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.

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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 slugs *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

<u>Chemical Control</u>. 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.

> <u>Precautions</u>: 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.

<u>Physical Control</u>. 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 (<u>Achatina fulica</u>) populations.

<u>Cultural Control</u>. 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.

<u>Biological Control</u>. 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 micro-organisms, 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

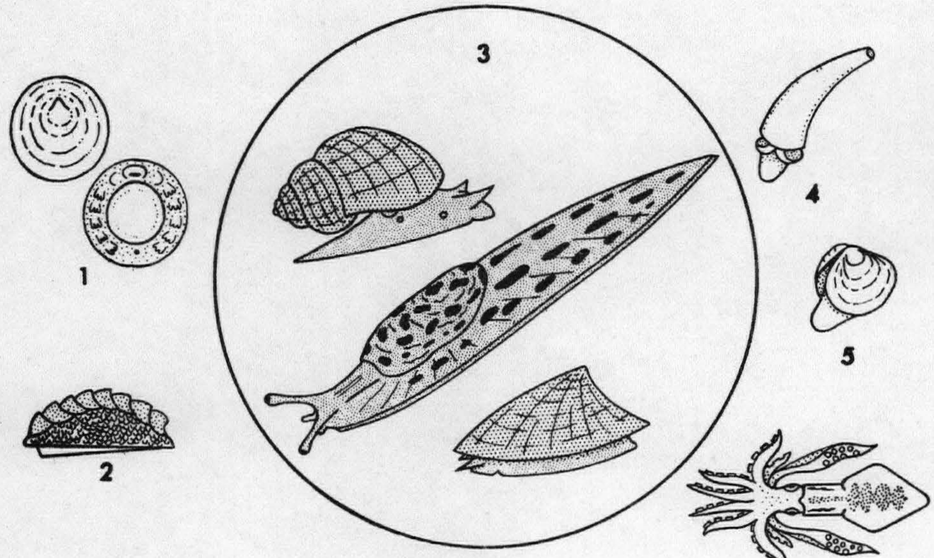
A. Representatives of the mollusk classes. 1, Neopilina, dorsal and ventral views, MONOPLACOPHORA; 2, chiton, AMPHINEURA; 3, snail, slug, and limpet, GASTROPODA; 4, tusk shell, SCAPHOPODA; 5, clam, PELECYPODA; 6, squid, CEPHALOPODA.

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.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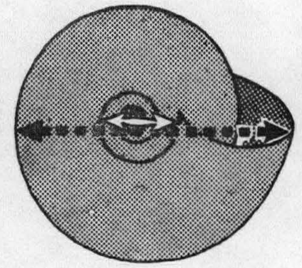

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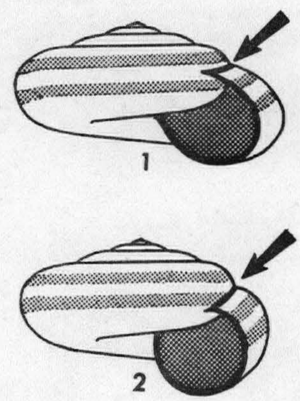
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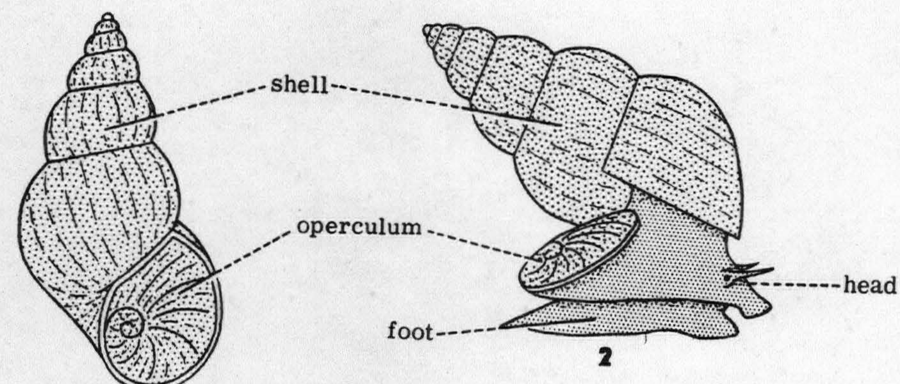
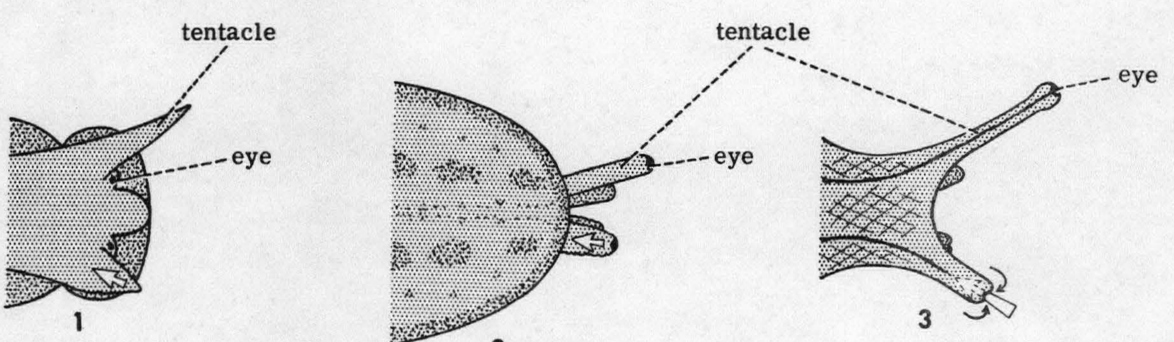

shell
operculum
head
foot
1
2

B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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.

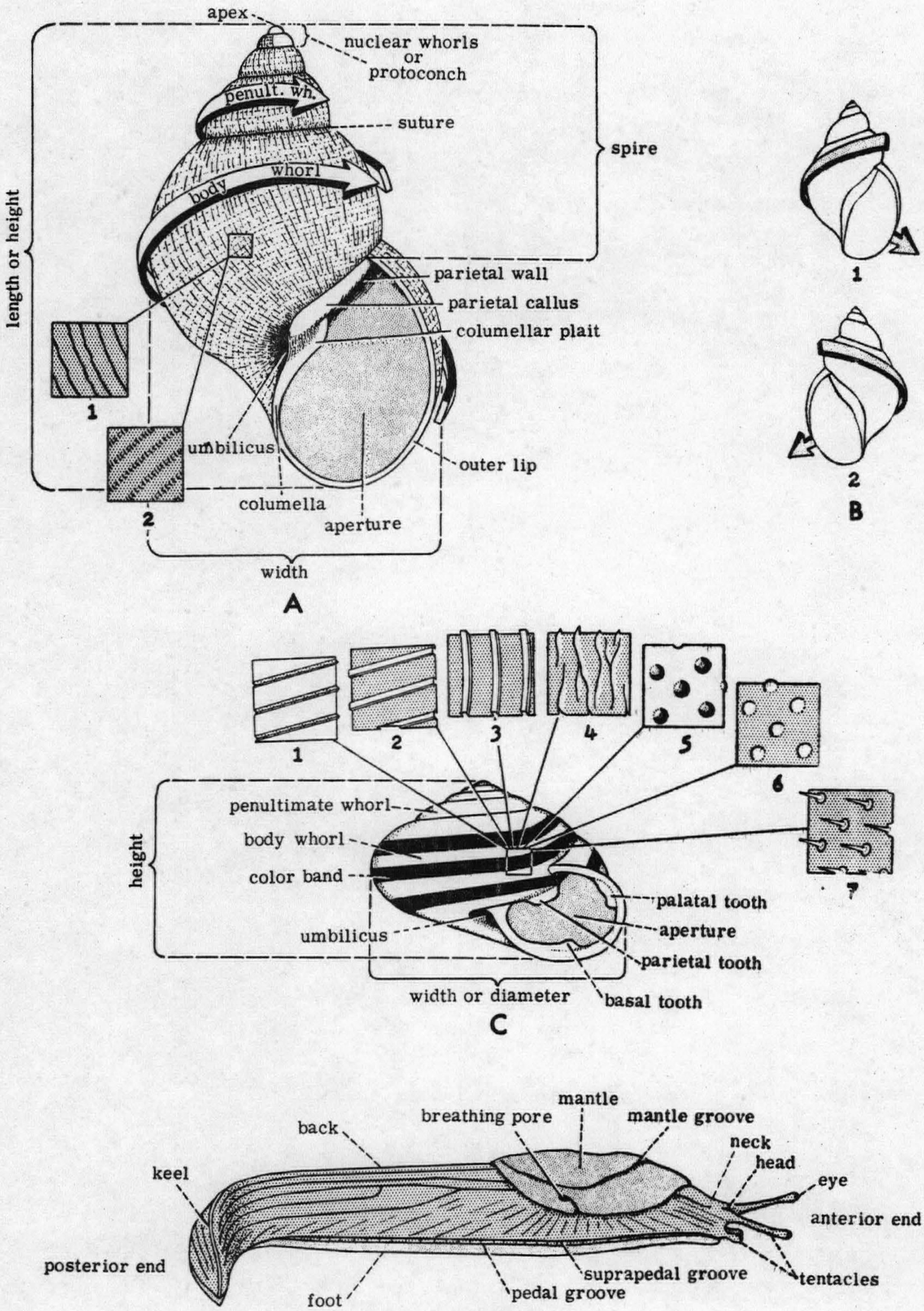
EXPLANATION OF PLATE II

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
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2
umbilicus
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

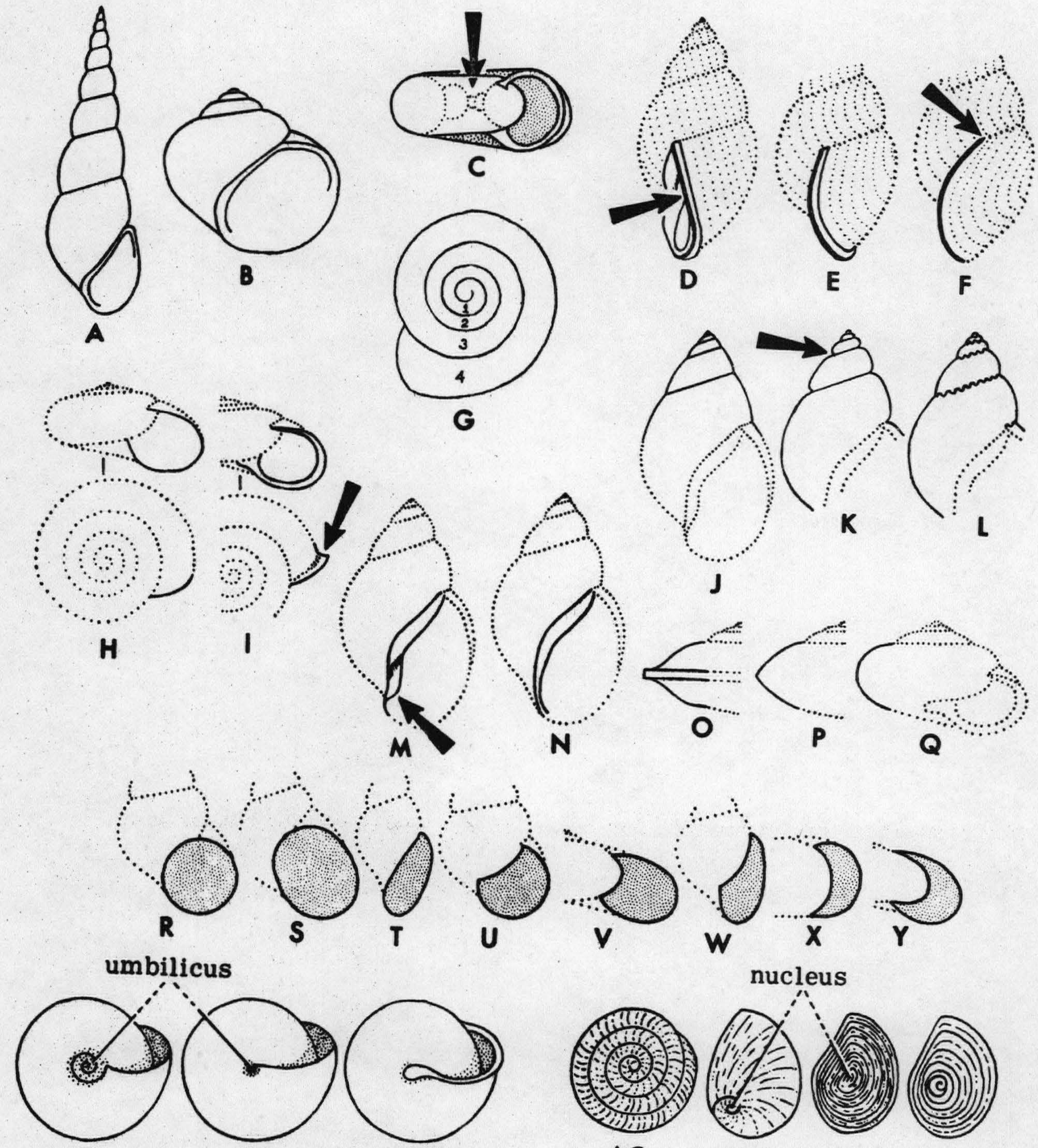
Plate IV, I

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.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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)

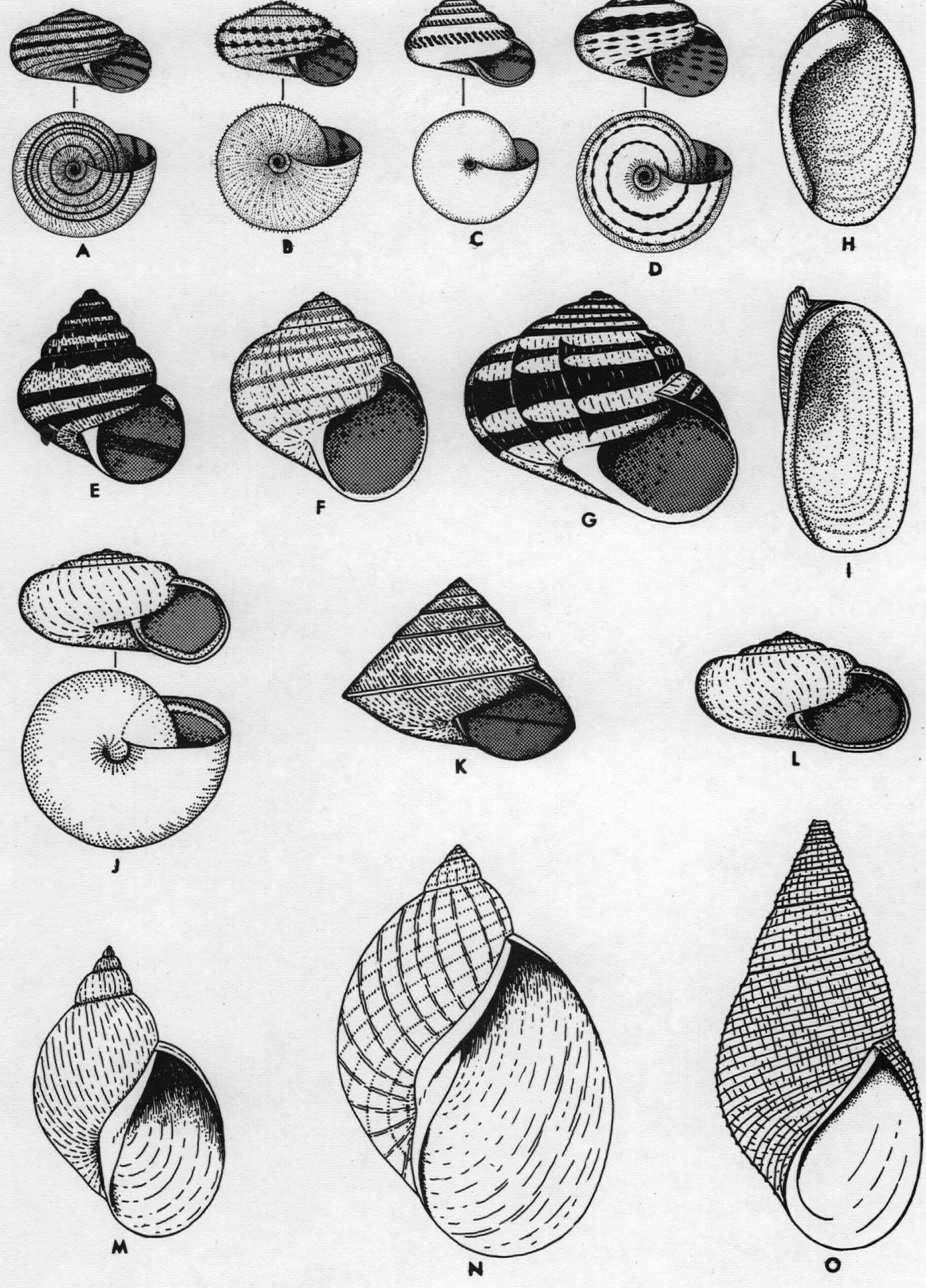
Plate VI, D

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

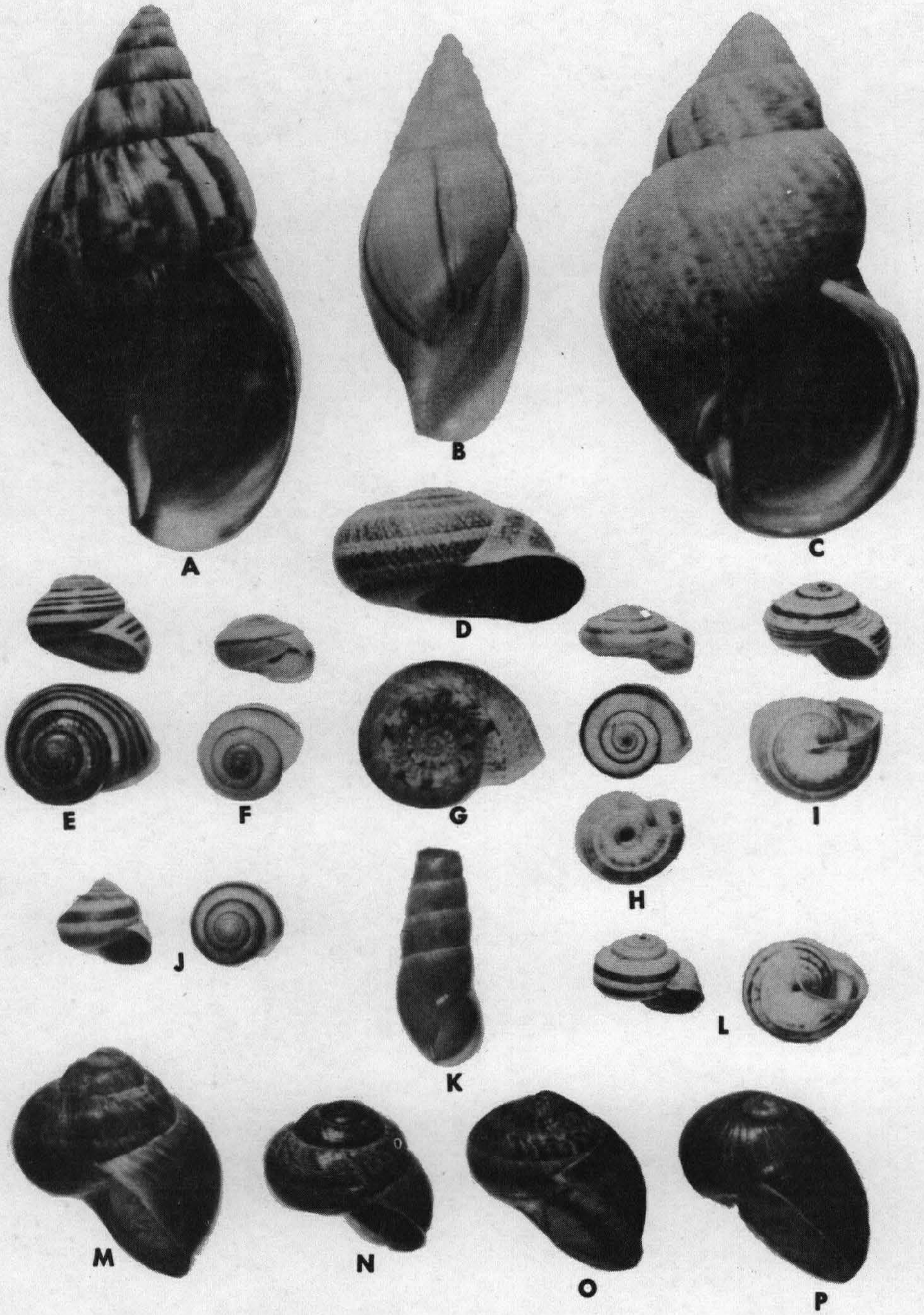
Shell thin, perforate, narrow, higher than wide, with somewhat flattened whorls. Color

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.

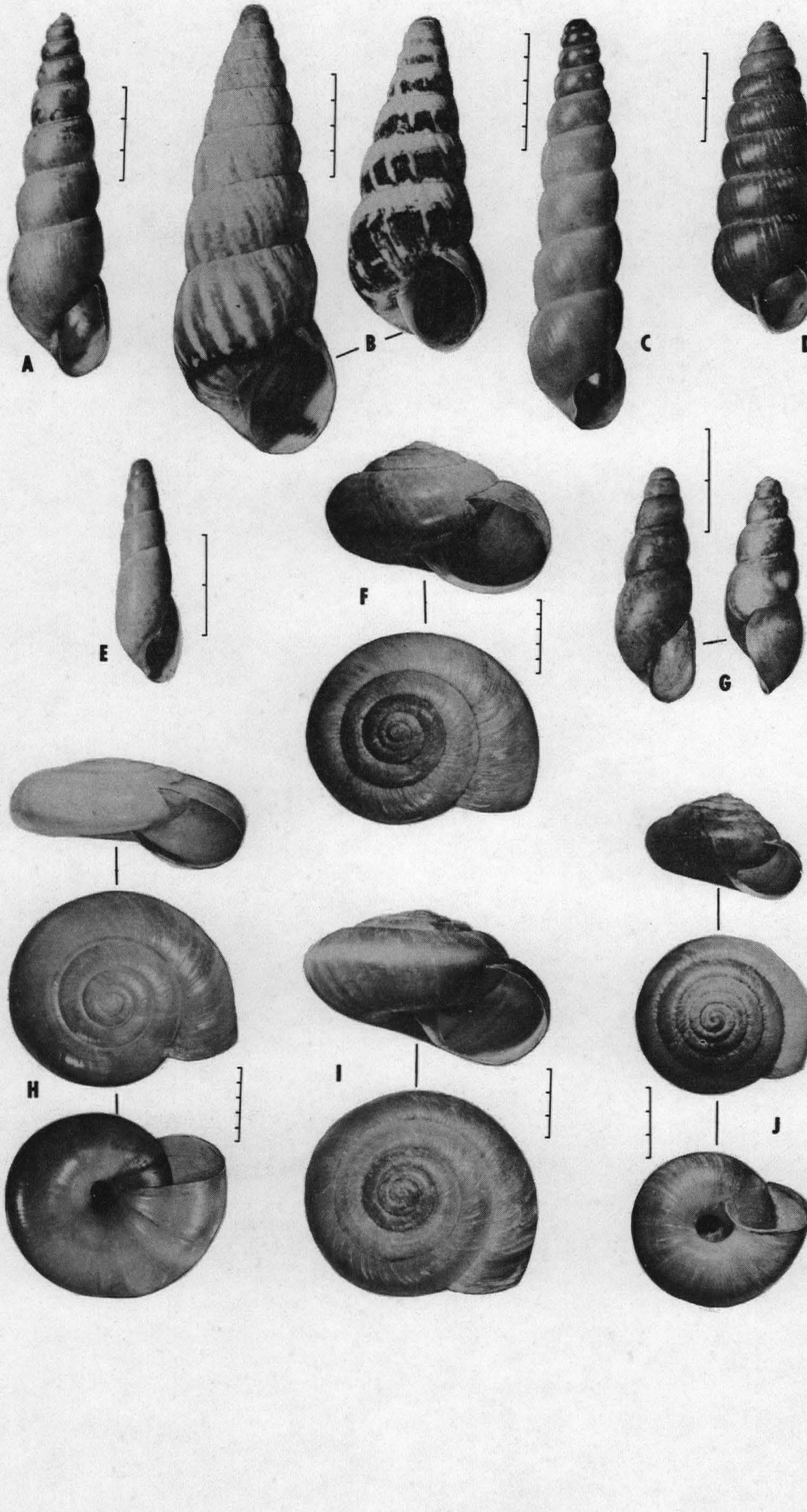
Distribution. Eastern Mediterranean region, Asia Minor.

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, Ofala, 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)

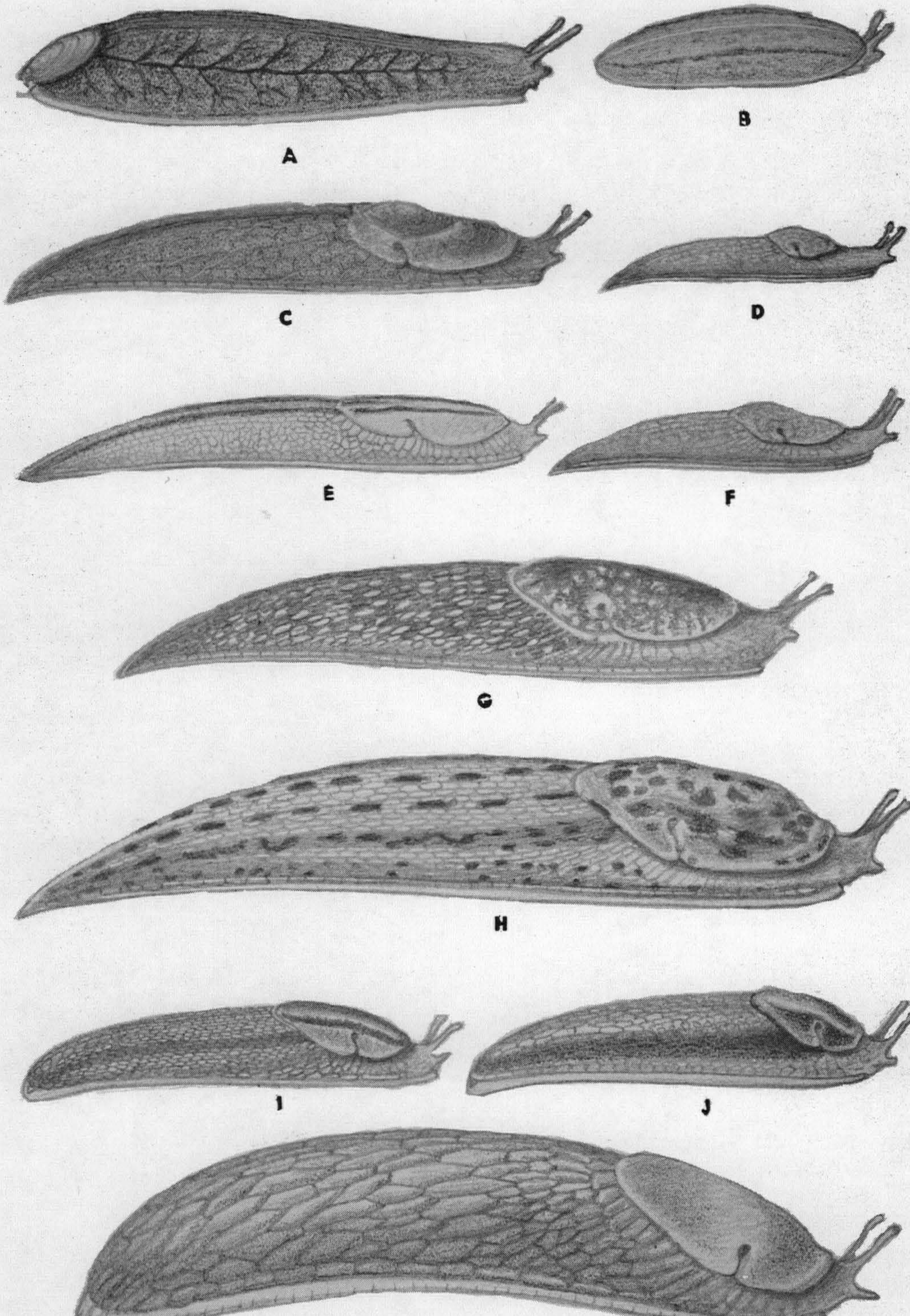
Plate VII, K

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.

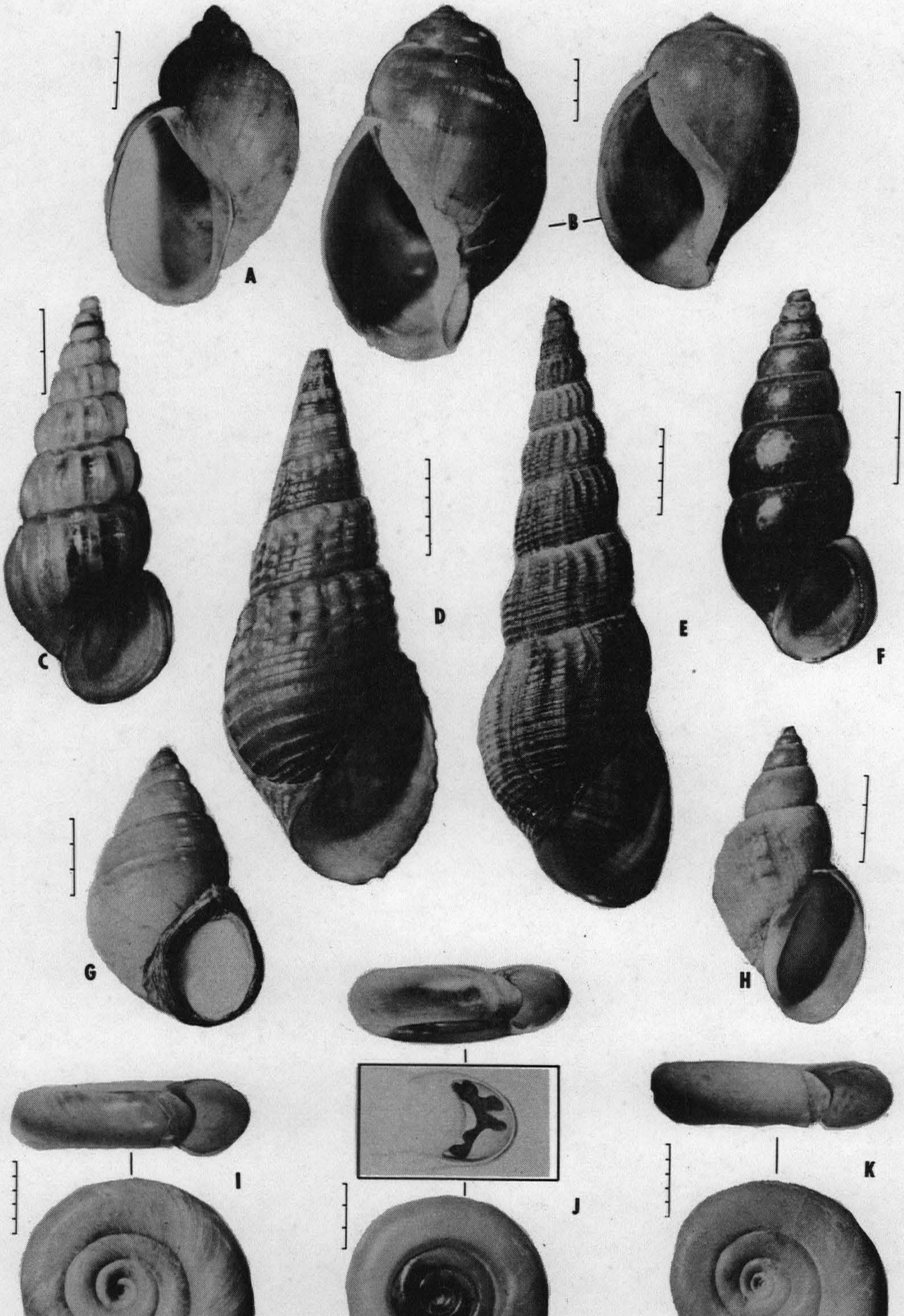
This species is one of the main carriers of the human liver fluke in the Orient.

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.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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

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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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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)'