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CONTENTS

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 viventes 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.

PRECIO: 50¢ el número.

REVIEW OF THE LITERATURE OF ETHNO-CONCHOLOGY PERTINENT TO ARCHEOLOGY

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Interests in the field of ethno-conchology are broad, and, due to the borderline nature of this field, knowledge of the subject can be secured only after searching through a mass of widely scattered literature. This review is intended as a service to those seeking information in this borderline field. The bibliography is probably incomplete, but a careful enough search has been made to insure the presentation of a working list containing most of the important papers. At present no similar source for gaining orientation is available. The bibliography itself is arranged to supply references.

The paper was written and the bibliography compiled in 1952 while the author was a graduate student at the University of Michigan. He is indebted to Professor Volney H. Jones of the Anthropology Department, University of Michigan, for many helpful suggestions and for reading the manuscript. The author is especially grateful to Professor Henry van der Schalie of the Zoology Department, University of Michigan, who first suggested to him the need for such a paper, and who rendered every possible assistance in its preparation.

MOLLUSKS AS TIME INDICATORS

To the student interested in problems concerning the antiquity of man in the Western Hemisphere, shells and shell artifacts offer many interesting avenues of speculation. Their use as geologic time indicators may be profitable if delicate enough techniques are developed. Eiseley (1937), in a much needed critique, cautioned against making sweeping correlations based upon mollusk forms as indices. He pointed out the pitfalls encountered in describing climatic changes in terms of changes observed in the mollusk fauna — such as at the Lindenmier Site where the mollusks found would seem to indicate a warm period at the time the site was laid down. Eiseley revealed that the fauna might possibly be interpreted instead as indicating a dry period at the height of glaciation.

Careful ecologic studies of the mollusks are necessary before the archeologist can make cultural diagnoses on the basis of climatic change. Along with this analysis careful stratigraphic collections of the mollusks must be made from archeological sites. The importance of collecting even unworked or broken shell was stressed by Boekelman (1936: 30) "Time and again we have heard from field workers of excavations where unworked shells, and especially broken specimens were not even removed from the sites."

Morrison (1942), in his study of the mollusks of certain archeological sites in the Pickwick Basin, observed a change in the mollusk fauna of that area. Working with a list of forms known to inhabit the region at the present he could see certain changes that have taken place since the shell mounds were deposited. An interesting note of caution along this line of investigation came from Byers (1951). He found Venus mercenaria north of its reported range in an area where it was known only from shell mounds. The shell mounds had been thought of as being deposited in a warmer period because of the southerly range of Venus. With new indications of its present distribution to the north, however, this position becomes more difficult to maintain.

Johnson (1942) in his introduction to the study of the Boylston Street Fishweir made this difficulty in the use of distribution data apparent when he said, "Changes in climate during the history of the deposit were based primarily on the evidence of the mollusks. The evidence obtained by Dr. Shimer was and is conclusive as far as it goes. However, in view of the ability of mollusks to exist under many exceptional conditions, the evidence was not over satisfactory." In the later investigations of the fishweir carried out by specialists at Johnson's suggestion still more, perhaps more complete, studies were made of the mollusks, along with complementary studies of the remainder of the fauna. Thus, in this same volume, Clench (Johnson, 1942), in reviewing the mollusks, observed that, based upon the mollusks from shell layer two, the water way may have been warmer -- warmer than at present anyway — when the strata were deposited. However, though many Ostrea, Pecten, and Venus, which indicate warmer conditions, were recovered, only a single specimen of Triphoris was found. This same Triphoris was listed by Clench as the "only example of a distinctly southern element found at the site."

An extensive literature exists on shell mounds and interpretations accounting for these middens. Gifford (1949), Kroeber (1911), Nelson (1909, 1910), Schenck (1926), and Uhle (1907) have reported on shell mounds in the California area. Cook (1946), in refining techniques used by Nelson, speculated on the length of residence of groups contributing to the shell mounds, basing his calculations upon the nutritional requirements of a certain size of population. Rouse (1951) obtained some indication of the duration of certain midden heaps in the West Indies by comparing them with historic Puerto Rican heaps which have known accumulation rates. Lovén (1935) described shell middens in the West Indies; Haag (1942a) and Moore (1893) have covered those in the American Southeast, and Holmes (1907) discussed heaps found along the Middle Atlantic coast. Alfred (1937) reported on the literature dealing with Wisconsin shell mounds, and Byers (1940) and Hadlock (1941, 1943) have written on New England shell sites.

With the advancement of radiocarbon dating techniques shell material has assumed another role as time indicator. Although perhaps not so reliable as wood and charcoal, there is indication that if the shell's original carbonate atom composition has not been altered by carbon of a different age the shell sample may give a valid time record (Libby, 1952). Conch shells from Ohio Hopewell mounds (Libby, 1952: 78) have given a date of 2,285 ± 210 for that group, and clam shells from an Aleut midden (Kulp, 1951) indicate an age of 4,600 ± 80.

Another radioactive isotope, Oxygen 18, may prove useful in establishing a record of the temperatures of early geologic time. Using mollusks and other invertebrates, Urey (1948) found direct correlations between the temperature and Oxygen 18.

USE IN DELIMITING CULTURE PERIODS AND ESTABLISHING EVIDENCE OF CULTURE CONTACT

When man utilizes shell material as an artifact of his culture over a long period of time, changes in his culture may be reflected in the shell artifact. The archeologist can use these trends and the lack of them to help set off one culture period from another. Heizer and Fenenga (1939) found Haliotis and Olivella shell artifacts especially good as indicators of culture periods in central California. In describing Haliotis ornaments they stated: "These, together with shell beads, are our most consistent indicators in characterizing culture periods. Shapes are limited — circular, rectangular, ovoid, etc. Differences are found in such techniques as size, position, and number of perforations, decoration, size and species used." Beardsley (1949), commenting on technique refinement in demonstrating Californian culture sequences, remarked: "Another methodological advance was the recognition of a class of burial artifacts in pottery-less California which is able to serve the important function filled by ceramic analysis in other areas. Shell bead and ornament types supply such a class, combining frequent occurrence and comparability of form with relatively sensitive variation." Haury (1937) suggested that specialized treatment of shell — etching and types of carving — because of short duration on the scene are more useful as phase indicators than are some of the more generalized treatments which show little variation over several phases.

Shell tempering of pottery has been one of the traits used to set off the Mississippian culture phase from the earlier Woodland phase of Eastern archeology. Ford and Willey (1941) in outlining the Temple Mound I stage in the central Mississippi Valley remarked: "Middle Mississippi is a term first used by W. H. Holmes to characterize the typical shell-tempered pottery found in such great quantities accompanying burials in the central part of the Mississippi Valley." Again, in speaking of the Middle Mississippi period following the Late Baytown in eastern Arkansas and western Mississippi: "Clay-tempered polished vessels are gradually replaced by vessels of similar shapes tempered with finely ground shell." Haag (1942b) found shell-tempered pottery occurring in two groups of Pickwick pottery; one a Middle Mississippi phase and the other as components of the Moundville complex. He found that Moundville shell-tempered pottery always overlay clay-grit, limestone, sand, and fiber-tempered ware.

However, shell-tempering is not to be thought of as infallibly accompanying Mississippian traits. Griffin's (1946) discussion of the Irene Savannah Focus indicated that in the preceding more Woodland-like cultures some Mississippian traits appeared — among them style of house structure and ceremonial mound complex — believed before to be found only associated with shell-tempered pottery.

Gifford (1949) has shown the usefulness of shell types in cross-dating cultures. Certain Californian shell types were found in Southwest Anasazi sites with evidence that they were most abundant in Basketmaker III time. Using Basketmaker dates the California material can thus be given a definite minimum date and assurance of an earlier time of manufacture in California.

Culture contact between Florida and the West Indies, and possible derivation of West Indian Ciboney culture from Florida has been suggested by Rouse (1949, 1951). Among the traits substantiating it are certain shell artifact types — shell gouges and hafted conch shell picks — and a dependence upon shellfish for food with the accumulations of great midden heaps. Lovén (1935) also pointed out probable Floridian influence on West Indian culture by the occurrence of discoid shell gorget types and a general excelling in the art of carving in shell.

The finding in widely scattered parts of the world of quite similar uses of shell, such as close similarity of elaborate ritual surrounding it, or styles of decoration, has led some people to speculate about the transmission of such traits. This speculation led Jackson (1917) to believe that the high pre-conquest cultures of the Americas were derived from Egypt and India. In spite of the many close resemblances most anthropologists today hold the view that early American cultures developed independently, without direct cultural influence.

However, shellfish undoubtedly helped stimulate trade and commerce at an early time in man's history. Johnson (1850) in describing the Tyrian purple industry of the Mediterranean area said, "This discovery is presumed to have been made 1400, or, at the most, 1500 years before the Christian era; and it was perhaps the principal commodity of Tyre when its 'merchants were princes and its traffickers the honorable of the earth'."

The tracing of early trade routes may often provide the archeologist with concrete information concerning contacts between cultures. Trade items of sufficiently stable composition to resist complete disintegration will, upon recovery from their final resting place, shed light on the movements of those early peoples and the diffusion of their artifacts. Marine shells are especially useful as such trade items even though in many instances disintegration has proceeded so far as to make accurate species identification impossible. It is, however, this correct identification which is so important in enabling the investigator to determine the locality from which the shell started its journey. Henderson (1930) made this point clear in connection with Haliotis fulgens and Haliotis rufescens from sites in the state of Washington. He reasoned that if the material were correctly identified it would indicate a longer trade route than expected or perhaps an earlier extended range for the species. Leechman (1942) also pointed out the possible confusion arising from misidentification of species which superficially resemble each other, such as the several species of abalones.

A knowledge of the techniques available to the archeologist in tracing old trade routes, and the limitations he may encounter, as presented by Colton (1941), aids greatly in defining the archeologist's objectives. One of these limitations, the identification of mollusk specimens, has already been mentioned. A mollusk, which under the best of conditions is difficult to identify, becomes, in the fragmentary or disintegrated state presented to the archeologist, unidentifiable except to a specialist who has long acquaintance with that species and its relatives. So in going over his material the archeologist soon finds that he must call upon the specialized knowledge of the malacologist.

After the shell is identified and has a known starting place, it next becomes of interest to know by what means it reached its final resting place. Martin, Quimby, and Collier (1947), in a chapter on trade and commerce, outlined methods of shell transport, and suggested possible dispersal routes in various sections of the country. Tower (1945) brought together many of the sources on trade routes in the Southwest, and looked at suggested trade routes in the light of additional shell material.

In this short paper I have been trying to integrate some of the rather diversified papers dealing with a special area of ethno-conchology, mollusks and their bearing on archeology. It is apparent that I have made no mention of the vast literature of ethno-conchology dealing with more general aspects of ethnology, e. g. the role of mollusks in the technology and philosophies of man. I have, therefore, imposed an artificial boundary; for those first and most important uses of mollusks as food, utensils, and ornaments must be studied and their role in the society determined if the archeologist is to come up with an accurate tracing of the culture. Thus, the archeologist can tell us that he finds no shell trumpets in sites along the Mississippi River, but to understand why there are none may require examination of ethnographies to see if some hint may be found in the customs, beliefs, or technology of the people.

In this artificial segment, then, that I have chosen for consideration, the following points seem to stand out as integrating factors:

1) Mollusks, if properly utilized, can provide us with an added tool in pinning down the facts of early man and his culture.

2) The use of mollusks calls for cooperation among specialists. As Colton (1941) remarked: "The study of ancient Indian commerce is the most highly technical branch of archeology and requires the services of technically trained investigators in many fields of science. Archeologists themselves can only formulate the problem because all the material has to be accurately identified so that the source can be determined." Other papers reviewed indicate that cooperation comes from such specialists as paleontologists, who determine the strata and ecological associates of fossil mollusks, physicists who develop methods for dating material, and oceanographers who can describe the myriads of sea organisms found with mollusks.

3) Along with all the specialized work goes the need for overall integration of the material into a unified picture of the progress being made in the unraveling of man's past.

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DISTRIBUTION RECORDS OF LAND SNAILS IN THE SOUTHEASTERN UNITED STATES

LESLIE HUBRICHT

During the Summer of 1959 the author lived for six months in Jacksonville, Florida and Savannah, Georgia. During this period over 1200 lots of land snails were collected. The region about Savannah was almost unknown conchologically and many species of land snails were found which were not known for that area. The present paper is a report on the more interesting species that were found there, to which have been added a few older records from the southeastern United States.

Mesodon christyi (Bland), GEORGIA: Richmond Co.: low woods, 1 mile southwest of Gracewood; swamp, near McBean Creek, 5 miles west of McBean. Not previously reported from south of Gaffney, Cherokee Co., South Carolina.

Mesodon wheatleyi (Bland). Reported from Coosa River near mouth of Yellow Leaf Creek, Chilton Co., Alabama (H. H. Smith, 8348 Clapp Collection). Upon examination, this specimen was found to be a small example of Mesodon thyroidus form bucculentus (Gould).

Triodopsis juxtidens (Pilsbry). GEORGIA: Burke Co.: Shell Bluff Landing. This is the shell described by H. A. Pilsbry (Land Mollusca of North America, 1, pt. 2: 807) from this locality under Triodopsis fraudulenta vulgata Pilsbry.

Mesodon perigraptus (Pilsbry). SOUTH CAROLINA: Beaufort Co.: oak woods, 12 miles west of Port Royal. GEORGIA: Effingham Co.: near Savannah River, near Ebenezer Church, Chatham Co.: swamp, 1.7 miles east of Silk Hope.

Triodopsis caroliniensis (Lea). GEORGIA: Richmond Co.: Near New Savannah Bluff Lock and Dam. Burke Co.: Shell Bluff Landing.

Guppya sterkii (Dall). GEORGIA: Chatham Co.: swamp, 1.7 miles east of Silk Hope. Not previously reported from Georgia.

Retinella dalliana (Pilsbry and Simpson). GEORGIA: Chatham Co.: near river, Randolph and Bay Sts., Savannah; Isle of Hope: roadside, Beaulieu Ave., Beaulieu; edge of woods, Semken Ave., 1 mile southwest of Thunderbolt. Not previously reported from north of Florida.

Ventridens demissus (Binney). GEORGIA: McIntosh Co.: low wet woods, 5.4 miles south of Eulonia. Glynn Co.: Boys Estate. Like examples from west Florida, these are without teeth or callus at any stage of growth.

Discus patulus (Deshayes). GEORGIA: Chatham Co.: low woods, 1.3 miles southeast of Pooler; oak-magnolia woods, 2.4 miles southwest of Silk Hope.

Strobilops texasiana floridana Pilsbry. NORTH CAROLINA: Washington Co.: Pettigrew State Park, 1.4 miles west of entrance. Tyrrell Co.: Pettigrew State Park, near entrance. Carteret Co.: waste ground, Broad and Gordon Sts., Beaufort. GEORGIA: Richmond Co.: near McBean Creek, 5 miles west of McBean; upland mixed woods, 3 miles northeast of Hephzabah. Tattnall Co.: near Ohoopee River, 5 miles northwest of Reidsville. Chatham Co.: roadside, just north of Halcyon Bluff; roadside, Beaulieu Ave., Beaulieu; oak-magnolia woods, 2.4 miles southwest of Silk Hope. McIntosh Co.: near Sapelo Plantation Landing, 1.3 miles northeast of Meridian. Glynn Co.: Boys Estate. Twiggs Co.: upland oak woods, 4 miles east of Westlake. Bleckley Co.: low mixed woods, 4.2 miles southeast of Cochran. Lowndes Co.: oak woods, 3 miles northwest of Valdosta. Grady Co.: mixed woods, 3.5 miles east of Whigham. Decatur Co.: low mixed woods, 7.5 miles southwest of Faceville. ALABAMA: Covington Co.: near Lightwoodknot Creek, 3.7 miles west of Opp; near Five Runs Creek, 6.5 miles south of Andalusia. There are no previous records between Virginia and Florida.

Gastrocopta tappaniana (C. B. Adams). NORTH CAROLINA: Currituck Co.: salt marsh, Point Harbor. Chowan Co.: swamp, 1.4 miles southeast of Edenton. Beaufort Co.: swamp, 4.5 miles southeast of Chocowinity; swamp, 1.4 miles northeast of Chocowinity; swamp, 4.2 miles east of Washington; near Pamlico River, opposite Washington. Craven Co.: near Batchelder Creek, 2.4 miles east of Tuscarora. Duplin Co.: low wet woods, 4.8 miles east of Kenanville. Onslow Co.: roadside, 5.3 miles northeast of Kellum. SOUTH CAROLINA: Horry Co.: swamp, 0.5 mile southeast of Gorley. Berkeley Co.: near Tail Race Canal, 2.5 miles north of Eherhardt. Orangeburg Co.: swamp, 3 miles south of wells. Beaufort Co.: swamp, 2.5 miles west of Pritchardville. Jasper Co.: low oak woods, 10 miles south of Hardeeville. GEORGIA: Screven Co.: near Savannah River, 17 miles northeast of Sylvania; near Brier Creek, 10 miles north-northeast of Sylvania. Effingham Co.: near Ogeechee River, 2 miles northwest of Eden. McIntosh Co.: swamp, 2.9 miles south of Darien. FLORIDA: St. Johns Co.: near Six Mile Creek, 6 miles southeast of Orangedale. Volusia Co.: swamp, Oak Hill; near St. Johns River, 5 miles west of Deland. Union Co.: Worthington Springs. Alachua Co.: near Orange Lake, 0.4 mile south of Island Grove. Not previously recorded from the coastal plain south of Virginia.

Vertigo oscariana Sterki. SOUTH CAROLINA: Colleton Co.: oak-magnolia woods, 6 miles southeast of Green Pond; near Ashepoo River, west of Ashepoo. Beaufort Co.: low mixed woods, 2.5 miles northwest of Sheldon. Hampton Co.: swamp, 0.8 mile southeast of Hampton. GEORGIA: Richmond Co.: near McBean Creek, 5 miles west of McBean.

Pupisoma dioscoricola (C. B. Adams). SOUTH CAROLINA: Charleston Co.: Folly Beach. Bamberg Co.: swamp, near Little Salkehatchie River, 4.2 miles north of Eherhardt. Colleton Co.: oak-magnolia woods, 6 miles southeast of Green Pond; swamp, 1 mile east of Ashepoo; near Ashepoo River, west of Ashepoo. Beaufort Co.: swamp, 2.5 miles west of Pritchardville. Jasper Co.: near Tullifinney Creek, 1 mile east of Coosawhatchie; low oak woods, 10 miles south of Hardeeville. GEORGIA: Effingham Co.: near Ogeechee River, 2 miles northwest of Eden. Chatham Co.: low woods, 1.3 miles southeast of Pooler; low woods, White Bluff. Toombs Co.: swamp, 6.5 miles south of Parkers. Tattnall Co.: near Ohoopee River, 5 miles west of Collins. Lee Co.: oak woods, 5.5 miles southeast of Sassar. Twiggs Co.: near creek, 4 miles east of Westlake. Telfair Co.: near Ocmulgee River, southeast of Lumber City. Glynn Co.: Sea Island; 5 miles north of Oakland, St. Simons Island; small island, 2 miles west of Jekyll Island. ALABAMA: Barbour Co.: near river, Eufala. Not previously recorded from north of Florida.

Pupisoma minus Pilsbry. SOUTH CAROLINA: Beaufort Co.: swamp, 2.5 miles west of Pritchardville; low mixed woods, 2.5 miles northwest of Sheldon; near Tullifinney Creek, 1 mile east of Coosawhatchie. Bamberg Co.: swamp, Salkehatchie River, 4.2 miles north of Eherhardt. Jasper Co.: mixed woods, 3 miles southwest of Levy. GEORGIA: Toombs Co.: swamp, 6.5 miles south of Parkers. Glynn Co.: small island, 2 miles west of Jekyll Island. Not previously reported from north of Florida.

Pupisoma macneilli (Clapp). SOUTH CAROLINA: Charleston Co.: near South Santee River, 7.5 miles north-northeast of McClellanville, Jasper Co.: low oak woods, 3 miles southwest of Levy. GEORGIA: Chatham Co.: low woods, 2 miles south of Port Wentworth; low woods, 2.5 miles north of Monteith. Previously recorded only from southwestern Alabama.

Carychium exiguum (Say). SOUTH CAROLINA: Georgetown Co.: swamp, 0.8 mile west of Pawleys Island. GEORGIA: Chatham Co.: swamp, near Middle River, Onslow Island.

Carychium floridanum Clapp. SOUTH CAROLINA: Calhoun Co.: roadside, 2.5 miles northeast of St. Mathews. Charleston Co.: near South Santee River, 7.5 miles north-northeast of McClellanville, Berkeley Co.: near Tail Race Canal, 2.5 miles northeast of Moncks Corner. Colleton Co.: near Ashepoo River, 0.7 mile west of Ashepoo. Beaufort Co.: swamp, 2.5 miles west of Pritchardville. Jasper Co.: swamp, 7.4 miles south of Hardeeville. GEORGIA: edge of woods, Semken Ave., 1 mile southwest of Thunderbolt; wet woods, 5 miles southwest of Savannah; oak-magnolia woods, 2.4 miles southwest of Silk Hope; low woods, 1.3 miles southeast of Pooler; low woods, 1 mile west of Garden City. Burke Co.: swamp, 1 mile south of Munnerlyn. Screven Co.: near Savannah River, 17 miles northeast of Sylvania. McIntosh Co.: low wet woods, 5.4 miles south of Eulonia. Glynn Co.: low woods, 1 mile northwest of Oakland, St. Simons Island. Decatur Co.: low mixed woods, 7.5 miles southwest of Faceville. Not previously known from north of Florida.

RECENT PUBLICATIONS

From time to time, as space permits, STERKIANA will call the attention of its readers to publications on non-marine Mollusca which may otherwise escape attention. These listings are not reviews in any sense although short notes outlining the scope of the work are appended to some of the titles. The editor will be glad to hear of papers on non-marine Mollusca appearing in serials other than those ordinarily received by workers in this field and which could be of interest to them.

BASCH, Paul F. (1959) Status of the Genus Gundlachia (Pulmonata, Ancylidae). Occ. Pap. Mus. Zool. Univ. Michigan, No. 602, 9 pp., 2 figs.

van BENTHEM JUTTING, W. S. S. and van REGTEREN ALTENA, C. O. (1958) A List of Printed Malacological Periodicals. Basteria, vol. 22, No. 1, pp. 10-15. (An up-to-date list useful for systematic search of literature).

CLARK, Arthur H., Jr. and BERG, Clifford O. (1959) The Freshwater Mussels of Central New York. Cornell Univ., Agric. Experiment Sta., N. Y. State Coll. Agric., Ithaca, N.Y., Mem. 367, 79 pp., 7 pls., 1 fig.(map). (Useful bibliography and key).

CLENCH, William J. (1959) Land and Freshwater Mollusks of Great and Little Inagua, Bahama Islands. Bull. Mus. Comp. Zool., Harvard Coll., vol. 121, No. 2, pp. 29-53, 1 pl., 1 map. (A useful summary).

GETZ, Lowell L. (1959) Notes on the Ecology of Slugs: Arion circumscriptus, Deroceras reticulatum, and D. laeve. Am. Midl. Nat., vol. 61, No. 2, pp. 485-498, 4 figs. (Much needed notes on 3 important species of slugs).

HARRY, Harold W., CUMBIE, Billy G., and MARTINEZ de JESÚS, José (1957) Studies on the Quality of Fresh Waters of Puerto Rico relative to the occurrence of Australorbis glabratus (Say). Am. Jour. Tropical Medicine and Hygiene, vol. 6, pp. 313-322. (Latest of 3 papers on this important species).

HUBRICHT, Leslie (1958) New Species of Land Snails from Eastern United States. Trans. Kentucky Acad. Sci., vol. 19, pp. 70-76. (Descriptions of Stenotrema angellum, Mesodon burringtoni, Triodopsis burchi, T. picea, T. palustris, Mesomphix ruidus, and Helicodiscus triodus).

JOHNSON, Richard L. (1959) The Types of Corbiculidae and Sphaeriidae (Mollusca; Pelecypoda) in the Museum of Comparative Zoology, and a Bio-Bibliographic Sketch of Temple Prime, an early Specialist of the Group. Bull. Mus. Comp. Zool., Harvard Coll., vol. 120, No. 4, pp. 4?1-479, 8 pls.

KARLIN, Edward J. and NAEGELE, John A. (1958) Slugs and Snails in New York Greenhouses. Cornell Extension Bull. 1004, N. Y. State Coll. Agric., 16 pp., 18 figs.

LEONARD, A. Byron (1957) Types of Late Cenozoic Gastropods in the Frank Collins Baker Collection, Illinois State Geological Survey. Ill. State Geol. Survey, Rept. of Investig. 201, 23 pp., 4 pls.

McCRAW, Bruce M. (1957) Studies on the Anatomy of Lymnaea humilis Say. Can. Jour. Zool., vol. 35, pp. 751-768, 15 figs.

McCRAW, Bruce M. (1959) The Ecology of the Snail, Lymnaea humilis Say. Tr. Am. Microsc. Soc., vol. 78, pp. 101-121, 3 figs.

TAYLOR, Dwight W. (1958) Geologic Range and Relationships of the Freshwater Snail Anisus pattersoni. Jour. Paleont., vol. 32, pp. 1149-1153.

van der SCHALIE, Henry and DUNDEE, Dee S. (1959) Transect Distribution of Eggs of Pomatiopsis lapidaria Say, an Amphibious Prosobranch Snail. Trans. Am. Microsc. Soc., vol. 78, pp. 409-420, 5 figs.

WAGNER, Frances J. E. (1958) Unusual Pleistocene Fossils from Southeastern Ontario. Trans. Roy. Soc. Canada, 3d ser., sec. IV, vol. 51, pp. 5-11, 4 figs. (Records a pearl from fossil Mytilus edulis and fossil glochidium of Anodontoides ferussacianus from the Cornwall area, Ontario, Canada).

SOME SNAILS AND SLUGS OF QUARANTINE SIGNIFICANCE TO THE UNITED STATES[1]

JOHN B. BURCH[2]

PREFACE

This publication is presented as an aid to Plant Quarantine officials whose work at the various inspection stations often calls for knowledge and identification of snails, which, if introduced into the United States, may become agricultural pests. Some are implicated as disease carriers. Because of our increasing knowledge of the role they play in the transmission of communicable diseases, the economic losses to gardens and orchards caused by foreign land snails, and the widely publicized depredations of the giant African snails in the Pacific, the importance of preventing entry of such undesirable alien pests is now becoming fully appreciated.

Included in this publication are species native to foreign countries, snails that have become pests in the past, species commonly encountered at inspection stations, and the more important human parasite vectors. To aid the worker who has had no training in the field of mollusks, the economic significance, control, habits, ecology of snails and slugs, and information on the groups as a whole are presented. Following the section on species descriptions is an identification key for the determination of the snails covered in this publication. A glossary, selected references, and index are also included.

Grateful acknowledgment is made to Harald A. Rehder, U. S. National Museum, and Henry van der Schalie, Museum of Zoology, University of Michigan, for advice and use of their facilities; and to William L. Brudon, Museum of Zoology, University of Michigan, and Arthur Cushman, U. S. Department of Agriculture, for their skillful work in producing the plates. A note of special gratitude goes to J. P. E. Morrison, U. S. National Museum, whose constant advice, helpful criticism, and unfailing support have contributed so greatly to the successful completion of this publication.

1/ ARS 82-1, February 1960, reprinted with permission of Agricultural Research Service, U. S. Department of Agriculture.

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CONTENTS

ECONOMIC IMPORTANCE

The economic importance of snails and slugs to man may be considered from two different aspects - that of a "positive" or beneficial nature and that of a "negative" or harmful nature. Only the negative aspects will be dealt with in this publication. From this point of view the economic importance of snails and slugs comes under three general categories: (1) Destruction of crops and gardens; (2) medical importance, both to man and his domestic animals; and (3) indirect effects resulting from immigrant mollusks affecting the balance of natural communities of plants and animals.

Destruction of Crops and Gardens

The land snails and slugs are of most concern as agricultural pests, while the fresh-water snails are of greater importance from the medical standpoint. Approximately 725 species of land snails and about 40 species of slugs are now recognized in the United States (exclusive of Alaska and Hawaii). Of these species 55 (44 snails and 11 slugs) are not native to the country, but they have been introduced either accidentally or purposely.

The native species are solitary in habit and do very little damage. The introduced snails and slugs are the most undesirable, because they are gregarious or colonial and may cause great damage by building up enormous populations over limited areas. They are of considerable economic importance through their depredations in greenhouses, gardens, and orchards. In many places they have caused as serious a damage to vegetables, ornamentals, and other plants as certain insect pests. Snails and slugs through their presence on walks, around foundations, and in cellars are also annoying to householders. Eradication of these pests is difficult and often costly.

Among the more serious foreign garden pests already established in this country are the slug Limax maximus, L. flavus, and Deroceras reticulatum. Commercial interchange of plants, cuttings, and floricultural materials facilitates their dispersal. The snails Helix aperta and Otala lactea have become established in California and considerable expense, time, and energy have been devoted to combating them. Theba pisana, an especial nuisance to citrus crops and at one time also well established in that State, apparently has been completely eradicated now.

One of the most serious threats to this country in recent years has come from the giant African snail, Achatina fulica. This voracious eater with an enormous reproductive capacity began its immigration from East Africa via human agencies about the turn of the 19th century. In the intervening years this snail has spread to India, Ceylon, the mainland of China, and the East Indies. Its dispersal in the Pacific Islands, nearly denuding some of them, was greatly facilitated during World War II by the rapid conquest of this area by the Japanese. They introduced the snail as a supplemental food source to many new places including New Guinea, New Britain, and New Ireland. The snail was introduced into Hawaii in 1936 and has subsequently cost the taxpayers some $200,000 for control measures, not counting for the damage to plants in that area. In 1948 it was brought to California on returned war equipment, but an intensive campaign prevented its introduction. Nevertheless, constant vigil must be maintained to insure that it is not introduced again to become established.

Medical Importance to Man and His Domestic Animals

Snails, as required intermediate hosts in the life cycle of parasitic trematode worms infecting man and his domestic animals, occupy a position of utmost importance in man's war against disease. Their role as necessary living quarters for the developing larval parasitic worms indirectly implicates them as being responsible for some of the most serious and economically important human communicable infections.

Although nearly every kind of mollusk is inhabited by some form of worm parasite, only relatively few snails are of medical importance. Of these, almost all live in fresh water. The worm parasites of importance to man and which require larval development in a snail are commonly referred to as blood flukes, lung flukes, or liver flukes, depending on the part of the body they infect.

Bilharziasis,[2] the human blood fluke disease, is rapidly replacing malaria as the major communicable malady of man. Progress in the control of this disease has not kept pace with that of other infections and, consequently, incidence of this disease is on the rise. Conservative estimates of the number of people infected now exceed 200 million. None of the species of snails that carry the larval blood flukes, such as Pomatiopsis (Oncomelania) hupensis, P. (O.) quadrasi, and P. (O.) nosophora in the Orient, Planorbina glabrata in the West Indies and tropical South America, and Biomphalaria alexandrina, Bulinus truncatus, and B. africanus in Africa, are endemic to the United States; but our widespread native species, Pomatiopsis lapidaria, has been experimentally infected with one strain of the human schistosome. Many millions of dollars have been spent by the United States and other countries in studying this disease and its snail carriers. Extensive research is being carried out on the local P. lapidaria. It is extremely important that the vector snails are not accidentally introduced into this country.

Clonorchiasis, caused by the liver fluke Clonorchis sinensis, is a human disease especially prevalent in the Orient because of the practice of eating uncooked, or partly cooked, fish. The snail mainly responsible is the operculate Parafossarulus manchouricus. Similar liver flukes, Fasciola hepatica and F. gigantica, are serious parasites of sheep and cattle. These parasites are carried by such snails as Fossaria truncatula in Europe and parts of Africa, F. ollula in Hawaii, and similar lymnaeids in other parts of the world.

Paragonimiasis, or the lung fluke disease, is less damaging to the body than bilharziasis and clonorchiasis, but nevertheless may be fatal. The adult worms measure about one-half inch in length and live on the inner walls of the lungs, where they produce tuberculosis-like lesions. It has been estimated that there are about three million cases of paragonimiasis in Asia and West Africa. The main vector snails of Paragonimus are Semisulcospira libertina and Tarebia granifera. The latter species has been accidentally introduced into Florida and has subsequently become established in the State.

It may seem that introduced snails and slugs would be of little concern to man if they could be kept out of gardens, orchards, and greenhouses, and are not capable of carrying disease organisms. However, this is often not the case, although the undesirable effect of snails in uncultivated areas may not become apparent immediately or even for considerable time.

Effects on Natural Communities of Plants and Animals

Natural communities, if not disturbed too greatly by outside influences, become stabilized structural entities, consisting of all the plants and animals which normally constitute the community coexisting in a more or less mutually satisfactory association. These animals and plants stand in a special relation to one another, the community organization depending chiefly on the manner in which they are interrelated, both among themselves and with their physical and chemical environment. Plants not only provide shelter and protection for other plants and animals, but supply food for the vegetarians or herbivores, which in turn tend to keep the plants from becoming too abundant. The number of plant feeders in the community is to a large extent controlled by carnivores and parasites.

The introduction of an animal, such as a strange snail, whose habits, fecundity, dearth of parasites or predators, are completely foreign to the community, may have rather profound and adverse effects on the organization of the communities and nearly every organism in it. The

2/ Often referred to as schistomiasis after the generic name of the human blood flukes, Schistosoma.

immigrant snails, in building up a large population, may not only out-compete the native well-regulated snails and other herbivores for food, but also by destroying vegetation deprive many organisms of essential shelter. Reduction in abundance or disappearance of the native herbivores results in the reduction or extinction of many carnivorous species, which may then affect other members of the community, either by relieving a check in their increase or depriving them of a livelihood. This can cause many beneficial animals and plants to permanently disappear from the area. Therefore, the indirect economic import of introduced species may actually be far greater than the direct and more obvious economic importance.

HABITS OF SNAILS AND SLUGS

Land Snails and Slugs

Native land snails and slugs may be found almost everywhere, but in general prefer habitats offering shelter, adequate moisture, and abundant food supply, and for snails, generally an available source of lime. Forested river valleys most generally supply such habitats, and those with outcrops of limestone usually show the most abundant and varied mollusk faunas. Introduced species often tend to be somewhat more urban. For example, in their native Europe the slugs *Limax marginatus* and *Milax gagates* live in woodlands and on damp rocks on open hillsides and are not slugs of cultivated areas. But in the United States they are mostly found around dwellings and in greenhouses and gardens.

Land snails and slugs are mainly nocturnal, but following a rain may come out of their hiding places during the day. Temperature and moisture are the main factors to account for their nocturnal habits, and not the presence of darkness *per se*. During the day they may be found resting under old boards and logs, under bricks and stones, in rock piles and cellars, among hedge rows, and beneath damp refuse and litter. Snails are most adaptable to unfavorable environmental conditions, such as drought, because they can cover the aperture of their shells with a mucous sheet, the epiphragm, which hardens and thereby prevents desiccation. Some snails have been known to remain in this dormant state for years, only to come out and resume activity when they are moistened.

Most land snails and slugs pass the winter in sheltered places under stones, logs, and boards, or buried in the ground. Some snails, *Theba pisana*, for example, are not so secretive, aestivating in the open on such objects as tree trunks and fence posts during periods of unfavorable humidity and temperature.

Fresh-water Snails

The habits of fresh-water snails are very variable, and each species is often associated with a distinctive kind of environment. Some prefer temporary woodland pools, mudflats, stagnant ponds, large lakes, or swiftly flowing streams. Some are amphibious rather than strictly aquatic, being found along banks of streams or canals usually a few inches above the water. *Pomatiopsis (Oncomelania) hupensis* of China and our native *P. lapidaria* are such species. *Fossaria ollula* is almost amphibious but more or less confined to shallow marshes. This is also true of *F. truncatula*, although it is also found in other types of semi-amphibious habitats. *Pomatiopsis (Oncomelania) nosophora* of Japan lives in small ditches or creeks fed by cool, clear water. Some snails, e. g., *Parafossarulus manchouricus*, prefer the muddy bottom of lakes, canals, and rivers. *Pomatiopsis (Oncomelania) quadrasi*, *Melanoides tuberculata*, *Tarebia granifera*, *Biomphalaria alexandrina*, and *Bulinus truncatus* are most often found in rather permanent, slow-running waters. *Bulinus africanus* most commonly occurs in quiet shallow pools, particularly those having abundant vegetation.

BIOLOGY OF INTRODUCED SPECIES

Any snail or slug of no economic importance in its native habitat may become a serious pest if moved to a new area. One may wonder why such animals, when introduced into strange countries, are able not only to become established, but often to multiply at astonishing rates. The answer, of course, lies in the "balance of nature" or the balanced community concept.

The organization of most communities is extremely complex because of the numerous interrelations of the associated species and individuals. The plants and animals that are associated to form a community have their lives so linked and interwoven that far-reaching changes in the whole community may be produced by a change in the relationship between any two species. Nevertheless, most natural communities maintain a striking degree of stability. The ability of communities to maintain themselves with only minor fluctuations in their composition is due to numerous regulatory mechanisms.

These regulatory mechanisms are of two general types, those that reduce the number of individuals of the various species and those that assist the species in maintaining themselves. Under the latter category is the ability of organisms to reproduce at a rate far in excess of the number that will actually survive to reproduce again. This high reproductive potential is necessary for species to insure continued existence in face of hazardous environmental conditions. In doing this they also provide a large margin which supports and insures continued existence of their predators and parasites. On the other hand, these predators and parasites, along with other environmental pressures, tend to check the density of populations, thereby preserving the balanced community organization. Thus, in stable communities there is a carefully adjusted balance between the reproductive potential of the constituents and the environmental resistance which they must face. Interference that tips the balance in either direction may produce serious consequences.

When a snail or slug species is introduced into a new area, it often leaves its predators and parasites behind. Therefore, these important checks are no longer present to curtail population growth. If other environmental factors are favorable, the species may then realize its full potential of increase, and if this potential is high, only a short period of unchecked reproduction will cause the population to irrupt. The invaders then proceed to consume certain plants in great quantity, destroying food and shelter of other organisms. Reduction in the abundance of these native species results, followed in turn by their predators and parasites. The whole organization of a community may in this way be completely disrupted by such an immigration. When the introduced species has exhausted its food supply, it may emigrate in many directions to other communities, thus leaving in its wake a path of devastation.

CONTROL

When undesirable snails and slugs become established in a new area, it is usually desirable to get rid of them. Sometimes this is almost impossible or the cost is prohibitive if they have become too well established. Nevertheless, even in such cases it is often feasible to diminish their importance by curtailing their increase and spread, or by protecting valuable vegetation. In the past, certain methods of control have been found that are both satisfactory and practical. These methods vary with the types and habits of the various mollusks, but generally come under four classes, i. e., chemical control, physical control, cultural control, and biological control.

Land Snails and Slugs

Chemical Control. Chemical control of land snails and slugs involves poison or repellent sprays and paints, irritating powders, and poison baits. Since snails must have lime to consolidate their shells and actively search for it if it is not readily available to them, use has been made of this by painting or spraying objects with a 1 percent solution of calcium arsenate mixed with lime water. This serves both as a lure and a poison. Other arsenicals used as sprays have often been ineffective because snails and slugs avoid them. Copper based sprays do not give satisfactory results without also injuring plants. Sprays of Bordeaux mixture, kerosene emulsion, Octaklor, pyrethrum, DDT-kerosene emulsion, soap solutions, salt solutions, and lime sulfur are good repellents but are usually not fatal to mature snails and slugs. They are, however, toxic to young snails. Most chemicals listed above are poisonous to humans and livestock. (Note precautions below).

The discovery of metaldehyde as a slug killer in 1934 has provided the most important chemical weapon against land snails and slugs known today, but it still is not always 100 percent effective. It may be used as a bait (a 3 to 6 percent mixture with wheat bran, cornmeal, or similar material is most common); as a dust (15-percent metaldehyde by weight); or as a liquid spray (20-percent metaldehyde by volume). Metaldehyde is often used in combination with calcium arsenate or sodium fluorosilicate to increase its effectiveness.

> Precautions: Metaldehyde, calcium arsenate, and chlordane are poisons, but with care they may be handled safely. Wash your hands and all utensils and tools promptly and thoroughly after applying baits. Store baits in closed containers in a place where they cannot be mistaken for food and where children, pets, or farm animals cannot reach them. See that the containers are properly labeled.
> Do not apply metaldehyde dusts or sprays to vegetable crops.

Protective barrier rings of coal tar, soot, ash, lime, salt, and other substances are often used (sometimes carbolated, phenylated, or kerosenated) to keep snails and slugs from valuable plants. Since some of these are also capable of killing vegetation or injuring the soil they should be used with caution. Lime, salt, soot, ash, and similar substances act as dehydrators, causing slugs and snails to secrete lime so copiously that they dry out and die.

Physical Control. Physical control involves active search for the pests and hand-picking or crushing them as they are found. Such measures are often impractical but in many places have proven to be the only satisfactory method of keeping down giant African snail (*Achatina fulica*) populations.

Cultural Control. Cultural methods are often of very definite value. This involves destroying habitats or hiding places of the snails or slugs by clearing underbrush, elimination of refuse piles, loose boards, and stones. Burning heavily infested areas has been successfully employed in California.

Biological Control. The biological method for pest control is based on the knowledge that in nature there exists a balance between mollusks and their enemies. This balance is shifted in favor of the introduced species when they become pests, but can be shifted in the opposite direction by importing their foreign predators or by conservation and augmentation of native established predators. In introducing predators extreme caution must be observed, however, because of the possibility that they may become more serious pests than their prey. Any introduction of foreign species can be made only after careful study.

Many mammals, birds, reptiles, amphibians, and insects have been recorded as occasional predators of snails and slugs. In this country, however, none offer an effective and practical means of control, except for small areas in which poultry, e. g., ducks and chickens, can be employed. Carnivorous snails attack and often effectively reduce populations of land mollusks. Members of the genus Haplotrema are common carnivorous snails in this country. The European carnivorous snail introduced into this country is Testacella.

Because of the alarm it has caused in recent years, Achatina fulica is perhaps the best known of all land mollusks in regard to its natural predators and biological control. Its most effective enemies are certain carnivorous snails, Edentulina affinis and Streptaxis kibweziensis. It is also fed upon by the monitor lizard, land crabs, a mongoose-like animal (Bdeogale tenuis), carabid and drilid beetles, and firefly larvae.

Fresh-water Snails

Methods of control that have been tried with fresh-water snails include drainage, drying, and filling of their habitats, clearing of vegetation, flushing, and encouraging predators. These have often been successful in limited areas for short periods of time, but such measures in larger lakes and streams are either not practical or are prohibitive in cost. Ducks, small mammals, amphibians, fish, and some insect larvae feed on fresh-water snails, but it is doubtful if they have much effect on population densities, and when other methods of control are used many of these predators are eliminated. The effects of bacteria, fungi, and viruses on snails have received very little attention so far.

The most widely used control methods practiced against fresh-water snails involve chemicals, and a great amount of money and research has gone into this method of control. Of the various chemicals known to kill fresh-water mollusks, copper sulfate is most commonly used because it is inexpensive and very toxic to snails in quantities too low to seriously affect most other fresh-water organisms except green algae. Perhaps the best examples of its effectiveness can be seen in North Central United States where "swimmer's itch" snails have been almost completely eliminated even from some of the larger lakes. Other molluscicides are sodium pentachlorophenate, copper pentachlorophenate, and dinitro-ortho-cyclohexylphenol.

GENERAL INTRODUCTION TO THE MOLLUSCA

The Phylum Mollusca, which includes the snails, is a large group of animals of extremely divergent form, second only to the arthropods in number of described species. Most mollusks have a hard external shell (although there are well-known exceptions such as the slugs and squid), a muscular saclike covering (the mantle) which secretes the shell, soft bodies with no segmentation (except for two deep-sea species) or internal skeleton, numerous mucous or slime glands, and a large "foot" that is variously modified for crawling, digging, or grasping prey. The shell, often of prime importance in species determination, is mainly composed of calcium carbonate (lime) and functions to protect the animal from injury, predators, desiccation, and other unfavorable conditions of the environment. The great diversity in structure, ornamentation, and color of mollusk shells has long made them a favorite of collectors.

Because of their great diversity and large numbers (nearly 100,000 species), mollusks are found in nearly all regions and habitats on earth. They are found in deep-sea dredgings, in sandy, shallow lagoons, on coral reefs, in arctic waters, hot springs, in both tidal and freshwater mudflats, in swift mountain streams, deep lakes, temporary woods pools, in the ground, on tops of high snow-covered mountains, in crater lakes, deserts, trees, densely populated urban areas, and even on and in other animals as parasites. They eat every possible food, from soil microorganisms, plankton, poisonous mushrooms, cactus plants, garden crops, refuse, paper, and fish, to living or decayed land animals and their excrement. Some are even cannibals, eating their own species. With such diversification it is small wonder that many are of considerable economic importance to man.

The importance of the foot in recognizing the various assemblages of related species within the phylum is seen in the names given the principal groups. There are six such groups, or classes, in the Mollusca (Plate I, A). Each class, except the chitons (AMPHINEURA) and the two species of segmented mollusks (MONOPLACOPHORA), has a name which bears reference to the foot, i. e. CEPHALOPODA, GASTROPODA, SCAPHOPODA, and PELECYPODA. Cephalo- refers to head; gastro- to stomach; scapho- to digging; pelecy- to axe; and -poda to foot.

In addition to modifications of the locomotor organ, these groups are further distinguished by other features such as basic structure of the shell, the absence, presence, or degree of development of the head, the degree of development of the nervous system and sense organs, modifications of the respiratory organs, and by structure of the radula or teeth.

The Class MONOPLACOPHORA includes only two living species, both found in abyssal marine waters. The saucer-shaped, limpet-like shell covers a bilaterally symmetrical animal with a mouth in front and anus behind. The round ventral foot is surrounded by five pairs of gills. The segmentation exhibited by these primitive mollusks suggests affinities with annelid worms and perhaps also with the arthropods. The radular teeth demonstrate relationships with the chitons.

The AMPHINEURA is another small primitive marine group which comprises the chitons (polyplacophorans) and a series of deep-water, wormlike, shell-less forms (aplacophorans). The shell of the chitons is divided into eight transverse calcareous plates (the only suggestion of segmentation) that cover the back. The foot is similar to that of the monoplacophorans (but more elongate) and also of the gastropods. The aplacophorans are covered by a mantle bearing minute calcareous spicules.

The GASTROPODA, the largest and most varied group of mollusks, includes snails, slugs, sea-hares, and limpets. They are found in marine and fresh waters and on land. They have retained the primitive flat ventral foot adapted for crawling, but in other ways have evolved significantly from the ancestral type. They have all undergone a torsion in the general body plan so that the digestive tract is no longer a straight tube, but the anus comes to lie in the side of the animal, often near the head. Most gastropods have a coiled shell and correspondingly coiled visceral mass. In some groups, e. g., many opisthobranchs and the land slugs, the shell has become so reduced as not to appear externally at all. In some cases it is a small bit of calcareous material enclosed in the mantle; in other cases it has been lost entirely. This reduction of the shell has been the result of a long continued evolution; slugs are not snails that have crawled out of their shells. The shells of the limpets have lost the spiral structure and present a low conical shape.

The SCAPHOPODA are burrowing mollusks having a conical foot which, by alternating extensions and contractions, pulls the animal through the substratum. The mantle and shell are tubular and open at both ends. The shell is long and tapering and accounts for the common name of this group, the tusk shells. They are marine mollusks which do not carry on respiration by means of gills but by folds in the mantle lining.

The PELECYPODA, or LAMELLIBRANCHIA, have an axe-shaped foot adapted for crawling or burrowing, and have completely lost the head and the buccal apparatus used by other mollusks in obtaining food. They are either marine, brackish, or fresh-water, and feed on micro-organisms that are swept in contact with them by water currents created by fine hairs on the gills. The body is enclosed by two symmetrical mantle flaps which secrete right and left shell valves that are held together by a tough ligament.

Because of this arrangement of the shell they are often referred to as "bivalves." This group includes the clams, oysters, and mussels, as well as the smallest pill-clams.

The CEPHALOPODA include the squids, octopuses, and nautiluses and are the most highly evolved of the mollusks. The foot has become divided into a number of prehensile "arms" or tentacles arranged symmetrically around the head or mouth, and from this close union of head and foot the class gets its name. A part of the foot is further modified to form a funnel which is used in swimming. By forcing water out of the mantle cavity through this funnel, the animal achieves water jet-propulsion. All cephalopods are marine and in many, such as the squid and octopus, the shell is internal or even lost.

THE GASTROPODS

Of the above six classes of mollusks, only members of the Gastropoda are of concern for purposes of this publication and are presented in added detail. Further discussion of the other classes is omitted.

The three subclasses of gastropods have been named in reference to the position or character of the respiratory apparatus. In the Prosobranchiata the breathing organ or gill is situated in front of the heart; in the Opisthobranchiata it is behind the heart. The Pulmonata have replaced the gill by a vascular lung which may breathe either air or water depending on the habits of the particular species. Some prosobranchs and opisthobranchs have also lost their gills, but because of other details of their anatomy they are retained in their respective groups. The opisthobranchs are all marine, but both the prosobranchs and pulmonates have representatives in fresh and salt water, and on land. The pulmonates have very few marine or brackish-water species; the prosobranchs have relatively few land species.

EXPLANATION OF PLATE I

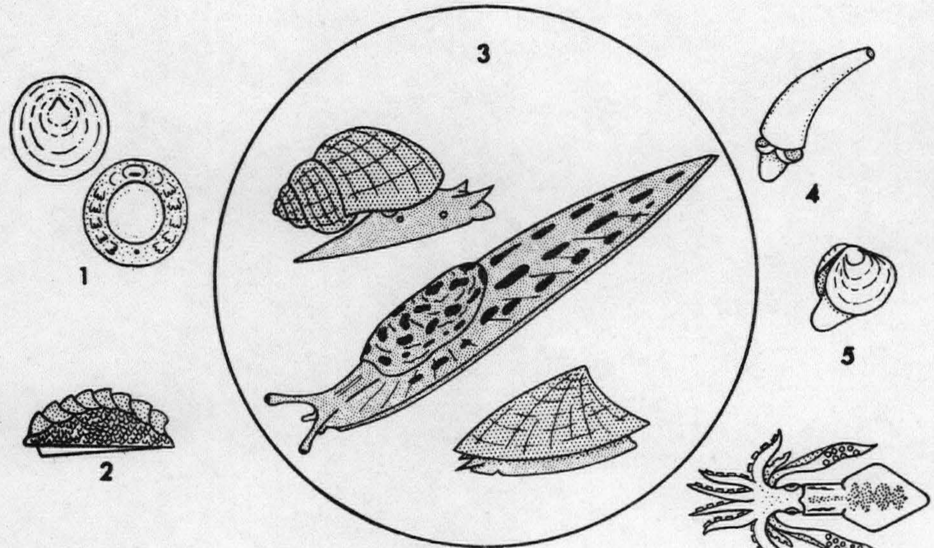
A. Representatives of the mollusk classes. 1, Neopilina, dorsal and ventral views, MONOPLACOPHORA; 2, chiton, AMPHINEURA; 3, snail, slug, and limpet, GASTROPODA; 4, tusk shell, SCAPHOPODA; 5, clam, PELECYPODA; 6, squid, CEPHALOPODA.

B. The prosobranch operculum. 1, The operculum in the shell aperture, sealing off the interior of the shell; 2, position of operculum while the snail is active.

C. Position of the eyes and method of withdrawal of the tentacles in the three pulmonate snail orders. 1, BASOMMATOPHORA, eyes at bases of contractile tentacles; 2, SYSTELLOMMATOPHORA, eyes at the tips of contractile tentacles; 3, STYLOMMATOPHORA, eyes at the tips of retractile tentacles.

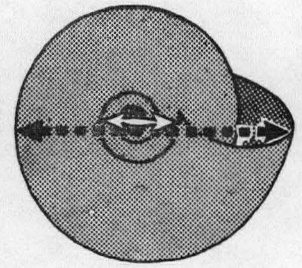
D. Method of measuring shell and umbilicus diameters.

E. 1, Last whorl not descending in front, i. e., not deflected; 2, last whorl descending in front, i. e., deflected.

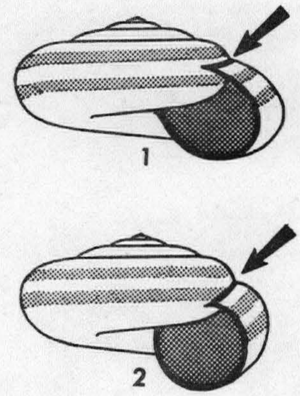


1
2
3
4
5
6

A

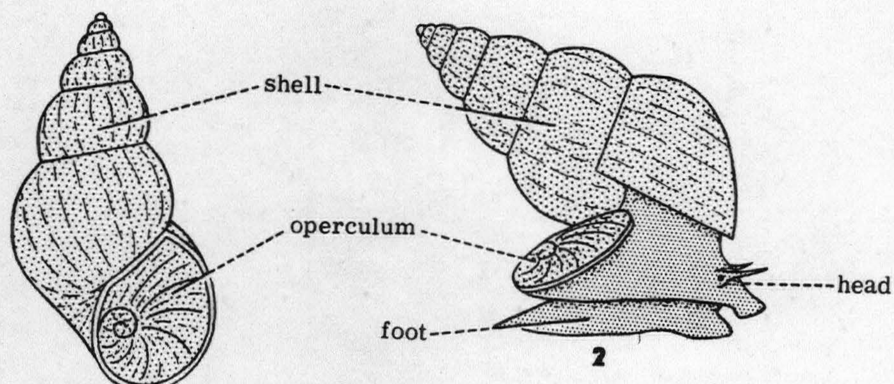


D



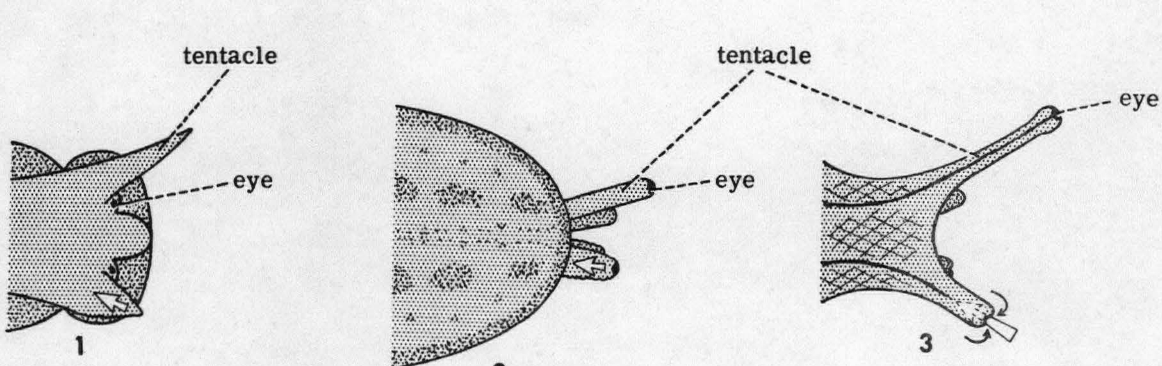
1
2

E



shell
operculum
head
foot
1
2

B



tentacle
eye
tentacle
eye
eye
1
2
3

C

In addition to respiratory and other anatomical differences, the pulmonates and prosobranchs usually can be distinguished by the presence or absence of an operculum or cover used to close the aperture when the snails are withdrawn into their shells (Plate I, B). Most prosobranchs have an operculum, but only the marine genus Amphibola of the pulmonates has such a protective structure.

The prosobranchs snails discussed in this publication represent two orders. The operculate land snail Helicina zephyrina belongs to the primitive Archeogastropoda and the fresh-water operculates (Parafossarulus, Pomatiopsis, Melanoides, Tarebia, and Semisulcospira) to the large, extremely diverse, and widespread order Mesogastropoda.

The pulmonate snails are divided into three large groups or orders - the Stylommatophora, the Systellommatophora, and the Basommatophora. Since each is represented by species of economic importance, they will be considered briefly. The largest order is that of the land snails and slugs, the Stylommatophora, or Geophila. This group is characterized by animals with eyes at the tip of the upper pair of tentacles, which are retractile, i. e., can be inverted like a rubber glove when the fingers are withdrawn (Plate I, C). The Systellommatophora, or Gymnophila, comprise a small group of tropical slugs (e. g., Veronicella) with contractile (not inversible) tentacles with eyes at the tips of the upper pair. The fresh water pulmonate snails (such as Fossaria, Bulinus, Biomphalaria, Planorbina, and Armigerus) also have contractile tentacles, but the eyes are situated at their bases. These snails are placed in the Order Basommatophora, or Limnophila.

The Stylommatophora are divided into four suborders, the Orthurethra, Mesurethra, Heterurethra, and Sigmurethra, on the basis of the internal structure and arrangement of the kidney and ureter. The sigmurethran group is the most advanced and by far the most important with the greatest number of species (and the only one considered in this publication). It differs from the others in that the ureter is abruptly reflexed from the apex of the kidney and passes to the posterior end of the lung cavity. It then follows the digestive tract anteriorly to the mantle edge. This sigmoid form of ureter is not found in the other three suborders.

The sigmurethran snails fall into two divisions according to the position of the pedal grooves of the foot. The pedal grooves are found at the boundaries where the tuberculate side walls of the foot join the smooth ventral sole. In the Holopoda, such as Helix, Cepaea, Otala, Lamellaxis, and Testacella, the pedal grooves are inconspicuous and in or close to the angle of the lateral margins of the foot. In the Aulacopoda, e. g., Oxychilus, Limax, Deroceras, Milax, and Arion, it is situated higher so that part of the sole actually comes around to form part of the more or less vertical side of the foot. In snails or slugs of this latter group there is a second rather weakly impressed groove above and running parallel to the pedal groove, the suprapedal groove (see Plate II, D).

IDENTIFICATION

Since the main purpose of this publication is identification of snails and slugs, it will be necessary to go into some detail on characters to be looked for and used in making species determinations. Many of these characters are illustrated in Plates I, II, and III. Necessary equipment for identification includes, at the most, a 10X hand lens.

The size and general form of the shell are important in recognizing snails. Their shape may take many forms, from very elongate (Plate III, A) to globose (Plate III, B), depressed (Plate III, H), and discoidal (Plate III, C). It may be either higher than wide, or wider than high. Its coils may turn in either a left or right hand direction (Plate II, B), be round, angular (Plate III, P, Q), or flattened, and have shallow, impressed, or crenulated sutures (Plate III, J, K, L).

The shell may have few or many whorls (Plate III, G illustrates how they are counted), may lack an opening (umbilicus) in its base, or may have either a narrow or wide one (Plate III, Z, AA, AB). Its columella, or central axial column, may be twisted or straight, and may or may not end abruptly (Plate III, M, N). Its outer lip may be straight or variously curved (Plate III, D, E, F), and is sometimes turned back, or reflected (Plate III, H, I).

The surface of the shell may be marked, i. e., colored or sculptured, in various ways (Plate II, A, C), or may be simply white and smooth. The outline of the aperture, due to the shape and relation of the whorls to each other, may take many forms, the more common ones shown in Plate III, R - Y. The aperture may or may not be closed by an operculum (Plate I, B) which itself has important characters. The operculum may be round, oval, or spindle-shaped, and concentric, paucispiral, or multispiral, depending on the way in which it is formed (Plate III, AC, AD, AE, AF).

In the slugs (Plate II, D), the general size, shape and contour of the body, and relative size of the mantle are important. Other characters used in their identification are: The position of the breathing pore, and the presence, or absence of a groove in the mantle; the color, pigment patterns, and texture of the skin; the presence, absence, or relative size of a sharp ridge, or keel, on the back; the relative size of the neck; the presence or absence of a caudal mucous pore; the relative development of the suprapedal groove; and the color of the mucus.

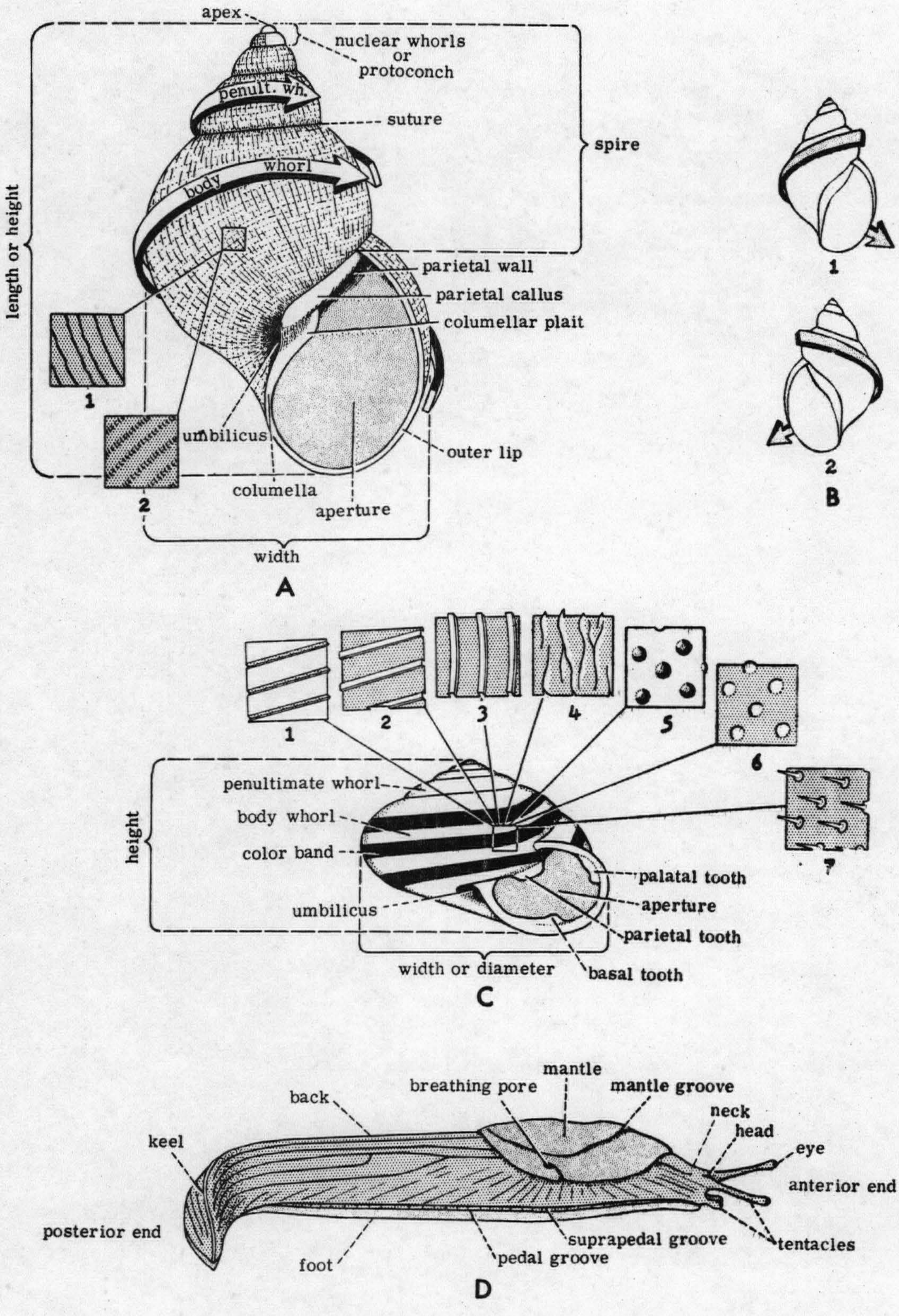
EXPLANATION OF PLATE II

A. Shell terminology. 1, Transverse or growth lines; 2, spiral lines or striae.

B. 1, Dextrally (to the right) whorled shell; 2, sinistrally (to the left) whorled shell.

C. Shell terminology and surface sculpture. 1, Striae (indented spiral lines); 2, lirae (raised spiral lines); 3, ribs (raised transverse lines); 4, wrinkles; 5, punctae or pits; 6, papillae; 7, hairs or bristles.

D. Slug terminology.



apex
nuclear whorls
or
protoconch
penult. wh.
suture
spire
body
whorl
length or height
parietal wall
parietal callus
columellar plait
1
umbilicus
2
outer lip
columella
aperture
width
A
1
2
B
1
2
3
4
5
6
7
penultimate whorl
body whorl
color band
height
palatal tooth
aperture
umbilicus
parietal tooth
width or diameter
basal tooth
C
mantle
breathing pore
mantle groove
back
neck
head
keel
eye
anterior end
posterior end
suprapedal groove
tentacles
foot
pedal groove
D

SYSTEMATIC ACCOUNT OF ECONOMICALLY IMPORTANT SNAILS AND SLUGS

I LAND SNAILS

Subclass PROSOBRANCHIATA

Order ARCHEOGASTROPODA

Family HELICINIDAE

This is a primitive, mainly tropical family of land operculates. The shells are all imperforate, the umbilical region occupied by a callous pad. One species has been intercepted by quarantine inspectors.

Helicina zephyrina Duclos

Plate V, J

This species has a thick shell, rather high spire, flat-sided whorls with non-impressed sutures, and a roundly lunate aperture with reflected lip. Adult shells measure 12 - 15 mm. in diameter. The color is pale yellow, usually with one reddish-brown spiral color band. The operculum is concentric.

Distribution. Mexico to Nicaragua.

Subclass PULMONATA

Order STYLOMMATOPHORA

Division AULACOPODA

Family ZONITIDAE

This family of medium to small land snails is almost world-wide in its distribution and contains many species endemic to North America. The shell is usually umbilicate and has a low spire that gives it a rather discoidal outline. The lip is thin and not reflected. The animal has the margin of the foot defined by a pedal groove, which places the family in the Aulacopod group. Introduced species of importance belong to the genus Oxychilus and are generally ound in and around greenhouses and cellars, and under rubbish or compost in gardens.

Oxychilus alliarius (Miller)

Shell small, smooth, highly polished, and amber or pale yellowish. Adults (with 4-5 whorls) measure 6-7 mm. in diameter. In living specimens the shell color is difficult to discern because the thin, semi-transparent nature of the shell allows the dark body of the animal to show through. The spire is hardly raised above the body whorl, giving the shell a rather discoidal appearance. The whorls are well-rounded at the periphery and are sculptured with fine, irregular growth lines. The sutures are moderately impressed. The umbilicus is about a millimeter in diameter and clearly shows the penultimate whorl. The aperture is ovate-lunate.

Distribution. Central and western Europe, Iceland. Introduced in the United States and found in and around greenhouses in New York, New Jersey, Michigan, Colorado, and California.

This snail and its two close relatives, O. draparnaldi and O. cellarius, are pests in greenhouses, and sometimes in gardens, where they are destructive to young and seedling plants. These snails are also predatory and carnivorous, feeding particularly on other snails.

Oxychilus draparnaldi (Beck)
(= O. lucidus (Draparnaud))

Plate VI, H

This species is very similar to O. alliarius but adult shells with an equal number of whorls (i. e., 4-5.5) are more than twice as large (12-16 mm.). The shell is strongly depressed and umbilicate, the umbilicus contained about 6 times in the diameter. Shell and animal coloration similar to O. alliarius. Aperture ovate-lunate.

Distribution. Europe, Orkney and Shetland Islands, Outer Hebrides, Asia Minor, North Africa, Madeira. Introduced in the United States, chiefly on the eastern seaboard. There are also records from Illinois, Colorado, California, Oregon, and Washington.

Oxychilus cellarius (Müller)

This species is intermediate in size between O. alliarius and O. draparnaldi; shells (with 5 whorls) measure about 9 mm. The general shell shape, color, and relative size of the umbilicus are similar to the above two species. The light gray color of the animal, however, immediately distinguishes it from the other two species that have dark gray or black bodies. It is further distinguished by its more broadly lunate aperture.

Distribution. Europe, Asia Minor, North Africa. Introduced into the United States and there are now records from many of the Northern States.

Family TESTACELLIDAE

This family consists of sluglike snails, which bear a small rudimentary shell near their posterior end. They are carnivorous, preying on soil invertebrates. One species, Testacella haliotidea, has been occasionally found in greenhouses in this country, and has apparently become successfully established in parts of Tennessee.

Testacella haliotidea Draparnaud

Plate VII, A; Plate IV, H

Shell rudimentary, depressed, ear-shaped, imperforate, and with a subspiral, posterior nucleus. The surface is rugosely striate. The apex is very small and short and is not separated from the columellar margin. The aperture is oval, Adult shells measure 6-10 mm. in length.

The animal is sluglike, tapering anteriorly, and is much too large to retract into its shell. The mantle is covered by the small, posteriorly placed shell.

Distribution. Great Britain, Western Europe, Algeria, Madeira, Canary Islands. Introduced into Cuba and the United States (Tennessee, and in greenhouses in Philadelphia, Chicago, and Berkeley, California).

This species spends much time in the ground, and in its native countries apparently feeds chiefly on earthworms.

Testacella maugei Férussac

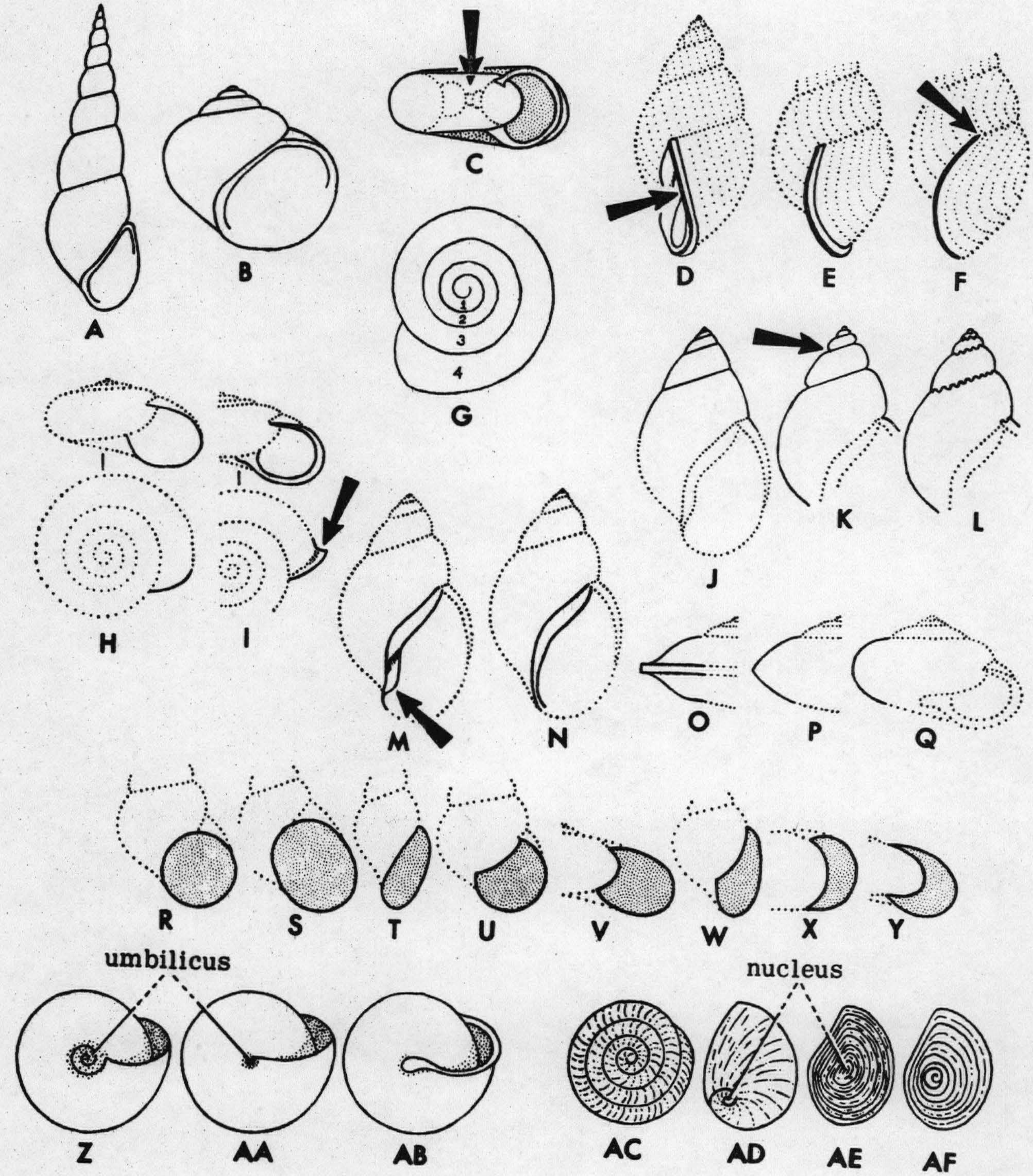
Plate IV, I

The shell of this species is similar to that

EXPLANATION OF PLATE III

SHELL TERMINOLOGY

A. Shell with whorls increasing gradually in size.
B. Whorls rapidly increasing in size.
C. Sunken spire.
D. Straight outer lip.
E. Curved outer lip.
F. Lip retracted to the suture.
G. Method of counting whorls.
H. Straight (not reflected) lip.
I. Reflected lip.
J. Sutures slightly indented.
K. Sutures strongly indented.
L. Crenulate sutures.
M. Truncate columella.
N. Straight columella.
O. Carinate periphery.
P. Angular periphery.
Q. Round periphery.
R. Round aperture.
S. Oval aperture.
T. Narrowly oval aperture.
U. Roundly lunate aperture.
V. Ovate-lunate aperture.
W. Narrowly ovate-lunate aperture.
X. Broadly lunate aperture.
Y. Deeply lunate aperture.
Z. Umbilicate shell.
AA. Perforate shell.
AB. Imperforate shell.
AC. Multispiral operculum.
AD. Paucispiral operculum.
AE. Concentric operculum.
AF. Concentric operculum with spiral nucleus.


A
B
C
D
E
F
1
2
3
4
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
umbilicus
Z
AA
AB
nucleus
AC
AD
AE
AF

of T. haliotidea but is larger and relatively narrower, with nearly parallel sides. Adult shells measure 13-18 mm.

Distribution. England, France, Portugal, Canary Islands, Madeira, Azore Islands.

Division HOLOPODA

Family OLEACINIDAE

This is a family of the Mediterranean region and tropical and subtropical America. Its species have large shells that are higher than wide, with narrowly ovate-lunate apertures and truncate or twisted columellae. One widespread species of South America, Euglandina striata, has been intercepted by Plant Quarantine inspectors.

Euglandina striata (Müller)

Plate V, B

Shell rather large. Adult shells (with 7-8 whorls) measure over 50 mm., are imperforate, fusiform, and high spired with crenulated sutures. The shell is longitudinally striate and white to light pinkish-yellow with inconspicuous, narrow, reddish-brown, longitudinal stripes. The whorls are only slightly rounded. The aperture is relatively narrow, the lip sharp and unexpanded, the columella abruptly truncate.

Distribution. Northern South America to southern Brazil.

This species is a very active predator which feeds on land snails. It is usually found in places where other land snails are numerous.

Family ACHATINIDAE

This is a large group of mainly tropical snails, which vary greatly in size from the giant African snail Achatina to the minute Cecilioides. Their shape varies from oval, as in the former species, to long and thin in the latter. All of them are longer than wide. Several species have proven to be of considerable economic importance after introduction into foreign lands. The species included in this publication belong to six genera, Cecilioides, Opeas, Lamellaxis, Subulina, Rumina, and Achatina.

Cecilioides aperta (Swainson)

The shell is imperforate, very small and slender, fragile, smooth, and transparent. Adults (with 5-6 whorls) are about 4-5 mm. long. The whorls are moderately rounded; the apex is round and blunt. The aperture is narrowly ovate-lunate, the columella slightly truncate and with a rather heavy callus on the parietal wall. The lip is sharp and not reflected. The animals of C. aperta, and also C. acicula, have the usual two pairs of tentacles, but they lack eyes.

Distribution. West Indies.

This species, and the related C. acicula, are ground dwellers that are transferred from place to place on the roots of tropical plants. By this method C. aperta apparently has been distributed to many places in the Old World tropics, to Florida, and to greenhouses in several Northeastern States. Its economic importance is probably slight.

Cecilioides acicula (Müller)

Plate VI, E

The shell of this species is very similar to C. aperta in size and general shape, but differs in having more flat-sided whorls with very fine spiral striae, no callus on the parietal wall, and an abruptly truncate columella.

Distribution. Central and western Europe. Introduced in Bermuda and the United States (records from Pennsylvania and Florida).

Opeas pyrgula Schmacker and Boettger

Shell perforate, small (about 8 mm. long in shells with 7 whorls), elongate with high tapering spire, the surface sculptured with weak, irregular, transverse striae or wrinkles. The sutures are crenulated; the aperture ovate-lunate; the outer lip thin, not reflected, and rounded; columella straight or slightly concave, but not truncated.

Distribution. Japan, China.

This species has been found around urban vegetable gardens in Pennsylvania and Virginia.

Opeas pumilum (Pfeiffer)

Plate VI, G

Shell similar to O. pyrgula in size and shape, but may be distinguished by its straight sutures, stronger sculpture, and lip that is strongly retracted to the suture.

Distribution. Tropical America. Introduced in Florida and found in greenhouses in Pittsburgh and Chicago.

Lamellaxis clavulinus (Potiez and Michaud)

Shell small, very high spired, perforate, moderately glossy and transversely striate, with straight outer lip and expanded columellar lip. Whorls moderately round, sutures straight. The columella is straight or sometimes slightly curved, the aperture ovate-lunate, its length 1/4 to 1/3 the shell length. Adult shells (with 7 whorls) measure about 7 mm.

Shells of this and related species, such as L. mauritianus, L. gracilis, and L. micra, are very similar to Opeas, but they are placed in a different genus because of details of soft anatomy. None of the shells, however, have the lip sharply retracted to the suture as in O. pumilum, and only the ribbed L. micra tends to have crenulated sutures like O. pyrgula.

Distribution. Islands of the Indian Ocean, Japan, Hawaii. Fould in Phipps Conservatory, Pittsburgh, Pennsylvania.

Lamellaxis mauritianus (Pfeiffer)

This species is similar to L. clavulinus, but differs from both it and L. gracilis by its more glossy surface and weaker transverse striation.

Distribution. Tropics of both hemispheres in greenhouses and in cultivated regions. Found in a number of greenhouses in the United States.

Lamellaxis gracilis (Hutton)

Plate VI, A

This species is similar to both L. clavulinus and L. mauritianus but can be distinguished from them by its heavier transverse striations and dull surface.

Distribution. Tropics of both hemispheres in cultivated regions. Introduced into the southeastern United States.

Lamellaxis micra (d'Orbigny)

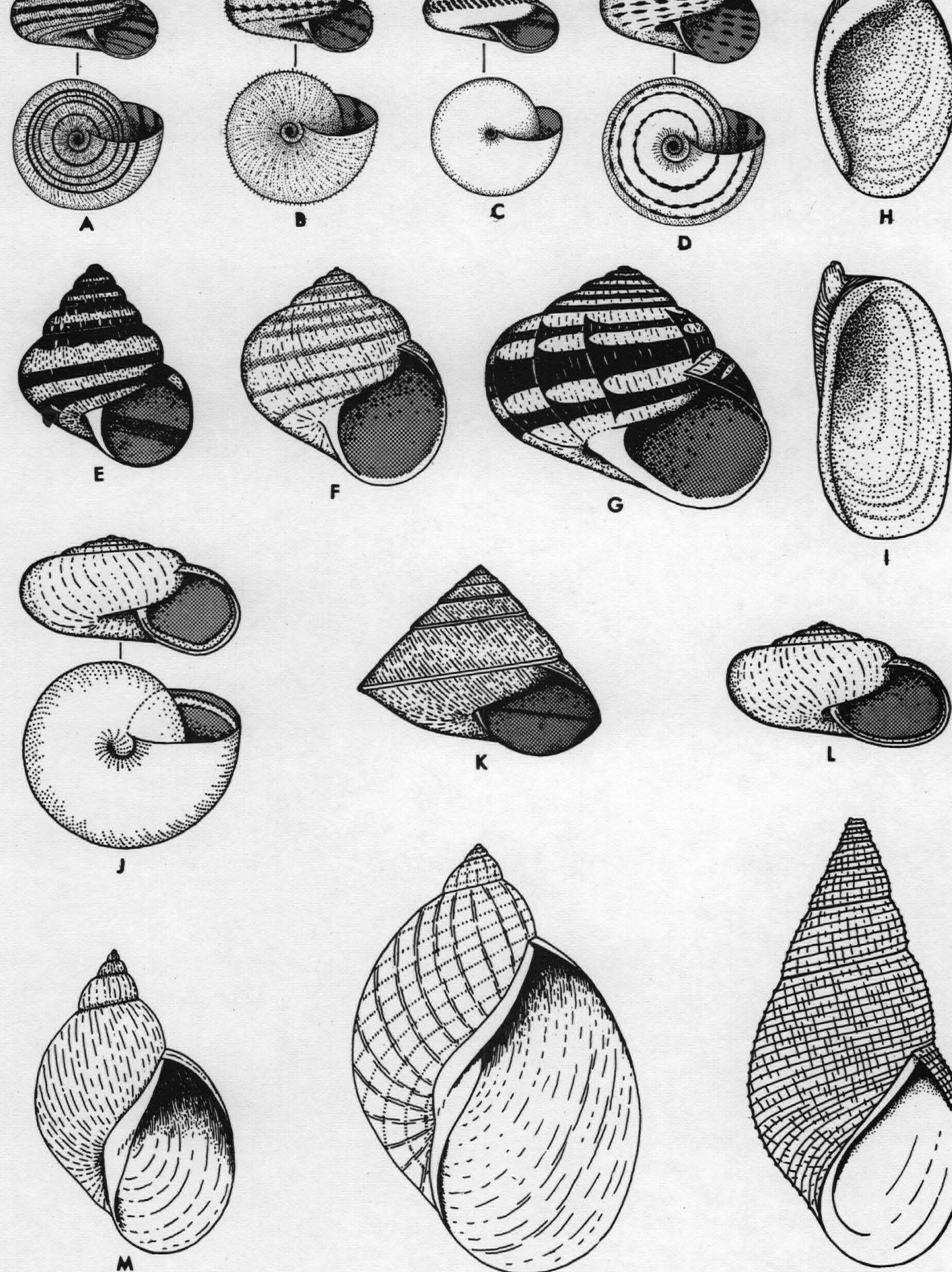
Plate VI, D

This snail differs from other species of Lamellaxis and Opeas by having widely spaced transverse ribs, a bullet-shaped spire, smaller aperture (less than 1/4 the shell height), and shorter whorls.

EXPLANATION OF PLATE IV

ECONOMICALLY IMPORTANT LAND AND FRESH-WATER SNAILS

A. Helicella striata (Müller).
B. Helicella conspurcata (Draparnaud).
C. Helicella pyramidata (Draparnaud).
D. Helicella variabilis (Draparnaud).
E. Cochlicella conoidea (Draparnaud).
F. Helix figulina Parreyss.
G. Helix lucorum Müller.
H. Testacella haliotidea Draparnaud.
I. Testacella maugei Férussac.
J. Monacha schotti (Pfeiffer).
K. Hygromia cinctella (Draparnaud).
L. Monacha carthusiana (Müller).
M. Fossaria ollula (Gould).
N. Radix natalensis (Krauss).
O. Semisulcospira libertina (Gould).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Distribution. West Indies, Mexico to Bolivia. Introduced into Florida.

Subulina octona (Bruguière)

Plate VI, C

Shell similar to Opeas and Lamellaxis, except that it is larger, perforate, and the columella is truncate. Shells (with 10 whorls) measure about 18 mm. Surface glossy, irregularly wrinkle-striate; sutures impressed; aperture small, oval, slightly lunate.

Distribution. Tropical America. Introduced into Africa, Ceylon, East Indies, Florida. It is occasionally reported from greenhouses in the Northern States.

Rumina decollata (Linnaeus)

Plate V, K

Shell large, perforate, glossy, sculptured with fine spiral striae; whorls only slightly rounded, sutures not impressed; columella straight, its lip margin reflexed; lip solid, but not reflected. The most obvious characteristic of the shell is its decollate, or broken off spire. In adult shells only 4-7 whorls remain, the other 8 to 10 having been lost by successive breakages. Adult decollate shells measure 25 to 45 mm.

Distribution. Mediterranean region of Europe, Asia, and Africa. Introduced in many of the southern United States.

This species appears to thrive whenever introduced in the South, usually in urban or suburban gardens and uncultivated plots. It is a very voracious eater, feeding on both vegetable matter and other snails.

Achatina fulica Férussac

Plate V, A

This is a very large species, adults often obtaining a shell length of 125 mm. or more. The shell is yellowish or horn-colored, with reddish-brown transverse streaks. The whorls are spirally striate, rounded, with moderately impressed sutures. The aperture is ovate-lunate to roundly lunate, the outer lip sharp and not reflected. The columella is abruptly truncate.

Distribution. East Africa and Madagascar. Introduced into India, China, Formosa, Ceylon, Borneo, Malaya, Mauritius, Philippine Islands, Hawaii, and many of the south Pacific Islands.

This "giant African snail" is an extremely serious agricultural pest, causing a great amount of damage nearly everywhere it has been introduced. It was imported at several maritime ports aboard returned war equipment, but did not become established.

Family BULIMULIDAE

This is mainly a South American family, although a few members reach into the southern United States, and to Australia, Melanesia and New Zealand. The shell is medium to large in size, generally rather oval, higher than wide, and often quite brightly colored.

Porphyrobaphe iostoma (Sowerby)

Plate V, C

Shell large, high-spired, thick, imperforate, with a dull to moderately glossy surface. The surface is covered with coarse, rather irregular growth-wrinkles and may or may not have spiral striae. Color white to pinkish-brown, mottled or flecked with yellow, brown, or purple. The columella has a plait, but is not truncate. The outer lip is characteristically purple, reflected and heavily thickened. The aperture is semi-ovate. Adult shells (with 5-6 whorls) measure 50-75 mm. in length.

Distribution. Peru, Ecuador. Often intercepted with bananas imported from those countries.

Family BRADYBAENIDAE (FRUTICICOLIDAE)

One species of this group of medium to small, depressed snails (Bradybaena similaris, a species which inhabits the coffee tree) has been encountered by Plant Quarantine inspectors.

Bradybaena similaris (Férussac)

Plate V, F

Shell wider than high, of medium size, thin, narrowly umbilicate, with a rather depressed spire. Sculptured with fine, irregular growth lines and fine spiral striae. Color light brown, often with a single, spiral chestnut band. Lip reflected, its columellar portion partly covering the umbilicus. Sutures impressed; aperture roundly lunate. Adult shells (those with a reflected lip) measure 12-16 mm. in diameter.

Distribution. Brazil, West Indies, Mauritius, China, Hawaii. Originally a native of the Chinese region, commerce has spread this species all over the world, wherever coffee is cultivated. It has recently been found in the United States at New Orleans. Of rather ubiquitous habits in Hawaii, it may be a serious pest to floriculture and horticulture.

Family CAMAENIDAE

Although this family is widely distributed in eastern North America, Latin and South America, and has representatives in Asia and Australia, only one species foreign to the United States has been met at Plant Quarantine stations.

Solaropsis monile (Broderip)

Plate V, G

Shell of medium size, very broadly umbilicated, sculptured with minute granules. Color light brown, with several spiral series of reddish, angular streaks or spots. Spire depressed below body whorl. Aperture roundly lunate, lip reflected. Adults (with 4-5 whorls and reflected lips) measure 20-30 mm. in diameter.

Distribution. Colombia, Ecuador - usually intercepted with bananas imported from those countries.

Family HELICELLIDAE

Several species of this large family of Europe, western Asia, and north Africa have been introduced into North America. They belong to the genera Cochlicella, Helicella, Monacha, and Hygromia, and are all either umbilicate or perforate and of medium to small size. Their shapes are variable, from long and rather narrow in Cochlicella barbara, to broad and flat in Helicella itala.

Cochlicella barbara (Linnaeus)
(=C. acuta (Müll.))
Plate VI, B

Shell thin, perforate, narrow, higher than wide, with somewhat flattened whorls. Color

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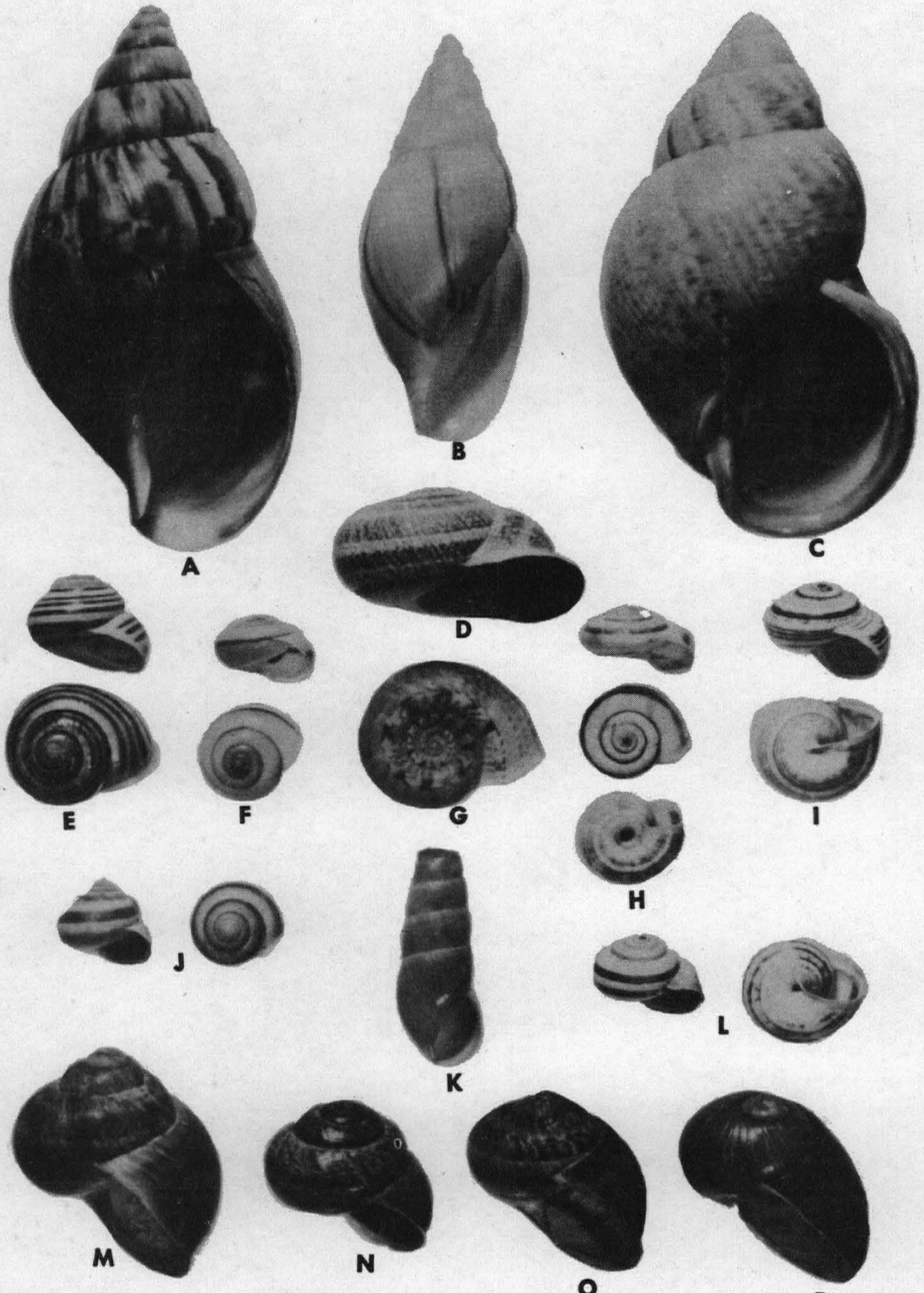
EXPLANATION OF PLATE V

ECONOMICALLY IMPORTANT LAND SNAILS

A. Achatina fulica Férussac.
B. Euglandina striata (Müller).
C. Porphyrobaphe iostoma (Sowerby).
D. Otala lactea Müller.
E. Cepaea hortensis (Müller).
F. Bradybaena similaris (Férussac).
G. Solaropsis monile (Broderip).
H. Helicella itala (Linnaeus).
I. Theba pisana (Müller).
J. Helicina zephyrina Duclos.
K. Rumina decollata (Linnaeus).
L. Helicella maritima (Draparnaud).
M. Helix pomatia Linnaeus.
N. Helicigona arbustorum (Linnaeus).
O. Helix aspersa Müller.
P. Helix aperta Born.

(Shells - natural size)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white, usually with reddish-brown transverse bands. The aperture is ovate-lunate, its outer lip sharp and not reflected. The columella is straight. Adult shells (with 8-10 whorls) are 18-20 mm. long.

Distribution. British Isles, Denmark, Sweden and southern Europe, the Mediterranean region, including North Africa. Introduced into Australia.

Extremely resistant to dry weather, this snail may seal the shell opening with a series of successive membranes (epiphragms) to prevent loss of water. For this resting state it may seal itself to the underside of or within crates, or any other materials stored outside in the region where it lives.

In western Australia, the species is reported to attack garden plants and others of economic importance.

Cochlicella ventrosa (Férussac)

This species is very similar to C. barbara, but is shorter and broader, and its whorls tend to be moderately rounded. Its width is more than half the height. Adult shells (with 7-8 whorls) are 9-12 mm. long.

Distribution. Mediterranean countries. Introduced into Bermuda, and the United States at South Carolina and California.

Cochlicella conoidea (Draparnaud)

Plate IV, E

This species is similar to both C. barbara and C. ventrosa, but is shorter and wider than either (almost as wide as high), and has a roundly lunate aperture. Adults (with 6-7 whorls) are 7-9 mm. long.

Distribution. Mediterranean region.

Helicella maritima (Draparnaud)

Plate V, L

Shell of medium size, wider than high, with a projecting apex. Last (body) whorl of full-grown shells descending in front. Color white, with reddish-brown spiral bands; surface dull, opaque. Umbilicus narrow, about 1/8 the diameter of the shell. Aperture roundly ovate; outer lip not reflected, but often ringed with a calloused thickening. Adults (with 5-6 whorls) measure 12-16 mm. in diameter.

Distribution. Western and southern Europe.

Helicella variabilis (Draparnaud)

Plate IV, D

This species is very similar to H. maritima, but has a wider umbilicus (about 1/5 the diameter of the shell). Adults (with 5-6 whorls) measure 12-19 mm. in diameter.

Distribution. Europe.

Helicella pyramidata (Draparnaud)

Plate IV, C

The shell of the species is similar to H. maritima and H. variabilis, but is somewhat smaller, has a higher spire with a sharper apex, an ovate-lunate aperture, and its last whorl is not deflected. Adult shells (with 5-6 whorls) measure 10-12 mm. in diameter.

Distribution. Mediterranean region.

Helicella caperata (Montagu)

This species is very similar to H. maritima, but is smaller. Adults (with 5-6 whorls) measure 8-12 mm. in diameter, have a more depressed spire, a slightly larger umbilicus (about 1/5 the diameter of the shell), and the last whorl does not descend in front.

Distribution. Western Europe, South Australia.

Helicella striata (Müller)

Plate IV, A

This species is similar to H. caperata but the shell has more prominent transverse lines. Adults (with 4-5 whorls) measure 9-10 mm. in diameter.

Distribution. Middle Europe.

Helicella conspurcata (Draparnaud)

Plate IV, B

This species is very similar to H. striata but is smaller and hirsute. Adults (with 4-5 whorls) measure 6-8 mm. in diameter.

Distribution. Southern Europe, the Mediterranean Region.

Helicella itala (Linnaeus)

Plate V, H

Shell similar to H. maritima and H. caperata, but differs by being more depressed (the spire only slightly raised above the body whorl), and more widely umbilicate (the umbilicus about 1/3 the diameter of the shell). Adults (with 5-6 whorls) measure 15-18 mm. in diameter.

Distribution. Europe, Asia Minor, Algeria.

Monacha cantiana (Montagu)

Plate VI, F

Shell of medium size, depressed, narrowly umbilicate, thin, translucent, and moderately glossy. Last whorl not deflected. Horn-colored to light brown. Whorls well-rounded; aperture roundly or ovate-lunate; outer lip sharp but often ringed inside with a callus or thickening. Adults (with 5-6 whorls) measure 16-18 mm. in diameter.

Distribution. Western and southern Europe, Ireland, England except northwestern part. Locally introduced into Canada.

Monacha carthusiana (Müller)

Plate IV, L

Shell very similar to M. cantiana but the umbilicus is narrower, often perforate or imperforate, and the last whorl descends slightly in front. Adults (with 5-6 whorls) measure 14-18 mm. in diameter.

Distribution. Europe.

Monacha schotti (Pfeiffer)

Plate IV, J

This species is similar to M. cantiana, but is smaller, more depressed, and the last whorl is deflected. The umbilicus is relatively wider, but very shallow, showing only 1/2 whorl or less. Adults (with 4-5 whorls) measure 12-14 mm. in diameter.

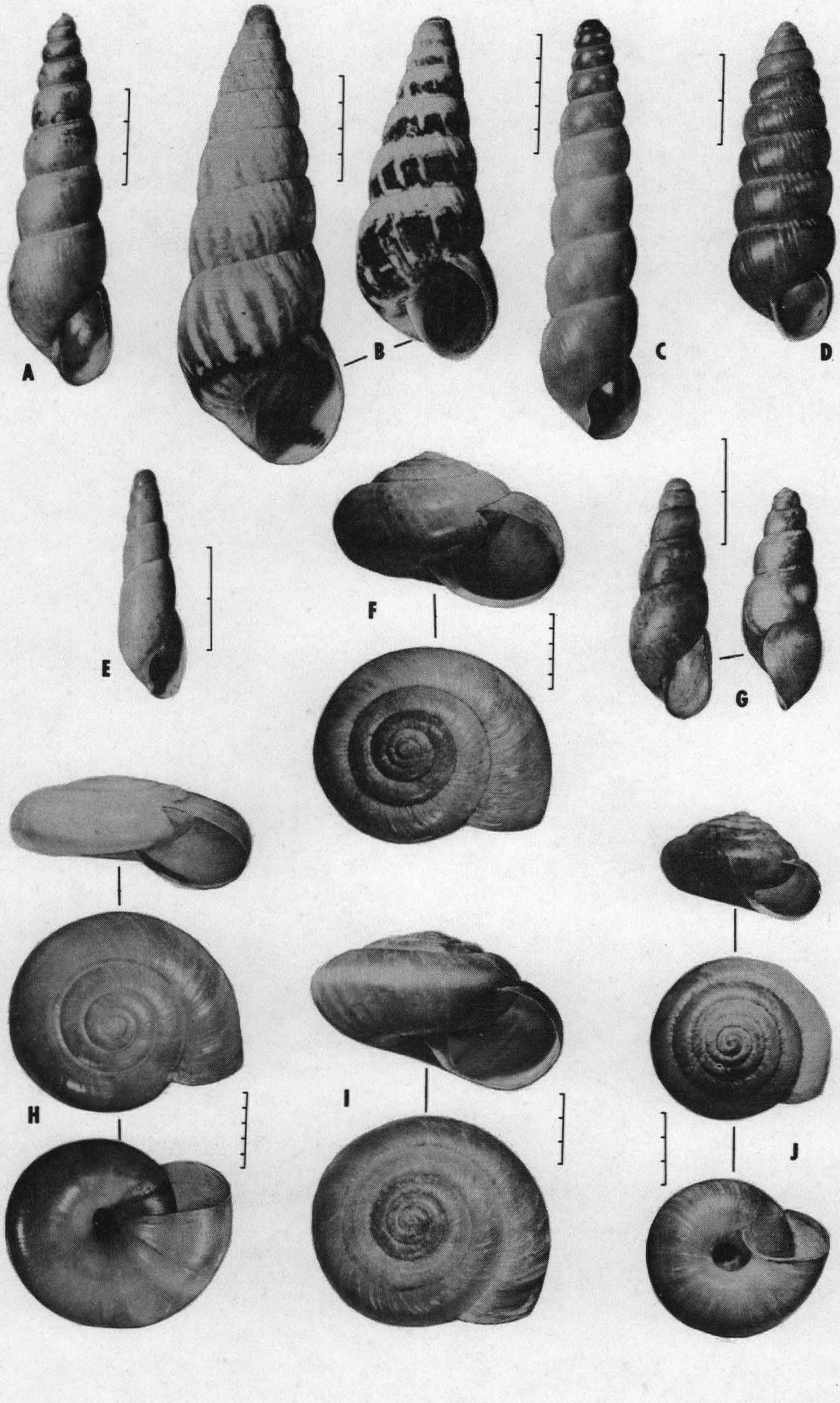
Distribution. Eastern Mediterranean region, Asia Minor.

EXPLANATION OF PLATE VI

ECONOMICALLY IMPORTANT LAND SNAILS

A. Lamellaxis gracilis (Hutton).
B. Cochlicella barbara (Linnaeus).
C. Subulina octona (Bruguière).
D. Lamellaxis micra (d'Orbigny).
E. Cecilioides acicula (Müller).
F. Monacha cantiana (Montagu).
G. Opeas pumilum (Pfeiffer).
H. Oxychilus draparnaldi (Beck).
I. Hygromia striolata (Pfeiffer).
J. Hygromia hispida (Linnaeus).

Scale lines represent millimeters.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Hygromia striolata (Pfeiffer)

Plate VI, I

This species is similar to Monacha cantiana, but is smaller; adults (with 5-6 whorls) measure 10-11 mm. in diameter, re more depressed, and have obtusely angular whorls. The periphery is often marked by a pale band. The young shell is covered with fine hairs but these tend to be lost as it grows older.

Distribution. Central Europe, France, England. Introduced into Canada and Massachusetts.

Hygromia hispida (Linnaeus)

Plate VI, J

Shell similar to H. striolata, but smaller, with rounded whorls, and often retaining its hirsuteness in adult shells. Adults (with 5-6 whorls) measure 7-9 mm. in diameter.

Distribution. Europe, central Asia to Siberia. Introduced into Canada and Maine.

Hygromia cinctella (Draparnaud)

Plate IV, K

Shell medium to small, thin, perforate to imperforate, smooth and conic with a keeled periphery. Horn-colored to light brown. The lip is sharp and not reflected. Adults (with 5-6 whorls) measure 12-13 mm. in diameter.

Distribution. Central and southern Europe.

Family HELICIDAE

The Helices comprise medium to large snails of European origin and include the edible snails Helix aperta, H. pomatia, H. aspersa, Otala lactea, and O. vermiculata. The shell in this family is usually banded, generally wider than high and loosely coiled so that the central column is hollow or umbilicate. However, in the adult the umbilicus is often closed over by an expansion of the lip. Genera of economic importance are Helix, Cepaea, Otala, Helicigona, and Theba. One species, One species, Cepaea hortensis, is widespread along the coast of northeastern North America; it is found from Newfoundland to Massachusetts.

Theba pisana (Müller)

Plate V, I

Shell of medium size, wider than high, and perforate. Its color is white, or ivory, and is usually banded with brown lines, some of which are generally interrupted into dots and dashes. The whorls are well-rounded and sculptured with many fine spiral striae. The nuclear whorls are usually dark brown or black, giving the appearance of a black dot on the top of the spire. The aperture is roundly- or ovate-lunate. The lip is sharp, but often ringed inside with a callus or thickening. Adult shells (with 4-5 whorls) are 18-20 mm. in diameter.

This species is most easily confused with Helicella maritima, but is perforate rather than umbilicate, and is spirally striate.

Distribution. Ireland, southwestern England, Switzerland, western France, Mediterranean countries. Introduced into the Atlantic Islands, South Africa, Australia, and formerly in California.

This species is now apparently completely eradicated in California. It was a particular pest to citrus crops and once established proved to be very difficult to control.

Helicigona arbustorum (Linnaeus)

Plate V, N

Shell large, perforate, somewhat globular, with well rounded whorls, which are strongly sculptured with fine spiral striae. Its color is yellow with horn-colored or reddish-brown markings and a single dark brown spiral band. The aperture is ovate-lunate. Adults (with reflected lips) measure 20-27 mm. in diameter and have 5-6 whorls.

Distribution. Chiefly a north European species, but extends into Spain, Italy, and the Crimean region. Introduced into Newfoundland.

Otala lactea Müller

Plate V, D

Shell large, depressed, imperforate and spirally striate. It is white with reddish-brown spiral color bands flecked with white, and has a dark brown aperture and lip. The whorls are well-rounded, the lip in adults widely reflected. The aperture is ovate-lunate. Adults have five whorls and measure 28-36 mm. in diameter.

Distribution. Southern Spain, North Africa. Locally introduced into Florida and Georgia.

Otala lactea and O. (Eobania) vermiculata are common food items of the people in their native countries. These two species are often referred to the genus Helix in the older literature.

Otala (Eobania) vermiculata Müller

This species is very similar to O. lactea but has a higher spire, a white aperture and lip, and is sculptured with spiral wrinkles or malleations instead of striae. Some individuals lack the spiral color bands.

Distribution. Mediterranean countries. Locally introduced into New Orleans.

Cepaea nemoralis (Linnaeus)

Shell large, imperforate, yellow, usually with 1 to 5 reddish-brown bands. The whorls are rounded, the aperture ovate-lunate, the lip in adults reflected and colored dark brown to almost black. Adults (with 5 whorls) measure 22-24 mm. in diameter.

Distribution. Central and western Europe. Introduced into Ontario, Massachusetts, New York, New Jersey, Virginia, Tennessee, Pennsylvania, Wisconsin, Colorado, and California.

Both this species and the related C. hortensis are eaten by Europeans; both have been reported to be garden pests in some areas. They are often placed in the genus Helix, particularly by older authors.

Cepaea hortensis (Müller)

Plate V, E

The shell of this species is very similar to C. nemoralis but is smaller (adults measure 16 to 21 mm. in diameter), slightly higher spired, and has a white instead of a brown lip.

Distribution. Central and northern Europe. It is also widely distributed in Iceland and along the northeastern coast of North America, from Newfoundland to Massachusetts.

Helix aspersa Müller

Plate V, O

Shell large, globose, rather thin, imperforate or nearly so, moderately glossy, sculptured with fine wrinkles. It is yellow or horn-colored with chestnut-brown spiral bands which are interrupted by yellow flecks or streaks. The aperture is roundly-lunate to ovate-lunate, the lip reflected. Adult shells (4-5 whorls) measure 32-38 mm. in diameter.

Distribution. Britain, western Europe, borders of the Mediterranean and Black Seas. Introduced into the Atlantic Islands, South Africa, Australia, New Zealand, Haiti, Mexico, Chile and Argentina. In the United States it has been introduced into South Carolina, Louisiana, and California, often causing considerable damage to vegetable and flower gardens.

This species is perhaps the most widely eaten of all European snails, and has been introduced into nearly every country that Europeans have settled.

Helix pomatia Linnaeus

Plate V, M

This species is similar to H. aspersa but is usually larger, perforate to narrowly umbilicate (sometimes imperforate), has a duller surface and uninterrupted spiral color bands, is sculptured with fine spiral striae rather than with wrinkles, and has an unreflected, but sometimes slightly expanded lip. Adult shells (with 4-5 whorls) measure 32-45 mm. in diameter.

Distribution. Central Europe, from southeast Russia to eastern France; from Denmark and southern Sweden in the north to the Balkan Peninsula in the south. Introduced into North Africa, Argentina, Uruguay, and into the United States at Jackson, Michigan, where it is damaging gardens. This is the "Edible Snail" of north and central Europe.

Helix figulina Parreyss

Plate IV, F

The shell of this species is very similar to H. pomatia but is smaller, imperforate, and has narrower spiral color bands. Adults (with 4-5 whorls) measure 25-30 mm. in diameter.

Distribution. Dalmatia, Greece, Asia Minor.

Helix lucorum Müller

Plate IV, G

This species is similar to H. pomatia and H. figulina, but has a larger, more depressed shell with darker color bands. It is either perforate or imperforate. Adults (with 5-6 whorls) measure 40-50 mm. in diameter.

Distribution. Central Italy, Balkan Peninsula, Asia Minor.

Helix aperta Born

Plate V, P

Shell imperforate, smaller than H. aspersa and H. pomatia, and has a relatively larger body whorl. It is thin and rather glossy with a brown or olive color and lacks color bands. The surface is finely sculptured with irregular striae. The aperture is more than 2/3 the height of the shell, has an ovate-lunate shape and an unreflected lip. Adult shells (with 3-4 rapidly widening whorls) measure 20-30 mm. in diameter.

In the resting stage this snail seals its aperture with a convex epiphragm. This outwardly curved membrane is thickened with calcium until it looks like a section of white egg shell.

Distribution. Southern Europe, Algeria.

This snail is a common food item of the people in its native countries. It has been introduced into Louisiana and California, where it has done considerable damage to flower and vegetable gardens. It apparently does little damage in citrus groves, preferring vegetables and truck crops.

II SLUGS

Subclass PULMONATA

Order SYSTELLOMMATOPHORA

Family VERONICELLIDAE

This is a tropical family of primitive slugs that have their eyes on contractile (not inversible) stalks or tentacles (see Plate I, C). The mantle covers the entire back of the animal and contains neither an external nor internal shell. The lung is posteriorly located, with the breathing pore and excretory openings behind the foot. Only one species (Veronicella floridana), found in Florida, is native to the United States.

Veronicella moreleti Crosse and Fischer

Plate VII, B

Animal large, oblong, with rounded back and sharply angular lateral borders. It is ashy to brownish-gray, mottled with black, and has a median whitish line with a long dark longitudinal band on each side about 1/3 the distance to the mantle margin. The mantle covers the entire back of the animal. Adults are 70-90 mm. long.

Distribution. Mexico.

This slug is a voracious feeder, often destructive in gardens.

Order STYLOMMATOPHORA

Division AULACOPODA

Family ARIONIDAE

This family of slugs, and also the Limacidae, have their eyes on inversible (not contractile) tentacles (see Place I, C), and have a mantle that covers only the anterior part of the body and which contains only an internal vestigial shell. Arion, of this family, can be distinguished from the limacid slugs, Milax, Deroceras, and Limax, by the position of the breathing pore. In the latter genera it is located in the posterior half of the mantle; in Arion in the anterior half.

Distribution. Holarctic in distribution, with species native to western North America, Asia, Europe, and Africa.

Arion circumscriptus Johnston

Plate VII, I

Animal small, pale creamy-[illegible], darker dorsally, with a black and sharply-defined lateral band extending the whole length of the body on each side. Posterior end rounded (when viewed from above), its mucous pore conspicuous. The suprapedal groove is indistinct. The mantle is granulate, but not concentrically wrinkled, with the breathing pore in its anterior half and below the right pigment band. This species exudes clear mucus.

Distribution. Northern and central Europe. Introduced into America; in this country there are local records from Maine, Massachusetts, New York, Pennsylvania, District of Columbia, Michigan, Indiana, Wisconsin, and California.

This species and the related A. hortensis and A. ater have been widely spread by commerce and can cause considerable damage to greenhouses and vegetable and flower gardens.

Arion hortensis Férussac

Plate VII, J

This species is very similar in size and shape to A. circumscriptus, but is darker, and the breathing pore is located in the right mantle pigment band rather than below it. It also has yellow or orange instead of clear mucus.

Distribution. Iceland, Faroes, Middle Europe, British Isles. Introduced locally into Canada, Pennsylvania, Washington, and California.

Arion ater (Linnaeus)

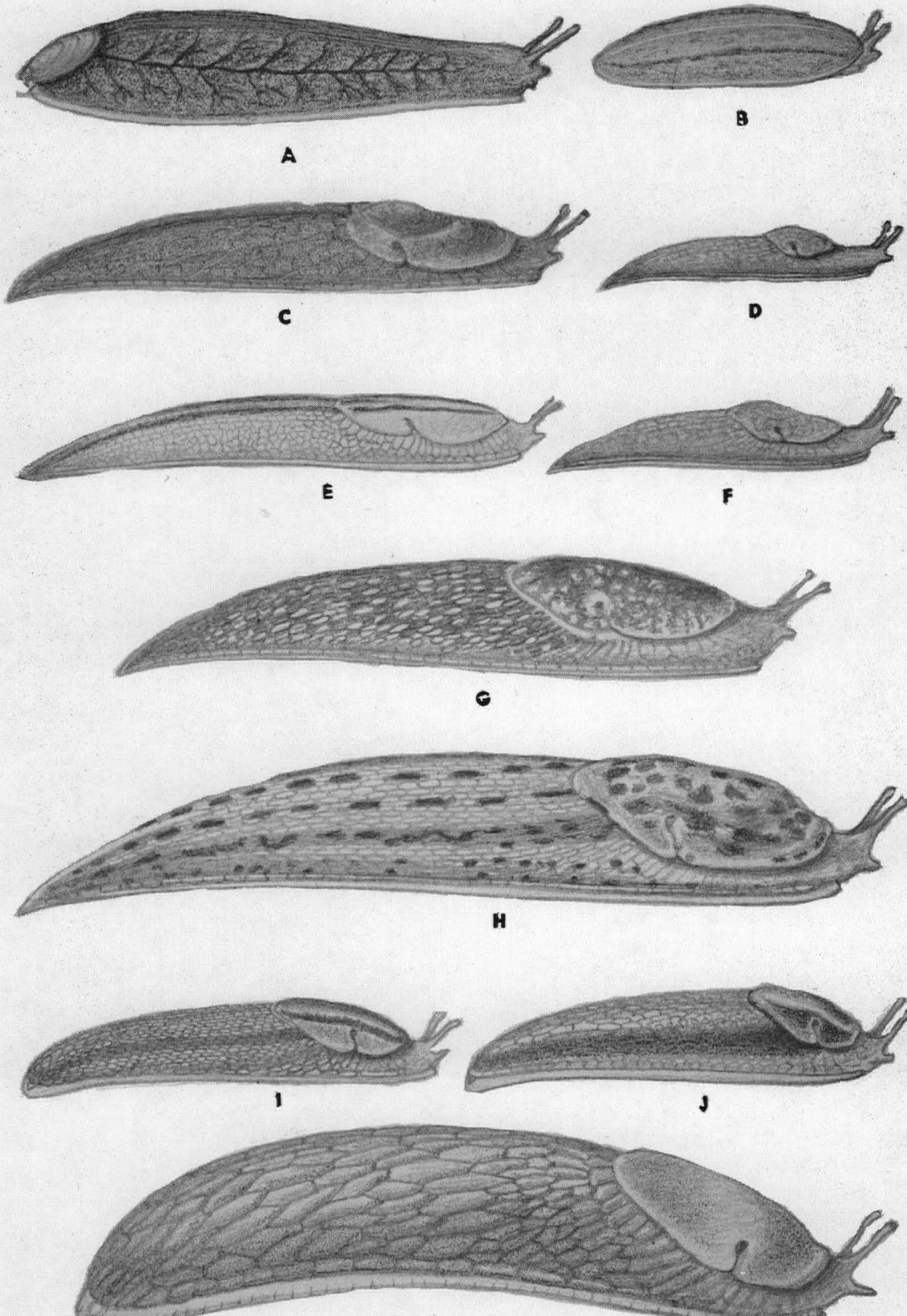
Plate VII, K

This slug has the same general characters as the two preceding species, but is much larger, has a bulkier body, and is without darker pigment bands. Adults measure up to 150 mm. when extended.

EXPLANATION OF PLATE VII

TESTACELLA AND ECONOMICALLY IMPORTANT SLUGS

A. Testacella haliotidea Draparnaud.
B. Veronicella moreleti Crosse and Fischer.
C. Milax gagates (Draparnaud).
D. Deroceras caruanae (Pollonera).
E. Limax marginatus Müller.
F. Deroceras reticulatum (Müller).
G. Limax flavus Linnaeus.
H. Limax maximus Linnaeus.
I. Arion circumscriptus Johnston.
J. Arion hortensis Férussac.
K. Arion ater (Linnaeus).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Distribution. Central and northern Europe. Introduced locally into Canada, Maine, and Michigan.

Family LIMACIDAE

Slugs of this family differ externally from Arion of the previous family by the posterior position of the breathing pore in the mantle, the keeled back, posteriorly pointed foot, and absence of a mucous gland at the tail. They are native to Europe and adjacent parts of Asia and Africa; in addition some species of Deroceras occur naturally in northern Asia and North America.

Milax gagates (Draparnaud)

Plate VII, C

Animal of medium size, dark gray or black without darker or lighter bands. The posterior end is pointed, without a mucous pore; the back strongly keeled. Sides of body with distinct pedal and suprapedal grooves. The mantle is slightly granulose, but not concentrically wrinkled, its central portion bounded by a groove. The breathing pore is in the right posterior half of the mantle. Adults are 60-70 mm. long when extended.

Distribution. British Isles, Europe, South Africa, Australia, Tasmania, Mediterranean countries. Introduced in many European colonies and in the United States (Pennsylvania, Virginia, Idaho, Washington, Oregon, and California).

This "Greenhouse Slug" is a destructive pest in gardens and greenhouses. It is largely subterranean in habit, burrowing in the soil and feeding on roots.

Deroceras reticulatum (Müller)
(=Agriolimax agrestis Linnaeus)
Plate VII, F

Animal small, with a relatively short neck, moderately keeled tail, and prominent pedal and suprapedal grooves. It is whitish, cream, or flesh-colored, usually heavily mottled with gray or black. The mantle is concentrically wrinkled, the breathing pore in its posterior half. Adults measure 35-50 mm. in length when extended.

Distribution. British Isles, Europe, and adjacent parts of Asia and Africa.

The "Gray Garden Slug" has been introduced by commerce into nearly every temperate and subtropical country settled by Europeans and is very widely distributed in the United States. It is gregarious, and in countries where it is introduced is usually confined to the vicinity of towns and cultivated areas. It is a destructive pest in gardens, feeding on almost any vegetable crop, and is especially injurious to young plants.

Deroceras caruanae (Pollonera)

Plate VII, D

Animal very similar to D. reticulatum but is smaller (about 25 mm. long when extended) and has a relatively longer neck, nearly as long as the mantle when the slug is active.

Distribution. Mediterranean countries. Introduced into the British Isles, Canary Islands, and locally in California.

Limax marginatus Müller
(=Limax arborum Bouchard-Chantereaux)
Plate VII, E

Animal of medium size with a pointed and keeled tail. Its color is generally light brown, often pale gray, with two or three deep gray or blackish longitudinal bands. Both the pedal and suprapedal grooves are prominent. The mantle is concentrically wrinkled, the breathing pore on the right posterior side. The mucus is colorless. Adults measure 50-75 mm. in length when extended.

Distribution. Europe generally. Introduced locally in Australia, New Zealand, Newfoundland, and in the United States in Maryland, Missouri, Colorado, and California.

Limax flavus Linnaeus

Plate VII, G

This slug is very similar to L. marginatus, but is larger, colored gray or black, and marked with yellowish spots. Its mucus is yellow rather than colorless. Adults are 75-100 mm. long when extended.

Distribution. Temperate Europe. Introduced into many European colonies, and in many places in the United States.

The habits of L. flavus in this country are very similar to those of Deroceras reticulatum. It is a slug of urban and suburban gardens, greenhouses, and other cultivated places.

Limax maximus Linnaeus

Plate VII, H

This species is similar to L. marginatus and L. flavus, but is usually larger, yellowish-gray, and spotted with black. Its mucus is colorless. Adults are often more than 100 mm. long.

Distribution. Europe, Asia Minor, Algeria. Introduced into North and South America, South Africa, Australia, Hawaii, and many places in the United States.

This slug is common in urban and suburban gardens, cellars, and similar places.

III FRESH-WATER SNAILS

Subclass PROSOBRANCHIATA

Order MESOGASTROPODA

Family BITHYNIIDAE

An aquatic group of medium to small operculate snails with a worldwide distribution. Its species have conical or subspherical shells and a corneous or calcareous operculum. This family is of great medical importance because some of its members carry the human blood and liver flukes in the Orient.

Parafossarulus manchouricus (Bourguignat)

Plate VIII, G

Shell broadly conic, imperforate, yellowish-brown to green, usually with 5-10 spiral ribs or lirae. Operculum thick and calcareous; concentric, with a small subcentral spiral nucleus. Adults (with 4-5 whorls) measure 8-12 mm. in height.

Distribution. China, Formosa, Japan.

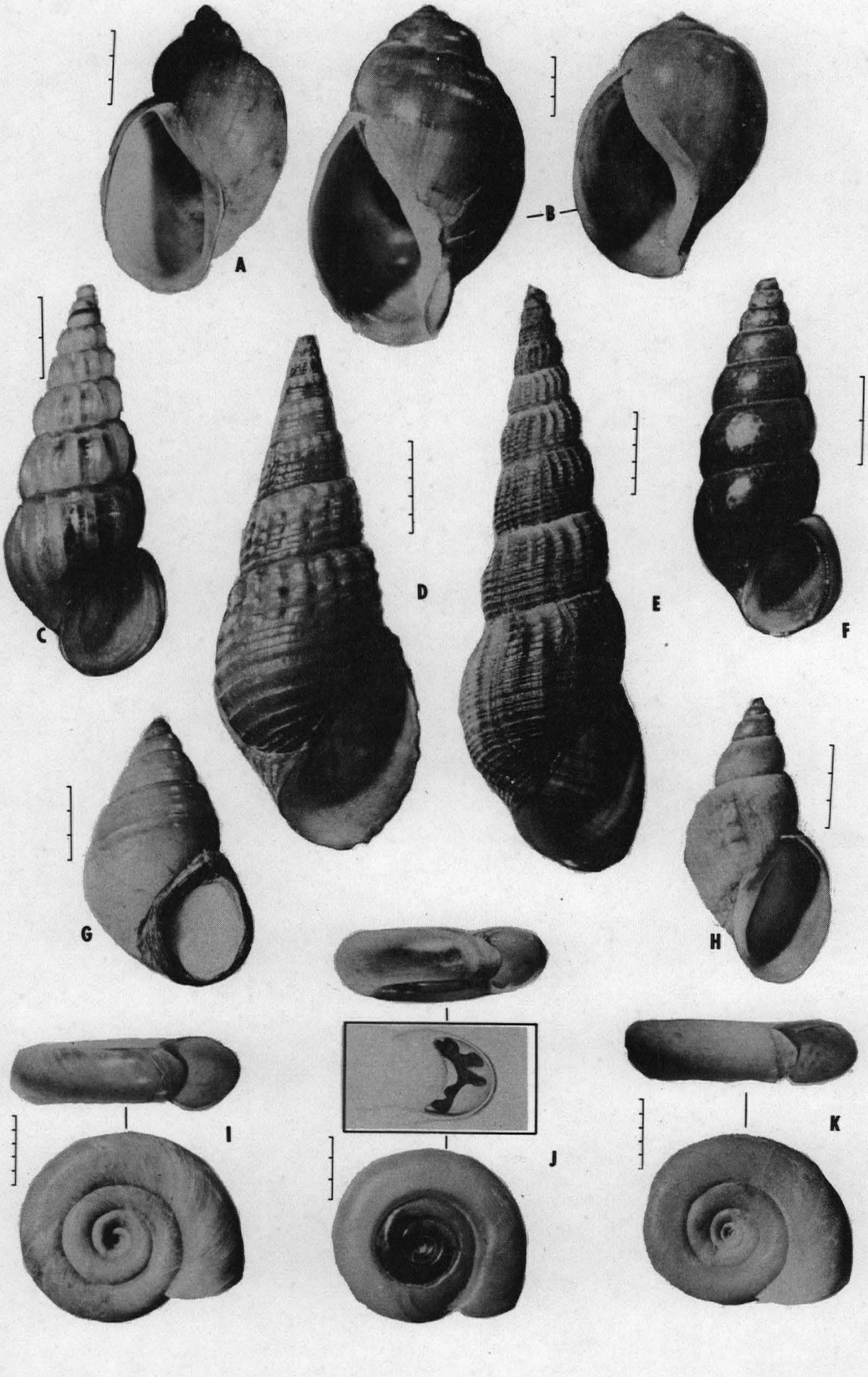
This species is one of the main carriers of the human liver fluke in the Orient.

EXPLANATION OF PLATE VIII

MEDICALLY IMPORTANT FRESH-WATER SNAILS

A. Bulinus truncatus (Audouin).
B. Bulinus (Physopsis) africanus Krauss.
C. Pomatiopsis (Oncomelania) hupensis (Gredler).
D. Tarebia granifera (Lamarck).
E. Melanoides tuberculata (Müller).
F. Pomatiopsis (Oncomelania) nosophora (Robson).
G. Parafossarulus manchouricus (Bourguignat).
H. Fossaria truncatula (Müller).
I. Planorbina glabrata (Say).
J. Armigerus obstructus (Morelet).
K. Biomphalaria alexandrina (Ehrenberg).

Scale lines represent millimeters.



A
B
C
D
E
F
G
H
I
J
K

Pomatiopsis (Oncomelania) hupensis (Gredler)

Plate VIII, C

Shell small and slender, conic, imperforate, gray-brown to yellowish, usually with many high transverse ribs. Operculum thin, translucent, colorless, and paucispiral. Adults (with 6-9 whorls) measure 7-10 mm. in height.

Distribution. Yangtze River drainage system in China.

This species and the related P. nosophora and P. quadrasi, are the vectors of schistosomiasis, or the human blood fluke disease, in the Orient. P. formosana has not been directly implicated in transmitting the human schistosome, but is known to carry a strain which infects livestock and probably can carry the human strain. All four species are commonly referred to the genus Oncomelania.

Pomatiopsis (Oncomelania) nosophora (Robson)

Plate VIII, F

This species is very similar to P. hupensis but is smaller, barely perforate, and lacks the heavy axial ribs. It is slightly larger and has a relatively narrower body whorl than P. formosana and P. quadrasi. The height of its body whorl is 2-3 times that of its penultimate whorl. Its color is chestnut brown. Adult shells (with 6-9 whorls) measure 5-10 mm. in height.

Distribution. Japan; central and southern China.

Pomatiopsis (Oncomelania) formosana (Pilsbry and Hirase)

Shell barely perforate, similar to its related species, but without the axial ribs of P. hupensis, and with a body whorl that is relatively broader than P. nosophora, and narrower than P. quadrasi. The height of the body whorl is 4 times that of the penultimate whorl. Color chestnut brown to horn. Adult shells (with 6-7 whorls) measure 6-7 mm. in height.

Distribution. Formosa.

Pomatiopsis (Oncomelania) quadrasi (Moellendorff)

Shell similar to its related species, with a relatively larger body whorl, imperforate or nearly so, and without axial ribs. The height of the body whorl is about 5 times that of the penultimate whorl. Color dark horn to chocolate brown. Adult shells (with 6-7 whorls) measure 3-5 mm. in height.

Distribution. Philippine Islands.

Family PLEUROCERIDAE

This family contains medium to large aquatic snails with rather solid, thick, conical to globose shells with corneous opercula. It is widely distributed with species in North, Central, and South America, Africa, and Asia. The genus of prime medical importance is Semisulcospira, which, along with Melanoides and Tarebia of the family Thiaridae, is often called Melania in the older literature. One species, Semisulcospira libertina, is the main vector of paragonimiasis, the human lung fluke disease in the Orient.

Semisulcospira libertina (Gould)

Plate IV, O

Shell large, imperforate, with rather flattened whorls and unimpressed sutures, sculptured with many small, raised, spiral lines (lirae) and often with low transverse wrinkles. The tip of the spire is often eroded away. Color light yellowish-brown to almost black. Operculum paucispiral, thin, dark brown, the nucleus near the base. Uneroded adults (with 9-12 whorls) measure 30-50 mm. in height.

Distribution. Japan, Korea, Okinawa, Formosa.

Family THIARIDAE

This is another widely distributed family of aquatic operculate snails of considerable medical importance. Their shells are similar to the pleurocerids, but their methods of reproduction are quite different. Several of the Oriental species are the principal vectors of human lung and liver fluke diseases.

Melanoides tuberculata (Müller)

Plate VIII, E

Shell similar to Semisulcospira libertina, but narrower, with smaller aperture, having more rounded whorls with impressed sutures, more conspicuous spiral lirae, and often transverse ribs on the spire whorls. In some localities, the shells are marked with transverse reddish-brown streaks. Uneroded adults (with 9-12 whorls) measure 30-50 mm. in height.

Distribution. Southern China, Formosa, Philippines, East Indies.

This species is a first intermediate host of the human liver fluke. It is sometimes placed in the genus Thiara.

Tarebia granifera (Lamarck)

Plate VIII, D

This species is similar to Semisulcospira libertina and Melanoides tuberculata but has shouldered, flat-sided whorls with impressed sutures, is sculptured with many spiral rows of small beads rather than lirae, and has a larger aperture. Color chestnut-brown to olive-brown. Uneroded adults (with 9-12 whorls) measure 30-50 mm. in height.

Distribution. Formosa, Philippines, Micronesia, Melanesia, East Indies.

This species is a first intermediate host of the human lung fluke. It is sometimes placed in the genus Thiara.

Subclass PULMONATA

Order BASOMMATOPHORA

Family LYMNAEIDAE

This and the following family, the Planorbidae, include aquatic lung breathers that lack opercula. Both families are world-wide in distribution and contain several medically important species. Of chief importance, all transmitting the human and domestic anima liver flukes, are the species Fossaria truncatula, F. ollula, and Radix natalensis. All three species are sometimes placed in the genus Lymnaea.

Fossaria truncatula (Müller)

Plate VIII, H

Shell small, perforate, opaque, moderately glossy, without regular spiral striae. Its color is whitish to pale horn. The sutures are impressed, the columella straight, without a plait. The aperture is ovate, less than 1/2 the height of the shell, its outer lip sharp, the columellar lip reflected. Adults (with about 6 whorls) measure 8-12 mm. in length.

Distribution. Europe, eastern and central Asia, Asia Minor, North Africa.

Fossaria ollula (Gould)

Plate IV, M

Shell similar to F. truncatula, but more globose, with a relatively larger body whorl and aperture (aperture length more than 1/2 the length of the shell), and somewhat darker in color (usually light brown). Sometimes a very slight columellar plait tends to be present. Adults (with about 6 whorls) measure 10-13 mm. in length.

Distribution. China, Japan. Introduced in Hawaii.

Radix natalensis (Krauss)

Plate IV, N

Shell small to medium, very thin, narrowly perforate or imperforate, translucent, moderately glossy, whitish to light brown or horn, sculptured with minute spiral striae. The spire is short with moderately impressed sutures; the body whorl and aperture are very large (the aperture length is more than 2/3 the height of the shell), the aperture ovate-lunate with sharp lips.

The columella is twisted into a distinct plait. Adults (with 4-5 whorls) measure 15-25 mm. in length.

Distribution. Africa, Madagascar.

Family PLANORBIDAE

This family contains mostly discoidal species, but a few, such as Bulinus africanus and Bulinus truncatus, are oval or elongate. The snails that carry the human blood fluke in Africa, South America, and the West Indies belong to this family.

Armigerus obstructus (Morelet)

Plate VIII, J

Shell relatively small and disk-shaped, rather glossy, whitish to light brown or olive horn, sculptured with fine spiral striae and growth lines. The spire is depressed below the body whorl, the sutures impressed. Aperture rather deeply lunate, usually with lamellae or teeth. Adults (with 5-6 whorls) are 5-8 mm. wide.

Distribution. Louisiana, Texas, Mexico, Guatemala.

This species is closely related to snails of the genus Biomphalaria and Planorbina and may be congeneric with these groups.

Biomphalaria alexandrina (Ehrenberg)
(Afroplanorbis, B. boissyi)

Plate VIII, K

The shell is similar to Armigerus obstructus but is larger and its aperture lacks teeth. Adults (with 5-6 whorls) are 18-22 mm. in diameter.

Distribution. Egypt, the Sudan.

This species and Bulinus africanus and Bulinus truncatus are the main carriers of the human blood fluke in Africa.

Planorbina (Australorbis, Taphius) glabrata (Say)
(=Biomphalaria alexandrina?)

Plate VIII, I

The shell of this species is identical to that of Biomphalaria alexandrina, but often becomes much larger, adults measuring up to 35 mm. in diameter.

Distribution. West Indies, northern South America.

This species is the carrier of the human blood fluke in the tropics of this hemisphere.

Bulinus (Physopsis) africanus Krauss

Plate VIII, B

Shell sinistral, higher than wide, globose, umbilicate, perforate or imperforate, whitish to chestnut brown, sculptured with fine growth lines; whorls evenly rounded. Aperture ovate-lunate; outer lip sharp; columella truncate. Adult shells (with 4-5 whorls) are 14-20 mm. high.

Distribution. Natal, Transvaal, Southern Rhodesia, Mozambique, southern Tanganyika.

Bulinus truncatus (Audouin)

Plate VIII, A

Shell very similar to Bulinus africanus, but with a straight or slightly curved rather than truncate columella, and shouldered whorls. Adults (with 4-5 whorls) are 14-20 mm. long.

Distribution. Northern and eastern Mediterranean countries, Egypt, the Sudan, and Uganda.

KEY FOR THE IDENTIFICATION OF ECONOMICALLY IMPORTANT SNAILS AND SLUGS

1a.	Animal WITH A VISIBLE SHELL; either land or fresh-water inhabitant	11
1b.	Animal WITHOUT AN EXTERNAL SHELL; land inhabitant	2
2a.	Mantle covering the ENTIRE back of the animal	Veronicella moreleti
2b.	Mantle covering only an anterior PORTION of the animal	3
3a.	Breathing pore in ANTERIOR half of right side of mantle; back never keeled in adults; posterior end ROUNDED when viewed from above	4
3b.	Breathing pore in POSTERIOR half of right side of mantle; back keeled, either at posterior end or entirely; posterior end POINTED when viewed from above	6
4a.	LARGE, adults more than 70 mm. (2-3/4 inches) when extended; sides of body WITHOUT dark longitudinal bands	Arion ater
4b.	SMALLER, adults less than 60 mm. (2-3/8 inches) when extended; sides of body WITH dark longitudinal bands	5
5a.	Breathing pore BELOW right mantle pigment band; mucus clear	Arion circumscriptus
5b.	Breathing pore IN right mantle pigment band; mucus yellow or orange	Arion hortensis
6a.	Back strongly KEELED; mantle granulate but NOT CONCENTRICALLY WRINKLED, its central part bounded by a groove	Milax gagates
6b.	Back keeled only near the end; mantle CONCENTRICALLY WRINKLED, without a groove	7
7a.	LARGE, adults more than 50 mm. (2 inches) when extended; body usually either BANDED or CONSPICUOUSLY SPOTTED	8
7b.	MEDIUM or SMALL, adults less than 38 mm. (1-1/2 inches) when extended;body not banded, and if spotted, either inconspicuously spotted or mottled	10
8a.	Mantle and back with dark longitudinal BANDS; body color generally light brown; mucus colorless	Limax marginatus
8b.	Mantle, and usually back, SPOTTED or mottled rather than with continuous bands; body color yellowish to gray; mucus yellow or colorless	9
9a.	Mantle and body BLACK-SPOTTED; mucus colorless	Limax maximus
9b.	Mantle and body gray with YELLOWISH SPOTS; mucus yellow	Limax flavus
10a.	Neck, when extended, almost as LONG as the mantle	Deroceras caruanae
10b.	Neck, when extended, much SHORTER than the mantle	Deroceras reticulatum
11a.	Shell too SMALL to cover contracted animal; land inhabitant	12
11b.	Shell large enough to conceal contracted animal; either land or fresh-water inhabitant	13

12a. Adult shell large, 13 mm. (1/2 inch) or more in length; elongate ... Testacella maugei
12b. Adult shell smaller, less than 10 mm. (3/8 inch) in length; oval .. Testacella haliotidea

13a. Shell WIDER THAN HIGH 14
13b. Shell HIGHER THAN WIDE 46

14a. Animal with an OPERCULUM (a cover to close aperture of shell) ..... Helicina zephyrina
14b. Animal WITHOUT AN OPERCULUM 15

15a. Spire of shell raised ABOVE body whorl 16
15b. Spire of shell depressed BELOW body whorl 43

16a. Shell SHARPLY CARINATE .... Hygromia cinctella
16b. Shell NOT CARINATE 17

17a. Shell IMPERFORATE or nearly so; adult shell generally
20 mm. (3/4 inch) or more in width 18
17b. Shell distinctly UMBILICATE, adult shell less than 20
20 mm. (3/4 inch) in width 28

18a. Lip REFLECTED 19
18b. Lip NOT REFLECTED, or only rarely slightly expanded 24

19a. Shell WITH fine spiral sculpture 20
19b. Shell WITHOUT fine spiral sculpture 22

20a. Shell sculptured with interrupted, fine, spiral WRINKLES
or MALLEATIONS .... Otala vermiculata
20b. Shell sculptured with more or less continuous, fine, impressed spiral LINES 21

21a. Shell WHITE with reddish-brown markings .... Otala lactea
21b. Shell YELLOW with reddish-brown markings .... Helicigona arbustorum

22a. Lip WHITE 23
22b. Lip REDDISH-BROWN to almost black .... Cepaea nemoralis

23a. Color bands always present and INTERRUPTED
by yellow flecks or streaks .... Helix aspersa
23b. Color bands CONTINUOUS, but not always present .... Cepaea hortensis

24a. Body whorl disproportionately LARGE; spire very SMALL;
shell not banded .... Helix aperta
24b. Body whorl proportionately SMALLER; spire distinctly RAISED
above body whorl; shell generally with color bands 25

25a. Shell LARGE, adult shell 25 mm. (1 inch) or more in width; nuclear
whorls not black or dark brown, but usually HORN-COLORED 26
25b. Shell MEDIUM, adult shell 20 mm. (3/4 inch) or less in width,
nuclear whorls black or dark brown .... Theba pisana

26a. Adult shell 40 mm. (1-5/8 inches) or more in width; depressed
(height 3/4 of width); with DARK brown spiral bands .... Helix lucorum
26b. Adult shell usually less than 40 mm. (1-5/8 inches) in width; al-
most as high as wide; generally with PALE BROWN or tan color bands 27

27a. Adults SMALLER, 30 mm. (1-3/16 inches) or less in width; IMPERFORATE .. Helix figulina
27b. Adults LARGER, 30 mm., or MORE in width; PERFORATE
to umbilicate .... Helix pomatia

28a. Lip of adult REFLECTED .... Bradybaena similaris
28b. Lip STRAIGHT, not reflected 29

29a. Shell translucent and very GLOSSY; spire very low,
hardly raised above body whorl 30
29b. Shell slightly glossy to DULL, opaque or only slightly translucent,
spire higher, a definite apex projecting above the body whorl 32

30a. Shell relatively LARGER, adult shell 10 mm. (3/8 inch) or MORE
in width; animal either pale or very dark 31
30b. Shell SMALLER, adult shell 8 mm. (5/16 inch) or LESS
in width; animal very dark .... Oxychilus alliarius

31a. Animal PALE gray .... Oxychilus cellarius
31b. Animal very DARK blue-black or blue-gray .... Oxychilus draparnaldi

32a. Whorls WITH spiral color bands 33
32b. Whorls WITHOUT spiral color bands 39

33a. WIDELY umbilicate, umbilicus 1/4 or more the diameter of the shell ... Helicella itala
33b. NARROWLY umbilicate, umbilicus 1/5 or less than the diameter of the shell ... 34

34a. Shell LARGER, adult shell 12 mm. (1/2 inch) or more in width 35
34b. Shell MEDIUM TO SMALL, adult shell usually less than 12 mm. (1/2 inch) in width .. 36

35a. Umbilicus very NARROW, 1/8 or less the diameter of the shell ...... Helicella maritima
35b. Umbilicus WIDER, about 1/5 the diameter of the shell .... Helicella variabilis

36a. Shell HIRSUTE (covered with fine hairs) .... Helicella conspurcata
36b. Shell NOT hirsute 37

37a. Spire HIGH and POINTED; aperture OVATE-LUNATE .... Helicella pyramidata
37b. Spire LOW and BLUNTLY CONVEX; aperture ROUNDLY LUNATE 38

38a. Surface with rather heavy, close, raised transverse lines .... Helicella striata
38b. Surface without prominent transverse lines .... Helicella caperata

39a. Shell LARGER, adult shell 14 mm. (9/16 inch) or more in width 40
39b. Shell SMALLER, adult shell less than 13 mm. (1/2 inch) in width 41

40a. Last whorl NOT DEFLECTED .... Monacha cantiana
40b. Last whorl DEFLECTED .... Monacha carthusiana

41a. Umbilicus SHALLOW, showing 1/2 whorl or less .... Monacha schotti
41b. Umbilicus DEEP, showing all the whorls 42

42a. Periphery of last whorl ROUNDED .... Hygromia hispida
42b. Periphery of last whorl obtusely ANGULAR .... Hygromia striolata

43a. Shell marked with interrupted, reddish COLOR BANDS; land .... Solaropsis monile
43b. Shell WITHOUT any COLOR BANDS; fresh-water 44

44a. Relatively LARGE, adult shell 15-30 mm. (1/2 - 1-1/8 inches) in width 45
44b. Relatively SMALL, adult shell less than 10 mm. (3/8 inch in width . Armigerus obstructus

45a. African in origin .... Biomphalaria alexandrina
45b. West Indies and South American in origin .... Planorbina glabrata

46a. Animal with an OPERCULUM (a cover to close aperture of shell); fresh-water inhabitants 47
46b. Animal WITHOUT AN OPERCULUM; land or fresh-water inhabitants 54

47a. Shell LARGE, adults 25 mm. (1 inch) or more in height; operculum paucispiral, with the nucleus near the base 48
47b. Shell MEDIUM to SMALL, adults less than 15 mm. (3/8 inch); operculum paucispiral or concentric, the nucleus a little distance from the base 50

48a. Spiral ridges on the shell intersected by TRANSVERSE FURROWS, making them appear as rows of beads .... Tarebia granifera
48b. Spiral ridges on the shell NOT intersected by transverse furrows, but continuous 49

49a. Whorls WELL-ROUNDED .... Melanoides tuberculata
49b. Whorls FLAT-SIDED, or only slightly rounded .... Semisulcospira libertina

50a. Shell usually with raised SPIRAL RIDGES; operculum THICK, calcareous, and CONCENTRIC, with a small subcentral, spiral nucleus .... Parafossarulus manchouricus
50b. Shell WITHOUT spiral ridges; operculum THIN, translucent, colorless and PAUCISPIRAL 51

51a. Whorls WITH transverse ribs .... Pomatiopsis (Oncomelania) hupensis
51b. Whorls WITHOUT transverse ribs 52

52a. Body whorl proportionately LARGE in both height and width, its height FIVE TIMES that of the penultimate whorl .... Pomatiopsis (Oncomelania) quadrasi
52b. Body whorl proportionately SMALLER, making the shell appear more slender, its height LESS than five times that of the penultimate whorl 53

53a. Height of body whorl about FOUR TIMES that of the penultimate whorl .... Pomatiopsis (Oncomelania) formosana
53b. Height of body whorl TWO TO THREE TIMES that of the penultimate whorl .... Pomatiopsis (Oncomelania) nosophora

54a. Spire partly BROKEN OFF in adult shells .... Rumina decollata
54b. Spire normally NOT BROKEN OFF 55

55a. Shell LARGE, adults up to 65 X 20 mm. (2-1/2 X 3/4 inches); land snails 56
55b. SHELL MEDIUM TO SMALL, adults less than 25 X 6 mm.
(1 X 1/4 inches); land or fresh-water 58

56a. Aperture NARROW, its width LESS than 1/2 its length .... Euglandina striata
56b. Aperture more OVAL, its width 1/2 or MORE of its length 57

57a. Lip of adult PURPLE, reflected; columella not TRUNCATE .... Porphyrobaphe iostoma
57b. Lip of adult NEITHER PURPLE NOR REFLECTED;
columella TRUNCATE .... Achatina fulica

58a. Whorls either WITH color bands or marked with alternating
transverse opaque and translucent bands 59
58b. Whorls WITHOUT color bands and alternating opaque and translucent bands 61

59a. Spire whorls ROUNDED; shell relatively WIDER,
width more than 1/2 the height 60
59b. Spire whorls FLATTENED; shell NARROWER,
width less than 1/2 the height .... Cochlicella barbara

60a. Shell almost as wide as high; aperture ROUNDLY LUNATE .... Cochlicella conoidea
60b. Shell distinctly higher than wide; aperture OVATE-LUNATE .... Cochlicella ventrosa

61a. Shell SINISTRAL (wound to the left); fresh-water 62
61b. Shell DEXTRAL (wound to the right); land and fresh-water 63

62a. Columella TRUNCATE .... Bulinus (Physopsis) africanus
62b. Columella STRAIGHT .... Bulinus truncatus

63a. Aperture MORE than 1/3 the height of the shell; fresh-water 64
63b. Aperture 1/3 or LESS the height of the shell; land inhabitants 66

64a. Columella STRAIGHT, without a plait; aperture LESS
than 2/3 the height of the shell 65
64b. Columella TWISTED into a distinct plait; aperture
MORE than 2/3 the height of the shell .... Radix natalensis

65a. Aperture MORE than 1/2 the height of the shell .... Fossaria ollula
65b. Aperture LESS than 1/2 the height of the shell .... Fossaria truncatula

66a. Base of columella TRUNCATE; shell imperforate 67
66b. Base of columella STRAIGHT, not truncate; shell perforate 69

67a. Shell SMALL, adults (with 5-6 whorls) less than 6 mm. (1/4 inch)
long; very glossy; shell surface SMOOTH or only very weakly striate 68
67b. Shell MEDIUM, adults more than 6 mm. (1/4 inch) long;
moderately glossy; shell surface STRIATE .... Subulina octona

68a. Base of columella ABRUPTLY truncate; no callus on parietal
wall; whorls nearly flat-sided; shell surface weakly STRIATE .... Cecilioides acicula
68b. Base of columella MODERATELY truncate; callus present on
parietal wall; whorls convex; shell surface SMOOTH .... Cecilioides aperta

69a. Shell surface sculptured with RAISED AXIAL RIBS; aperture length LESS than 1/4 the shell height. .... Lamellaxis micra
69b. Shell surface WITHOUT raised axial ribs; aperture length MORE than 1/4 the shell height. 70

70a. Sutures distinctly CRENULATE (that is, undulated or scalloped)...... Opeas pyrgula
70b. SUTURES STRAIGHT or only very slightly crenulate 71

71a. Upper lip STRONGLY RETRACTED to the suture .... Opeas pumilum
71b. Upper lip STRAIGHT or only moderately retracted at the suture. 72

72a. Shell HEAVILY STRIATE; NOT GLOSSY .... Lamellaxis gracilis
72b. Shell moderately to weakly striate; GLOSSY 73

73a. Shell very glossy; weakly striate .... Lamellaxis mauritianus
73b. Shell moderately glossy; moderately striate .... Lamellaxis clavulinus

GLOSSARY

ANGULAR Having an angle rather than a round contour (Plate III, P).

APERTURE The opening or "mouth" of a gastropod shell (Plate II, A, C).

APEX The tip of a gastropod shell farthest away from its aperture (Plate II, A).

AXIAL Parallel to the axis or columella of the shell; running across or transverse to the direction of the whorls; the opposite of "spiral."

BASAL Pertaining to, situated at, or forming, the base; that part of the shell furthest from its apex.

BODY WHORL The last whorl of a spiral gastropod shell, measured from the outer lip back to a point immediately above the outer lip (Plate II, A, C).

BREATHING PORE Outside opening of the pulmonary cavity in lung breathing snails (Plate II, D).

BROADLY LUNATE See Plate III, X.

CALCAREOUS Composed of carbonate of lime (calcium carbonate).

CALLUS A deposit of lime or shell material, often as a thickening near the umbilicus.

CAUDAL Situated in or near the tail or posterior end.

COLUMELLA The internal column around which the whorls revolve; the axis of a spiral shell (Plate II, A; Plate III, N).

CONCENTRIC From or about the same center, as in the case of lines of growth in some opercula (Plate III, AE, AF).

CONTRACTILE Capable of reducing length by shortening and thickening (Plate I, C).

CORNEOUS Horn-like.

CRENULATE Scalloped or notched (Plate III, E).

DECOLLATE Cut off, that is, the top several whorls of the spire (Plate I, K).

DEEPLY LUNATE See Plate III, Y.

DEPRESSED Flattened.

DEXTRAL Would or spiraled to the right (Plate II, B-1).

DISCOIDAL Round and flat like a disk.

EMBRYONIC SHELL The earliest whorls that are formed in the egg.

EPIPHRAGM A hardened mucous covering that seals the aperture in most land and some fresh-water snails, and prevents desiccation during dry spells.

FOOT The locomotory organ of mollusks; it is often variously modified for digging, grasping prey, etc. In snails it is the long, broad, ventral surface of the animal (Plate I, B; Plate II, D).

FUSIFORM Shaped like a spindle.

GASTROPOD A member of the mollusk class Gastropoda; a snail, slug or limpet (Plate I, A).

GLOBOSE Globular. Formed like a globe; spherical.

GRANULOSE Covered with minute grains or beads.

GROWTH LINE A line on the surface of a shell indicating a rest period during growth (Plate II, A).

HIRSUTE Covered with hairs (Plate II, C-7).

IMPERFORATE Lacking a perforation or umbilicus on the ventral or anterior end of the shell (Plate III, AB).

IMPRESSED Marked by a furrow (Plate III, K).

INVERSIBLE Capable of withdrawing by being inverted (Plate I, C-3).

KEEL A sharp edge; carina (Plate II, D; Plate III, O).

LAMELLA A fold or raised callus in the aperture of a shell.

LIMPET A gastropod with a low, conical, unspiraled (or nearly so) shell.

LIP Edge of the aperture; also called peristome (Plate II, A; Plate III, D, E, F, H, I).

LIRAE Raised lines or ridges running in the same direction as the whorls (Plate II, C-2).

LIRATE Bearing raised spiral lines or ridges (Plate II, C-2).

LUNATE Shaped like a half-moon (Plate III, U, V, W, X, Y).

MALLEATE Dented as if hit with a hammer.

MANTLE A membranous flap or outer covering of the softer parts of a mollusk; it secretes the shell.

MOUTH The opening or aperture of a gastropod shell.

MUCUS A viscid, slippery secretion; slime.

MULTISPIRAL Having many spirals or whorls (Plate III, AC).

NARROWLY OVAL See Plate III, T.

NARROWLY OVATE-LUNATE See Plate III, W.

NUCLEUS The first part or beginning of a shell or operculum, that is, the nuclear whorls or protoconch in snail shells (Plate II, A: Plate III, AD, AE).

OBLONG Longer in one direction than in another, with sides more or less parallel.

OPAQUE Not transparent or translucent.

OPERCULATE Bearing an operculum or cover to close the aperture (Plate I, B).

OPERCULUM A horny or calcareous plate that serves the purpose of closing the aperture when the snail withdraws into its shell (Plate I, B; Plate III, AC, AD, AE, AF).

OUTER LIP The outer edge of the aperture (Plate II, A).

OVATE-LUNATE See Plate III, V.

PALATAL Pertaining to the outer lip of a spiral gastropod shell.

PARIETAL Pertaining to the inner wall of the aperture; the part of the body whorl opposite the outer lip (Plate II, A).

PAUCISPIRAL Of few rapidly enlarging whorls or turns (Plate III, AD).

PEDAL GROOVE A longitudinal groove in the body of a snail that marks the boundary where the tuberculate side wall of the foot joins the smooth ventral sole (Plate II, D).

PENULTIMATE WHORL The whorl before the last, or body whorl (Plate II, A, C).

PERFORATE Having a minute opening at the base of the shell (Plate III, AA).

PERIPHERY The part of a whorl most distant from its central axis.

PLAIT A fold on the columella (Plate II, A).

REFLECTED Turned back (Plate III, 1).

ROUNDLY LUNATE See Plate III, U.

SCULPTURE The natural surface markings, other than those of color, usually found on snail shells (Plate II, A, C).

SHELL The hard, usually calcareous, protective covering of mollusks (Plate I, B). In some forms, such as slugs, it is vestigial and contained inside the mantle, or lost entirely (Plate II, D).

SHOULDERED Having the whorls more or less flattened beyond the sutures.

SINISTRAL Wound or spiraled to the left (Plate II, B-2).

SLUG A common designation for a snail without an external shell. The shell is either rudimentary and inclosed in the mantle or wanting entirely (Plate II, D).

SNAIL A common designation for a member of the mollusk class Gastropoda; the term includes those forms commonly called slugs and limpets (Plate I, A).

SPIRAL Winding, coiling, or circling around a central axis; the form of the shell of most snails.

SPIRE All of the whorls above the aperture (Plate II, A).

STRIAE Impressed lines; usually designating those impressed lines running in the same direction as the whorls (Plate II, A, C-1).

STRIATE Bearing impressed spiral lines (Plate II, A, C-1).

SUBCENTRAL Nearly central; slightly off center.

SUPRAPEDAL GROOVE A groove above, and running parallel to, the pedal groove in certain snails (Fig. 7).

SUTURE The line where one whorl of the shell is in contact with another (Plate II, A; Plate III, J, K, L).

TRANSLUCENT Partly transparent.

TRANSVERSE Parallel to the columella or axis of the shell; at right angles to the direction of the whorls; the opposite of spiral.

TENTACLE An elongate sensory structure on the heads of snails (Plate I, B; Plate II, D). In some groups it bears an eye at its tip, in others at its base (Plate I, C).

TRUNCATE Cut off (Plate III, M).

TOOTH A short, high callus, or deposit of shelly material, in the aperture of some shells (Plate II, C).

UMBILICATE Having an umbilicus or rather wide opening at the base of the shell; opposite of "imperforate" (Plate III, Z).

UMBILICUS An opening in the center of the columella or axis of the shell (Plate II, A, C; Plate III, Z).

VARIX A ridge of shell material formed at the outer lip, or position on the shell which was once the outer lip.

VECTOR An animal that carries and transmits disease-causing organisms.

WHORL One complete spiral turn of a gastropod shell (Plate II, A).

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INDEX

ERRATA

Page 15, para. 3, line 1, last word, for 'slug' read 'slugs'.
Page 16, footnote, line 1, for 'schistomiasis' read 'schistosomiasis'.
Page 19, para 4, line 2, for 'phenylated' read 'phenolated'.
Page 25, para 3, line 2 from bottom, for 'ound' read 'found'.
Page 27, 2d column, first heading, underline 'Cecilioides aperta'.
Page 28, 2d column, 2d line, for 'Fould' read 'Found'.
Page 28, 2d column, last para., line 2, underline 'mellaxis' and 'Opeas'.
Page 29, col. 1, line 3, for 'Brugu re' read 'Bruguiere'.
Page 31, col. 2, para 5, line 1, for 'the', read 'this'.
Page 31, col. 2, para. 5, line 2, underline 'maritima' and 'H. variabilis'.
Page 32, col. 1, line 7, after 'Southern Europe', delete comma and insert 'and'.
Page 32, col. 1, line 12, underline 'rata'.
Page 33, col. 1, line 5, for 're' read 'are'.
Page 33, col. 1, line 9, delete 'it' and insert 'the animal'.
Page 33, col. 2, line 2, delete 'One species'.
Page 33, col. 2, line 5, for 'Newf oundland', read 'Newfoundland'.
Page 37, col. 2, para. 3, line 9, for 'injuiious', read 'injurious'.
Page 40, col. 2, line 5, for 'anima' read 'animal'.
Page 43, para 25b, line 1, delete comma at end of line and insert semicolon.
Page 43, para. 26b, line 2, for 'BROWN', read 'brown'
Page 44, para. 27a, line 1, for 'less' read 'LESS'
Page 44, para. 33b, delete 'than'.
Page 47, col. 2, under DECOLLATE, line 2, for 'PlateI' read 'Plate V',
Page 49, col. 1, under SUPRAPEDAL GROOVE, line 3, delete '(Fig. 7)' and insert '(Plate II, D)'.
Page 52, col. 1, for 'Helicinidae' read 'HELICINIDAE'.
Page 53, col. 3, under Testacella haliotidea, add '43'.
Page 53, col. 3, after Testacella haliotidea, add 'maugei 26, 28, 43)'