an expansion of the inner side of the shank, separated from the summit by a deep rounded sinus; the outer lateral being more expanded than the inner. Formula of the denticles: $\frac{11}{2+2}$ - 8 - 18 - 24.

Shell depressed-conic; base concave carinated; umbilicus large and deep; aperture oblique. Operculum thin, corneous, sub-spiral. Rostrum of moderate size; tentacles rather long, tapering. Verge rather elongated compressed, geni-

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culated, and bifid, the inner branch being very small, less than one-fourth the size of the outer one and arising at the inner angle of the geniculation.

(PAGE 73)

Station, fresh water.

Distribution, California. *(Stimpson.)*

Cochliopa rowellii, Tryon.--Shell depressed, wider than high, consisting of 3½ whirls, which are regularly convex and rapidly enlarging; spire small, but little elevated, apex acute, sutures well marked; base convex, except that the region surrounding the umbilicus is flattened and inclining towards the axis, its outer boundary, consequently, is marked by an angle; umbilicus small, but very distinct; aperture half-ovate, the labrum well rounded and thin, the labium but slightly rounded, thickened, elevated from the body-whirl, forming an acute angle with the labrum above, and not impinging on the umbilicus. Surface marked with close, regular, minute striae, which become enlarged in the flattened umbilical region into sharp crowded lines visible without a glass. Color light horn or yellowish, operculum darker. Operculum paucispiral, the lines of accretion very distinct and regular. Length 2.5, diam. maj. 4, min. 3; length of apert. 2, breadth 1½ mill. Fig. 143.

Clear Lake, California: Rev. J. Rowell. My cabinet and cab. of Mr. Rowell.

This species cannot be compared with any hitherto described, being much more depressed, and widely distinct in the form of the umbilical region. It may possibly form a species of the genus *Somatogyrus*, recently proposed by my friend Mr. Theo. Gill for a small mollusk from Iowa, which I described in the Proceedings of the Academy for Sept. 1862. *(Tryon.)*

Amnicola rowellii, Tryon, Proc. Phila. Acad. 1863, 147, pl i, f. 8, 9.

In addition to the fac-simile of one of the original figures of this species given above, Fig. 144 is drawn from No. 9312 of the collection, which was presented by Mr. Tryon. Fig. 144.

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Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

9312 1 California. G. W. Tryon. Fig. 144.

GILLIA, Stimpson.

Lingual dentition of the type: Rhachidian tooth moderately long, deeply trilobate below; basal teeth close to the basal margin, and projecting beyond it. Intermediate tooth with the body subrhomboidal, slightly excavated in the middle. Outer

(PAGE 74)

lateral tooth with a smaller number of denticles than the inner. Formula of the denticles: $\frac{9}{2 - 2}$ - 8 - 14 - 10. Shell rather large, subglobular, thin, subperforate, smooth; spire

(FIG. 145.)

small; suture not impressed. Aperture large, broad, ovate, oblique; outer lip thin, acute, not projecting anteriorly. Operculum thin, corneous, regularly ovate. Rostrum rather broad. Tentacles tapering, pointed. Verge small, simple, lunate. Ova-capsules hemispherical, each containing a single egg, and deposited singly or in groups or linear series.

Station, fresh water.

Distribution, the eastern parts of the United States of North America. *(Stimpson.)*

Gillia altilis, Lea.--Shell smooth, subglobose, thick, pale horn-color; spire short; sutures small; whirls four, obtusely angular above; aperture large, nearly round, white.

Fig. 146. Santee Canal, South Carolina: Prof. Ravenel; Susquehanna River at Havre de Grace, Md

(Paludina altilis, Prof. Ravenel's letter.) My cabinet and cabinet of P. H. Nicklin. Diam. .27, length .32 inch.

Last summer I found a number of this globose little species on the banks of the Susquehanna, and then considered it new, but on examination I found I had the same species, Prof. Ravenel having sent it to me years ago

under the name of *Paludina altilis*. I am not aware that Prof. R. has ever described it, never having seen any account of it. His specific name for it is retained, but I have placed it among the *Melaniae*, it having a distinct spiral operculum. It belongs to a natural group in the genus *Melania*, which have very low spires and a very large body whirl. There is a very slight impression on the superior part of the whirls below the suture. The aperture is about two-thirds the length of the shell. The epidermis in young specimens is a very pale yellow, almost white. *(Lea.)*

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Melania altilis, Lea, Proc. Am. Phil. Soc. II, 13 (1841); II, 150 (1842); Trans. VIII, 174, pl. v, f. 23; Obs. III, 12 (1843).--DeKay, N.Y. Moll. 95 (1843).
Paludina altilis, Ravenel, Cat. (no descr.)
Leptoxis altilis, Haldeman, Mon. Lept. 6, pl. v, f. 152 (1847?).

Mr. Lea also gives the river Schuylkill, at Philadelphia, as the habitat of this species (Pr. Am. Phil. Soc. II, 150). I have myself found it in great plenty in the Delaware, at Burlington, crawling on the mud exposed by the fall of the tide, together with *Amnicola limosa* and other species.

Mr. Lea's figure is copied in my Fig. 146.

Judging from the description and figure given by Haldeman of *Leptoxis crenata*, I should be inclined to refer it to this species, especially as its habitat is the same (Santee Canal). I have, however, followed the system of giving all the described species of this genus, without regard to synonymy--it being very difficult to decide doubtful cases. See the remarks under that species.

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.
9217 4 Delaware River, N. J. W. G. Binney.

Gillia crenata, Haldeman.--Shell obliquely transverse, subglobose, polished, rather solid, with four convex whirls, and impressed suture; aperture oblique, very

Fig. 147.

Fig. 148.

large, angular posteriorly. Peritreme continuous on the same plane. Color yellowish-green, aperture white.

Paludina crenata, Say in cabinet.
Paludina altilis, Rav. in cab.

Santee Canal, S. C.

Distinguished from *altilis* by its obliquity, greater thickness, straighter and thicker labium, comparatively shorter spire. In other respects the species are much alike. This seems to belong to the same genus as the European shells which Dr. Jay gave me as *Paludina naticoides* and *Lithoglyptus fuscus*. *(Haldeman.)*

Leptoxis crenata, Haldeman, Mon. 6, 67, pl. v, f. 153 (1847?).

The above is a copy of the original description and figure of this species. I am inclined to believe it to be identical with the

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Gillia altilis of the Santee Canal. The shell found in the Delaware, and considered by Mr. Lea as *Melania altilis*, and included by me in the preceding article as a form of *Gillia altilis*, may prove to be a distinct species. If so, its synonymy will be *Leptoxis altilis*, Haldeman, not *Melania altilis*, Lea.

DOUBTFUL SPECIES OF GILLIA.

Leptoxis rapaeformis, of Haldeman's Monograph, probably belongs to this genus. The species figured by him without name (pl. v, f. 157) certainly does.

SOMATOGYRUS, GILL.

Lingual dentition of type: Rhachidian tooth very short and broad. Intermediate tooth with the body perforated. Inner and outer lateral teeth with about the same number of denticles. Formula of the denticles: $\frac{7}{4 - 4}$ - 7 - 14 - 14. Shell rather large,

(FIG. 149.)

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globular, thin, smooth, perforate; spire small; suture impressed; body whirl globose, more or less shouldered above. Aperture large, oblique, rhombo-ovate, narrowly rounded in front and behind, with its peritreme thin and acute, and with its entire margin uniformly in one plane, the outer lip not projecting anteriorly. Operculum rather thick, corneous, subovate; inner margin concave near the upper extremity. Foot rather short. Rostrum broad. Tentacles tapering, pointed.

Station, fresh water.

Distribution, the central parts of North America. *(Stimpson.)*

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Somatogyrus depressus, Tryon.--Shell orbicular, sub-hyaline; whirls four, convex, the last large, equalling five-sixths the length of the entire shell; umbilicus narrow; aperture semicircular, labrum appressed within; suture impressed. Length and breadth four mill. (Fig. mag. 2½ times.)

Fig. 150.

Hab. Mississippi River, at Davenport, Iowa: Prof. Sheldon. Coll. Acad. Nat. Sciences, and Smithsonian Institution, Prof. D. S. Sheldon, George W. Tryon, Jr.

Shell subhyaline, rather solid, orbicular, with the spire depressed, consisting of four whirls; apex acute, suture profoundly impressed. Body whirl very convex, equalling five-sixths the length of the shell, narrowly umbilicate. Aperture semicircular, the inner lip being nearly straight. The only shell which this resembles is *Vivipara subglobosa*, Say, which differs in being double the size of *A. depressa*, with a rather more exserted spire, and in having a more concave inner lip. *(Tryon.)*

Amnicola depressa, Tryon, Proc. Ac. N. Sc. Phila. 1862, p. 452.

Somatogyrus depressus, Gill, Pr. Phil. Ac. 1863, 34 (no descr.)

Fig. 150 is drawn from Mr. Tryon's original figure.

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.

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9014 3 Davenport, Ia. G.W. Tryon. .....

Somatogyrus isogonus, Say.--Subglobose, horn-color, volutions about four, rounded, obsoletely wrinkled; spire very short, about one-third the length of the aperture; suture profoundly impressed so as to form a shoulder on the whirls; aperture much dilated, oval, being as obtusely rounded above as at the base; umbilicus linear, distinct; operculum obviously spiral. Length under three-tenths of an inch. Inhabits Bear Grass Creek, near Louisville. Not very numerous. It is remarkable by the oval form of the much dilated aperture, and by the deeply indented suture. In old specimens the base is almost acutely angulated. *(Say.)*

Fig. 151. Fig. 152.

Melania isogona, Say, N H. Diss. II, 227 (1829); Descr. 19; Binney's ed. 144.

Amnicola isogona, Lea, Tr. Am. Phil. Soc. IX, 16 (1844); Obs. IV 16.---Woodward, Man. pl. ix, f. 23.

Paludina isogona, DeKay, N.Y. Moll. 85, pl. vii, f. 133.

Paludina pallida, Lea, Trans. Am. Phil. Soc. VI, 22 pl. xxiii, f. 104 (1839); Obs. III 22.

?Paludina fontinalis, Philippi, Conch. II, 5, p. 2, pl. ii, f. 9 (1846).--Küster, Chemn. ed. 2, 56, pl. x, f. 27, 28.

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Leptoxis isogona, Haldeman, Mon. 6, pl. v, f. 155 *(Mudalia)* (1847?).

Paludina subglobosa, Say, J.A.N.Sc. V, 125 (1825); Binney's ed. p. 115,--DeKay, N.Y. Moll. p. 86 (1843) --Haldeman, Mon. pl. x, f. 7, 8.

Mr. Lea's description and figure of *Paludina pallida* are copied below.

Paludina pallida.--Shell ventricose, thin, light horn-color, smooth; sutures impressed; whirls four, convex; aperture nearly round.

Fig. 153. Near Cincinnati, Ohio: T.G. Lea. My cabinet. Diam. .3 length .4 inch.

This shell has recently been found by my brother, and I believe has not before been observed. It might at first be mis-

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taken for a young shell, on account of its pale yellow color and translucency. In form, however, it differs from any species I have examined, the last whirl being very much enlarged, and the aperture being very large. *(Lea.)*

A translation of Philippi's description of *Paludina fontinalis*, and a fac-simile of his figure here follow. The shell described by him may be *S. integer*.

Fig. 154. *Paludina fontinalis*.--Shell minute, subglobose, subperforate, solid, greenish-yellow; whirls four, convex, the last ventricose, twice the length of the shell; aperture ovate, dilated. Height 2½''; height of the aperture 1¼''

Melania integra, Say (ubi?), according to specimens.

Ohio, United States of America. *(Philippi)*

An authentic specimen of *Paludina subglobosa*, preserved in the Philadelphia Academy, is without doubt identical with the shell received as Say's *Melania isogona*. A drawing of the specimen and copy of Say's description here follow.

The strict rules of nomenclature would require the substitution of *subglobosus* for *isogonus* as the specific name of this species. It does not, however, seem advisable in this case to abandon the name by which the species has so long been known.

Fig. 155. *Paludina subglobosa*, Say.--Shell subglobose; whirls three and a half, much rounded, rapidly enlarging; suture profoundly impressed; aperture subovate: umbilicus very narrow, nearly closed by the labrum; spire very short, convex.

Inhabits the Northwestern Territory. Length less than three tenths of an inch.

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I obtained this shell when traversing the northwestern part of the Union. It is much larger than the *porata*, nob., which it resembles considerably, but its whirls are much more

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rapidly enlarged, and the umbilicus is much narrower. *(Say.)*

Fig. 152 is from Haldeman's Monograph.

Cat. No.	No. of Sp.	Locality.	From whom received.	Remarks.
9216	2	Ohio.	W. G. Binney.	
9223	3	.....	.....	.....
9224	4	Ohio.	Gen. Totten.	*Pal. subglobosa*, teste Ward.

Somatogyrus integer, Say.--Subglobose, horn-color; volutions rather more than three, rounded obsoletely wrinkled; spire very short, less than half the length of the aperture: suture rather deeply impressed; body Fig. 156. whirl large, aperture dilated ovate, acute above; columella flattened; polished; labrum regularly rounded; base regularly rounded, without any undulations or sinus; umbilicus none; operculum obviously spiral; Length nearly one-fifth of an inch. Animal, foot longer than wide, rounded behind, with the anterior angles a little excurved; eyes black, conspicuous; tentacula rather long and slender.

Inhabits the Ohio River and many of its tributaries.

This is a very common little shell, abounding more in many situations than any other species, particularly in the vicinity of the Falls of the Ohio. It may readily be taken for a young shell. *(Say)*

Melania integra, Say, New Harm. Diss. II, 276 (1840); Descr. 19; Binney's ed. p. 144.--DeKay, N.Y. Moll. 96 (1843).

Anculotus pumilus, Conrad, teste Haldeman and Reeve.

Anculotus integer, Reeve, Con. Icon. 35 (1861).

Leptoxis integra, Haldeman, Monr. Lept. 6, pl. v, f. 15? (1847?).

Amnicola integra, Haldeman, Jour. Phila. A.N. S. VIII, 200 (1842).

Paludina fontinalis, Philippi? see last species.

Fig. 156 is copied from Haldeman's Monograph.

Fig. 157 is a fac-simile of the drawing of its lingual dentition, given by Troschel (Gebiss der Schnecken).

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(FIG. 157.)

(PAGE 80)

Anculotus pumilus, Conrad, which is considered a synonym in Haldeman's *Leptoxis*, is thus described in New Fresh-Water Shells. p. 62. An authentic specimen in the Academy's collection, at Philadelphia, does not appear to be *A. integra*.

Anculotus pumilus.--Shell very small, obliquely oval, blackish; spire consisting of one entire convex whirl; apex eroded; body whirl regularly convex; base with a groove behind the columella, aperture suborbicular, patulous.

Inhabits the Black Warrior River and Bayou Teche; the latter locality was communicated by Prof. Green, who supplied me with a specimen. *(Conrad.)*

This species is nearly allied to, if not identical with *Somatogyrus isogonus*.

Cat. No.; No. of Sp.; Locality.; From whom received. Remarks.
9219 2 Ohio. ....
9228 3 Flemington, Centre Co., Pa. .....

AMNICOLA, Gould & Haldeman.

Jaws present. Lingual dentition of *A. porata:* Rhachidian tooth very short and broad, with a tongue-shaped process from the middle of the anterior surface, reaching beyond the base. Intermediate tooth with a short broad body having a strongly projecting infero-interior angle, and a very long peduncle. Formula of the denticles: $\frac{7}{4+4} + 5 + 18 + 30$. Shell small, rather

(FIG. 158)

short, ovate or subglobular, thin, smooth, perforate; spire not acute. Aperture broadly ovate, not oblique; outer lip thin and

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Fig. 159 sharp, not projecting anteriorly. Operculum corneous. Foot rather short and broad expanded and broadly rounded behind. Rostrum short. Tentacles cylindrical, blunt at their tips. Verge short, bifid, with a globular base. Fig. 160.

Ova-capsules semi-lenticular in form, with a laminiform limb. Each contains but one egg.

Station. fresh water.

Distribution, North America. *(Stimpson.)*

Amnicola sayana, Anthony.-- Shell lengthened, conic, composed of six very convex shining whirls; suture strongly impressed; lines of growth very fine; base with a narrow umbilic; aperture suborbicular; the labium slightly flattened, a small portion of it in contact with the body whirl. Fig. 161.

Color bright yellowish-brown, translucent. Inhabits southwestern Ohio.

It is found on wet earth and roots of trees on the margin of a small stream near Cincinnati. *(Haldeman.)*

Cyclostoma cincinnatiensis, Lea, Oct. 1840, Proc. Am. Phil. S. I, 289; 1843 Tr. Am. Phil. Soc. VIII, 229 pl. vi, f. 62.
Amnicola sayana, Haldeman, Mon. p. 19 pl. i, f. 11 (1844?); pt. 4, p. 4 of wrapper (1842); J.A.N.S. Phila. VIII, 200 (1842). --Anthony, Cincin. Shells (1843), no desc.
Paludina sayana, Küster in Chemn. ed. 2, p. 49, pl. ix, f. 30-32.
Chilocyclus cincinnatiensis, Gill, Proc. Phila. Ac. 1863, 34 (no descr.)
Cyclostoma sayana, Jay, Cat. [4] 198 (1852), no descr.; *Amnicola*, p. 278.

Troschel (Gebiss der Schnecken p. 107, pl. viii, f. 1) figures the lingual membrane of this species, and his figure is copied in my figure 162; No. 8934 of the collection is from Mr. Anthony. No. 8971 is labelled by Mr. Lea *'Cyclostoma cincinnatiensis.'*

Found in Ohio and New York.

This species was first described by Mr. Lea (in Oct. 1840) as a *Cyclostoma*, under the spe-

cific name of *cincinnatiensis*. After the true characters of the genus *Amnicola* had been recognized by Gould and Haldeman, it became necessary to include in it this species. It would then have borne the name of *Amnicola cincinnatiensis* had not the shell published in Jan. 1840, by Mr. Anthony, as *Paludina cincinnatiensis* also been found to belong

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to the genus *Amnicola* and become known as *Amnicola cincinnatiensis* Mr Anthony's name, having priority of publication,

(FIG. 162.)

was retained. He suggested the substitution of *Amnicola sayana* for Mr. Lea's shell, but never described it. Prof Haldeman followed his suggestion, giving Mr. Anthony as authority for the new name of *Amnicola sayana*. I have personally consulted the works containing the two descriptions and find the internal evidence supports Prof. Haldeman's view of the priority of Mr. Anthony's name. Dr. Stimpson refers this species to *Pomatiopsis*. If included in that genus it should bear the name of *Pomatiopsis cincinnatiensis*, Lea.

Mr. Lea's description and an enlarged view of the outline of his figure here follow: --

Fig. 163.

Cyclostoma cincinnatiensis.--Shell elevated in the form of a cone, smooth, shining, transparent, umbilicate; whirls 6, apex obtuse; margin of the lip reflected.

Vicinity of Cincinnati. Diam. .13, length .22 inch.

A small species which has been sent to me several times by my brother, who seems first to have observed it. It is about the size, and nearly the color, of *Paludina limosa*, Say. It is found on wet earth and roots of trees, on the margin of a small stream near Cincinnati. *(Lea.)*

Cat. No.	No. of Sp.	Locality.	From whom received. Remarks.
8966	12	Elyria, O.	W. G. Binney. .....
8967	10	.....	" "

8968	20	Greenwich, N.Y.	Dr. Ingalls. .....
8969	20+	Greenwich, N.Y.	Dr. Lewis. *tenuipes*, teste Ingalls.
8970	6	Ohio.	J. G. Anthony. *Cyclostoma cincinnatiensis*, teste Lea.
8971	5	Ohio.	J.G. Anthony. Cabinet series.
9293	5	Otter Tail Creek, Minn.	Kennicott.

Amnicola porata, Say.--Shell obtusely conic, or subglobose; volutions four, convex, obsoletely wrinkled across; spire obtuse; labrum and

(PAGE 83)

labium equally rounded, meeting above in a subacute angle; the upper edge of the latter appressed to the preceding whorl; umbilicus very distinct. Fig. 164.

Inhabits Cayuga Lake Cabinet of the Academy.

This species, which was found by Mr Jessup, is rather larger and more globose than *P. limosa*, to which it is allied, and has a more distinct umbilicus. It resembles *P. decipiens* of Ferussac, but is much less acute, and rather smaller. *(Say.)*

Paludina porata, Say, Journ. Acad. N. Sc. Phila. II, 174 (1821); Binney's ed p. 69.--Küster in Chemn. ed. 2 p. 63, pl. xii, f. 4, 5.--Philippi, Abbild. II, t. II, f. 10 (1846), not Adams *(=lustrica)*.

Amnicola porata, Haldeman, Mon. p. 13, pl. i, f. 8 (1844), not of Gould, Inv., Linsley, Prescott, Mighels, Adams, &c. *(=limosa)*.--DeKwy, N.Y. Moll. p. 88 pl. xxxv, f. 333 (1843).--Chenu, Man. de Conch. II, 308, fig. 2194.

Big Sioux River and Moose Factory are the only other localities of which I have heard.

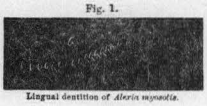
Cat. No.	No. of Sp.	Locality.	From whom received. Remarks.
8976	20+	Big Sioux.	Dr. F. V. Hayden. .....
8933	..	"	" Cabinet series.
9025	2	Moose Factory, Br. Am.	C. Drexler.

Amnicola pallida, Hald.--Shell thin in texture, conical, rather robust, composed of four

The figures on the two following pages are to accompany Binney's Land and Fresh Water Shells of North America, Part II, the last instalment of which was reprinted in STERKIANA 21: 3–40. The remaining figures will be reprinted in STERKIANA from time to time, as they can be prepared.

A. L.

Fig. 1.



Lingual dentition of *Alexia myosotis.*

Fig. 2.

Animal of *Alexia myosotis.*

Fig. 3.

Jaw of *Alexia myosotis.*[1]

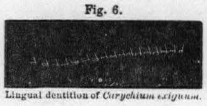
Fig. 4.

Alexia myosotis.

Fig. 5.

Carychium exiguum.

Fig. 6.



Lingual dentition of *Carychium exiguum.*

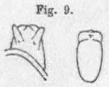
Fig. 7.

Carychium exiguum.

Fig. 8.

Carychium exiguum,

Fig. 9.



Carychium exiguum.

Fig. 10.

Melampus olivaceus.

Fig. 11.

Melampus bidentatus.

Fig. 12.

Melampus bidentatus.

Fig. 13.

M. bidentatus, var. *linsatus.*

Fig. 14.

Melampus flavus, twice natural size

Fig. 15.

Melampus coffeus, natural size.

Fig. 16.

Animal of *Tralia,*[1] enlarged.

Fig. 17.

Tralia floridana.

Fig. 18.

Tralia pusilla.

Fig. 19.

Tralia cingulata, 2½ natural size.

Fig. 20.

Leucosia sayii.

Fig. 21.

Paltyes lirata, 4 times nat. size.

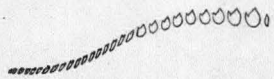
Fig. 22.

Blauneria pellucida.

Fig. 23.

Valvata sonata.

Fig. 24.



Lingual dentition of *Ancylus newberryi.*

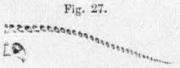
Fig. 25.

Animal of *Limnæa desidiosa.*

Fig. 26.

Jaws of *L. columella.*

Fig. 27.



Lingual membrane of *L. columella.*

Fig. 28.

Limnæa appressa, Say.

Fig. 29.

Limnæa jugularis.

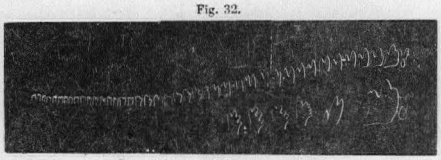
Fig. 30.

Limnæa stagnalis.

Fig. 31.

Limnæa speciosa.

Fig. 32.



Lingual dentition of *Limnæa jugularis.*

Fig. 33.

Limnæa bulla.

Fig. 34.

Limnæa ampla.

Fig. 35.

Limnæa auricularia.

Fig. 36.

Limnæa decollata.

Fig. 37.

Limnæa decollata.

Fig. 38.

Limnæa columella.

Fig. 39.

Limnæa macrostoma.

Fig. 40.

Limnæa columella, var. *chalybea.*

Fig. 41.

Limnæa stagnal.

Fig. 42.

Limnæa cor-cula.

Fig. 43.

Limnæa cista.

Fig. 44.

L. ovata. *L. ovata.* *L. macrostoma* *L. columella.* *L. chalybea.* *L. stagnal*

Fig. 45.

Lingual dentition of *L. columella.*

Fig. 46.

Limnæa megasoma.

Fig. 47.

Limnæa megasoma.

Fig. 48.

Limnæa reflexa.

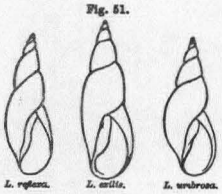
Fig. 49.

Limnæa umbrosa.

Fig. 50.

Limnæa axilis

Fig. 51.



L. reflexa. *L. axilis.* *L. umbrosa.*

Fig. 52.

L. palustris, var. distorta

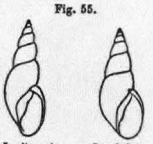
Fig. 53.

Limnæa attenuata.

Fig. 54.

Limnæa subulata.

Fig. 55.



L. attenuata. *L. subulata.*

Fig. 56.

Limnæa sumassi.

Fig. 57.

Limnæa sumassi.

Fig. 58.

Limnæa sumassi ?

Fig. 59.

Limnæa kaydeni.

Fig. 60.

Limnæa elodes.

Fig. 61.

Limnæa palustris.

Fig. 62.

Limnæa nuttalliana.

Fig. 63.

Limnæa expansa.

L. elodes.

Fig. 64.

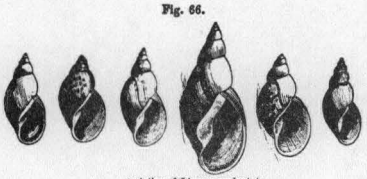
L. expansa.

L. nuttalliana.

Fig. 65.

Limnæa palustris.

Fig. 66.



Varieties of *Limnæa palustris.*

Fig. 67.

Limnæa proxima.

Fig. 68.

Limnæa desidiosa.

Fig. 69.

Limnæa obrussa.

Fig. 70.

Limnæa acuta.

Fig. 71.

Limnæa philadelphica.

Fig. 72.

Limnæa fusiformis.

Fig. 73.

L. desidiosa. *L. philadelphica.* *L. acuta.* *L. obrussa.* *L. fusiformis.*

Fig. 74.

Limnæa truncatula.

Fig. 75.

Limnæa emarginata.

Fig. 76.

Limnæa emarginata.

Fig. 77.

Limnæa emarginata.

Fig. 78.

Limnæa emarginata.

Fig. 79.

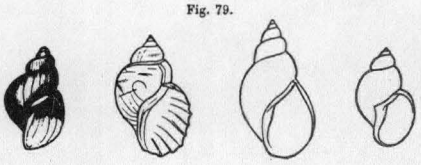


Fig. 80.

Limnæa catascopium.

Fig. 81.

Limnæa catascopium.

Fig. 82.

L. catascopium.

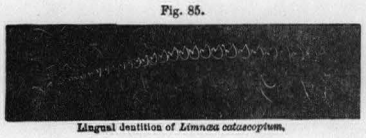
Fig. 83.

Limnæa pinguis.

Fig. 84.

Limnæa virginiana.

Fig. 85.



Lingual dentition of *Limnæa catascopium.*

Fig. 86.

Limnæa catascopium ?

Fig. 87.

Limnæa exporata.

Fig. 88.

Limnæa umbilicata.

Fig. 89.

Limnæa cahlii.

Fig. 90.

Limnæa pingelii.

Fig. 92.

Limnæa adelina.

Fig. 91.

Limnæa kobolti.