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The front cover shows *Triodopsis multilineatus algonquinensis* creeping on stems of *Scirpus* in a marsh one and one-half miles south of Muscotah, Atchison County, Kansas.

HANDBOOK

OF

GASTROPODS IN KANSAS

BY

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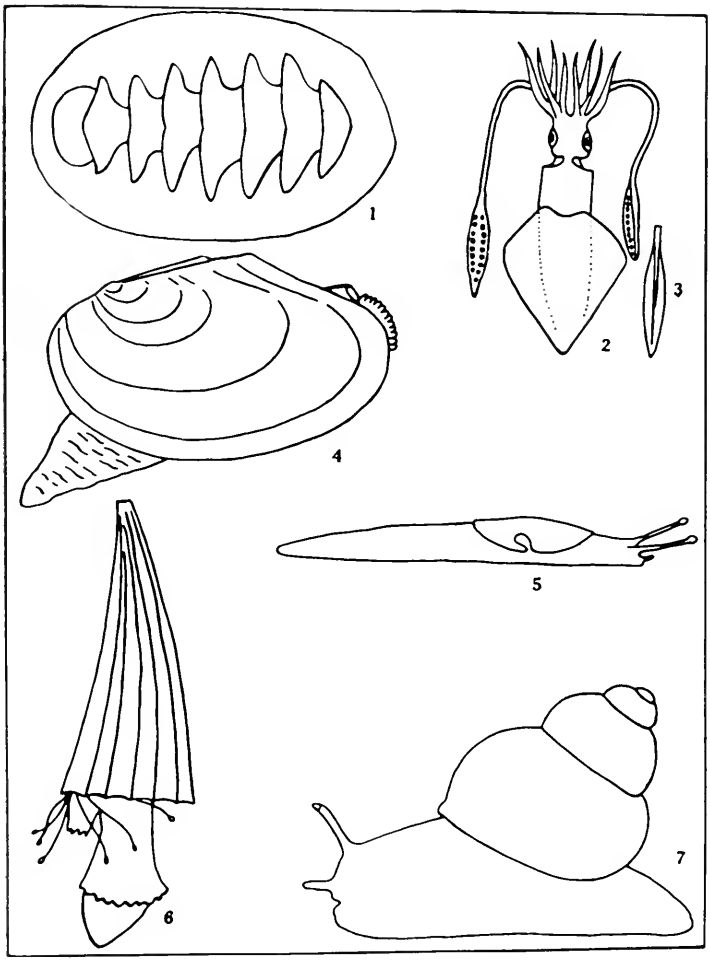


The Classes of Mollusca

FIG. 1. Class Amphineura. A chiton (*Cryptochiton*) in dorsal view, showing typical eight shell-plates exposed. Approximately × ⅔.

FIG. 2. Class Cephalopoda. A squid (*Loligo*) in dorsal view. × ¼.

FIG. 3. The pen, or internal shell of *Loligo*. The familiar cuttle bone of commerce is another type of internal shell from a squid. × ¼.

FIG. 4. Class Pelecypoda. A mussel, *Anodonta*, in lateral view, showing extended foot, and incurrent and excurrent siphons. Approximately × ⅔.

FIG. 5. Class Scaphopoda. A tusk shell (*Dentalium*) in lateral view, showing the conical foot extended, and the peculiar tentacles, called, captacula. Approximately × 1.

FIG. 6. Class Gastropoda. A slug, *Deroceras*, seen in lateral view, showing the saddlelike mantle. Approximately × 2½.

FIG. 7. Class Gastropoda. A snail (*Triodopsis*) seen in lateral view, showing the position in which the shell is carried. Approximately × 1¾.

INTRODUCTION

This handbook deals with the gastropods (snails) that are presently known to occur in Kansas; its aim is to list and describe the kinds of these animals that live within the State, to show their distribution as now known, to serve as an aid to the identification of gastropods in Kansas, and to discuss the ecological and economic implications of the gastropod fauna.

No claim for completeness can be made for this account of the gastropods in the State, but every effort has been made to make it so. The distribution of several minute species is undoubtedly incomplete; the difficulty of finding them makes the accumulation of data slow and tedious. Other groups of gastropods undoubtedly need the kind of revisionary study that Miles (1958) has recently given the members of the family Succineidae in the State. A few kinds of gastropods that are known to occur in nearby states have never been reported from Kansas in habitats where they should occur; further collecting will probably add some of these to the known fauna of Kansas.

Gastropods belong to a large group, or phylum, of animals termed Mollusca, that inhabit the oceans, brackish or fresh water, and the land. All the animals within this large group have certain characteristics in common: symmetrical and usually unsegmented soft bodies with soft skin; a more or less well-developed head; a muscular foot; and most of them possess a peculiar rasping tongue or radula, by means of which they feed. The skin is reflected as a single or bilobed flap, the mantle, which generally secretes a protective shell. The shell, however, may be reduced to a remnant, or may be wanting, depending on the species. Respiration is by means of gills, through the general external body surface, or in the "pulmonates," by a sort of lung chamber formed from a pouch on the mantle.

The Phylum Mollusca includes five great subgroups (or classes), each with its own particular set of characteristics. Familiar examples of these classes are illustrated here (Figs. 1-7).

Class Amphineura.—Chitons or sea-mice (Fig. 1). Entirely marine; bodies elongated, flattened; shell, when present, consisting of eight plates; head reduced; tentacles absent; foot flat and adapted for crawling; and gills usually numerous; dwelling chiefly in shallow coastal waters.

Class Scaphopoda.—Tooth or tusk shells (Fig. 5). Shell and mantle appear as a slender tube, slightly curved, and open at both

ends; foot coneshaped; delicate "tentacles" around mouth; no gills; marine, dwelling in shallow water in mud or sand.

Class Gastropoda.—Snails, slugs, limpets (Fig. 7). Soft organs of body typically enclosed within spirally coiled or cup-shaped shell; head distinct, having one or two pairs of tentacles—when two pairs are present one bears eyes; foot large and flat, adapted for crawling; marine, brackish or freshwater, or terrestrial in habit.

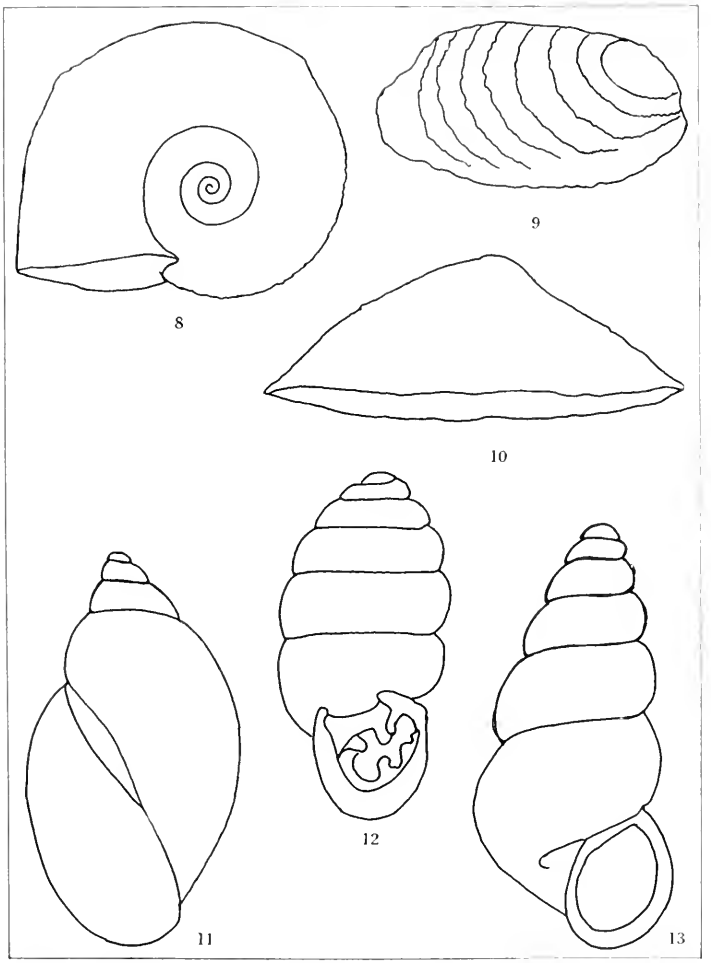
Class Pelecypoda.—Mussels, clams and oysters (Fig. 4). Shells and mantle divided into left and right halves; the two parts of shell hinged by a ligament, and closed by one or two adductor muscles; head absent; mouth small and simple; foot hatchet-shaped, adapted for pushing and burrowing; living in marine, brackish or fresh waters; feed on microscopic material suspended in water, which they remove by ciliary action.

Class Cephalopoda.—Squids, octopi, and nautili (Fig. 2). Shell internal, external, or wanting; head large; eyes conspicuous and complex; mouth with horny armature and radula, surrounded by eight or ten arms or tentacles developed from foot; "brain" in cartilagelike covering; exclusively marine.

MORPHOLOGICAL FEATURES OF GASTROPODA

FORMS OF THE SHELL

One of the most conspicuous features of gastropods is the shell, which is present in nearly all species. It assumes an almost infinite variety of forms among gastropods in general; some of the most common forms in Kansas are shown in Figures 8-13. In some gastropods (*Helisoma, Gyraulus*, and others) the shell is discoid, the spirals of the shell all lying in the same plane, or nearly so. In others, the shell is conispiral, the whorls coiling around an elongate axis (columella) either to the right as in *Pomatiopsis* (Fig. 13) or to the left as in *Physa* (Fig. 11). In *Ferrissia* and related genera the shell is cup-shaped or patelliform (Fig. 10) and the spiral form is suppressed. In many slugs the shell is wanting or represented by isolated calcareous nodules, but in *Deroceras*, one of the common slugs in Kansas, the shell is flattened and scalelike, and borne internally (Fig. 9). In the *Pupillidae*, a large group of minute terrestrial gastropods, the shell is said to be pupoid in form, and the aperture is commonly armored with a series of excrescences or "denticles" (Fig. 12, 17). Common terms applied to the shell and the technique of determining the height and diameter of the shell are shown in Figures 16 and 17.



Common Forms of the Shell Among Gastropods in Kansas

FIG. 8. Discoid shell as seen in dorsal view of *Helisoma*. Approximately × 2½.

FIG. 9. Scalelike shell of the slug *Deroceras* as seen in dorsal view. The shell is internal, is an almost flat plate, having growth lines arranged approximately concentrically around a protoconch. Approximately × 20.

FIG. 10. Patelliform shell of *Ferrissia*, as seen in lateral view. The shell is cuplike, and lacks obvious spiral form. Approximately × 20.

FIG. 11. Conispiral shell of *Physa*, seen in apertural view. The shell shows sinistral ("left-handed") coiling, characteristic of the shells in this genus. Approximately × 6.

FIG. 12. Pupoid shell of *Gastrocopta*, seen in apertural view, and showing the characteristic lamellae or denticles in the aperture. Approximately × 8.

FIG. 13. Conispiral shell of *Pomatiopsis*, seen in apertural view. The shell shows dextral ("right-handed") coiling. Approximately × 12.

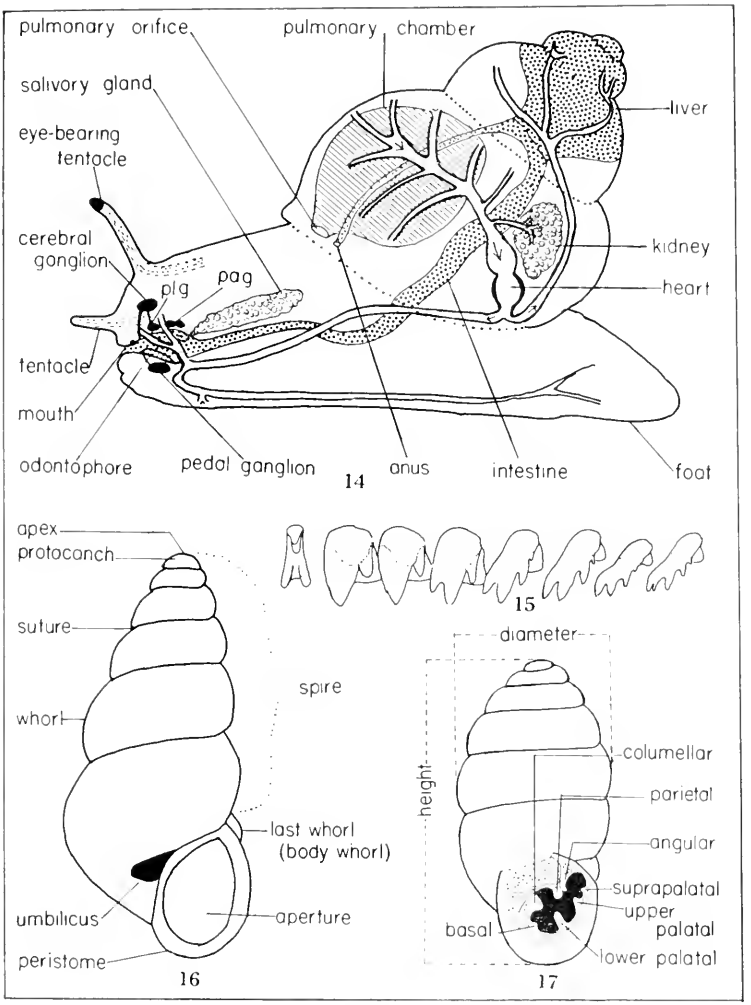
Internal Anatomy of Gastropods

The nervous system consists of two cerebral ganglia, the paired pedal and visceral ganglia, and two or three additional pairs, all of which are united by commissures (Fig. 14; pl. g., pleural ganglion; pa. g., parietal ganglion). A complete crossing (torsion) of the commissures of the visceral ganglia occurs in the Subclass Streptoneura but in the Subclass Euthyneura they are parallel. Both of these Subclasses are represented in the gastropod fauna of Kansas.

The jaw and radula constitute the armature of the mouth (Fig. 14) of gastropods. The jaw is usually composed of a connected series of a few or several horny plates on the upper wall of the oesophagus. Opposed to this is the radula, a horny grating strap, resting upon the odontophore, a tonguelike swelling at the bottom of the buccal cavity. In most species the radula is long and composed of many interconnected small hooklike teeth situated in transverse and longitudinal rows (Fig. 15). By a kind of "licking" action the animal is able to scrape or rasp its food into the mouth, crushing and masticating it against the opposing jaw. The great diversity of teeth in the radulae of different groups of mollusks has been the basis for a large part of the classification of these animals.

The digestive system consists of an oesophagus back of the buccal cavity, a crop, gizzard, large salivary glands, a stomach imbedded in the digestive gland, or "liver", which lies within the spire and apex of the shell, and an intestine which empties out through the rectum into the mantle cavity (Fig. 14). The digestive gland consists of a complex mass of tubules ending in glandular alveoli. The alveoli are digestively active and contain cells of three kinds; secretory, resorptive and lime-containing. The secretory cells of some terrestrial pulmonates contain an enzyme that dissolves cellulose of plant cell-walls and liberates the protoplasmic contents, no part of which is digested in the crop or stomach. The resorptive cells possess intracellular proteolytic enzymes acting on the protoplasmic content of plant cells. A diastatic enzyme is also known which converts starchy material into glucose.

The circulatory system consists of a heart having one auricle, and in some species two. From the heart a highly branched system of blood vessels extends to every part of the body. The heart receives the blood directly from the gill or lung chamber. Near the heart and respiratory mechanism is a kidney, which has an excretory duct emptying into the mantle cavity (Fig. 14).



Internal and External Morphology of Gastropods

FIG. 14. Diagrammatic general view of internal organs of *Triodopsis*, except reproductive system; for latter see fig. 18. Height of spire has been exaggerated in fig. 14. Approximately × 3.

FIG. 15. Typical radular teeth, from radula of *Lymnaea*. Figure shows part of the teeth in one-half of a transverse row; central tooth at left in figure. Approximately × 400.

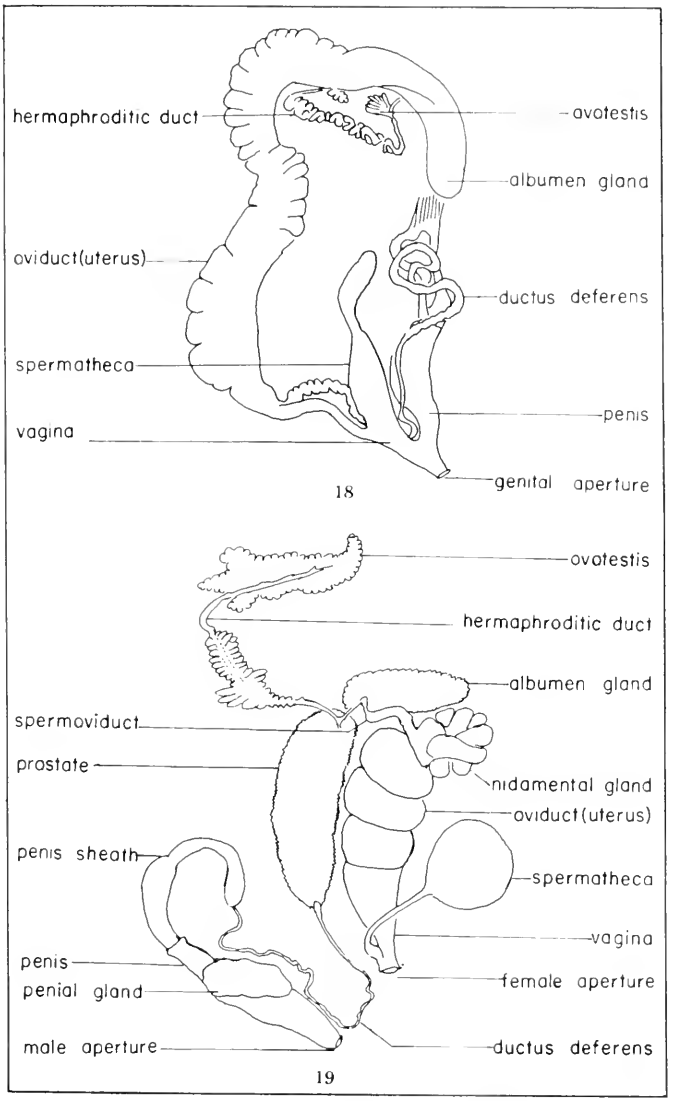
FIG. 16. Terms commonly applied to the shell of a gastropod. *Pomatiopsis;* approximately × 12.

FIG. 17. The terminology applied to the apertural lamellae or denticles in the family Pupillidae, and the technique for determining the height and the diameter of a shell. *Gastrocopta,* approximately × 10.

Reproductive systems of gastropods differ widely. Some groups have the sexes in two individuals as in the Ctenobranchiata whereas in others the sexes are combined in the same individual as in the Pulmonata (Figs. 18 and 19). In the latter group each individual may act as male or female alternately or simultaneously in copulation. The ovotestis and hermaphroditic duct are common to both male and female parts of the reproductive system. The female part of the system typically consists of an albumen gland, oviduct or uterus, vagina, and spermatheca, whereas the male part typically consists of a ductus deferens and penis. Generally in the aquatic pulmonates (Basommatophora) (Fig. 19), the male and female external genital apertures are separate; the opening of the male apparatus is behind the right or left tentacle and the female apparatus opens on the same side at the base of the neck near the respiratory cavity. In the terrestrial pulmonates (Stylommatophora) the ducts of the male and female apparatus open to the exterior through a common duct (Fig. 18). The hermaphroditic genitalia is widely used in differentiating families, genera, and species of gastropods.

Although both aquatic and terrestrial pulmonates are typically hermaphroditic, so far as known these animals do not ordinarily fertilize their own eggs; under certain conditions some kinds seem able to do so. Generally speaking, the mating act results only in a mutual exchange of sperm, which are stored in a special receptacle, the spermatheca (figs. 18, 19). Later, when an individual having sperm stored in the spermatheca reaches a condition which permits of the deposition of eggs, sperm are in some manner released from the spermatheca in order to fertilize the ova. Sperm, of course, must reach the upper parts of the genital tract above the nidamental glands, because after the tough, outer coats of the shell have been secreted around the egg, it can no longer be fertilized.

The fate of sperm that accidentally reach the spermatheca of the snail that produced them (and many observations show that this can and does happen) is not definitely known. It has been shown, however, that in certain kinds of pulmonate gastropods, individuals are biologically resistant to their own sperm after they reach the spermatheca. In other words, any such sperm quickly die, and therefore do not survive long enough to fertilize eggs from the same individual.



The Reproductive Organs of Pulmonate Hermaphroditic Gastropods

FIG. 18. The reproductive organs of *Triodopsis*, a terrestrial pulmonate gastropod, in which there is a common genital opening for both male and female reproductive products. Approximately × 5.

FIG. 19. The reproductive organs of *Physa*, in which there are separate apertures for male and female reproductive products. Approximately × 8.

PURPOSE OF REFERENCES TO LITERATURE

The recognition of the true relationships among living organisms results from a detailed knowledge of their anatomy and physiology that can be gained only by years of patient study by highly skilled and experienced students. Such details are beyond the scope of this handbook, and in general are not treated here. Most of the kinds of snails occurring in Kansas can be recognized by careful observation and comparison of the shells, and, except for members of the family Succineidae and the slugs in the State, keys designed to aid in the identification of the species of gastropods in Kansas are based entirely upon characters of the shell.

The references to literature found immediately below the name of several species listed in this handbook are intended to assist the student who may wish to acquire a greater knowledge of gastropods. The first reference is to the original description of the species, other references cite previous records or discussions of the species in Kansas, and finally, a reference is made to the first use of the currently correct name of the species and to some standard treatise in which the species is discussed in detail.

Most of the aquatic snails in Kansas are discussed by Baker (1928); he gives detailed descriptions of species, and discusses the characters of genera, families and other categories, illustrates the important anatomical features of aquatic gastropods, and gives information about their life histories and their geographical distribution.

The standard publications from which to gain further information about terrestrial gastropods are by Pilsbry (1939;1940;1946;1948). The reader who wishes to gain further knowledge of the terrestrial gastropods of Kansas and their relatives outside the state, will find Pilsbry's monumental treatise of invaluable assistance.

Pilsbry arranges the terrestrial gastropods of North America (north of Mexico) in phylogenetic order; that is to say, according to his judgments of the interrelationships of the many kinds of land snails in the region, including the presumed evolutionary sequences of orders, families, genera, species, and subspecies. He places great reliance upon the details of the anatomy of the body of the animal, with special emphasis upon the anatomy of the reproductive system, and upon the architecture of the radula, inasmuch as the experiences of many students of gastropods, working over the

years, has shown that the characters of these organs are the most reliable clues to the actual relationships of snails. Nevertheless, Pilsbry illustrates the shell of almost every kind of terrestrial gastropod discussed in his treatise; these excellent figures may be more useful to the amateur than those of the soft anatomy. There are numerous keys, but most of these are based upon genital anatomy, and require some skill in interpretation.

GENERAL CLASSIFICATION AND ECOLOGY OF THE AQUATIC GASTROPODS IN KANSAS

The families Viviparidae, Amnicolidae, Pomatiopsidae, and Pleuroceridae represent the Subclass Streptoneura in Kansas. They are of the Order Ctenobranchiata and have the following characteristics in common: visceral nerve-commissures crossed in torsion producing 8-shaped loop; radula with but seven teeth in each transverse row; sexes separate; large pectinate gill within the mantle cavity; a corneous operculum closes aperture of shell when animal is withdrawn; shell coiled in elevated spiral.

Of these four families, one, the Viviparidae, has probably been extirpated in Kansas within the last thirty years. Another, the Pomatiopsidae, in Kansas has only one species (*Pomatiopsis lapidaria*) confined to a small marshy area in the northeastern part of the state. In Kansas, the family Pleuroceridae has one species (*Goniobasis potosiensis*) confined to the Ozarkian region in the southeastern part of the state, and another species (*Pleurocera acuta*) found in Kansas at only three localities in the southeastern part of the state since 1941. In Kansas, the family Amnicolidae has a single representative species (*Amnicola integra*), occurring in the northeastern and southeastern parts of the state.

Although each species of these families as represented in Kansas has somewhat distinct ecological requirements, all of the species depend on permanent water that is more or less free from turbidity, siltation, and pollution. Unlike the pulmonate aquatic gastropods of the Subclass Euthyneura the ctenobranchiates must remain in water to carry on respiration through their gills. A possible exception is *Pomatiopsis lapidaria*, which is generally considered amphibious; nevertheless it requires a permanently shaded cool and moist habitat not subject to great changes in the physical environment. The presumed extirpation of the Viviparidae and sparsity of *Pleurocera* in eastern Kansas where species of the Viviparidae were orig-

inally known to occur probably is the result of many factors operative since the state was first settled, but increased turbidity in streams probably has been a primary factor. Lack of a suitable habitat probably accounts for the present absence of any of the species of the Viviparidae and the sparseness of the populations of the one species of the family Pleuroceridae. Drainage of shallow lakes and marshes that were common before the country was settled has directly eliminated the habitats of many aquatic animals as well as those of aquatic gastropods (Franzen and Leonard, 1943, pp. 366-368). The plowing of grasslands, particularly sloping areas, overgrazing, and the cutting of the woodlands has been responsible for increased rate of run-off after heavy rains. The consequences of this are erosion of exposed soils, siltation of streams, and deep cutting of channels in stream beds. It is now not uncommon to see extreme fluctuation in the water levels of rivers and small streams in eastern Kansas. Perhaps more often than not they have a muddy appearance indicating high content of silt. In summer the water levels often become low and flow is sluggish or lacking. The pollution of streams by sewage and refuse from industrial plants has also affected if not eliminated the habitats of some species, especially in areas where coal or petroleum are produced.

The families Physidae, Planorbidae, Lymnaeidae, and Ancylidae are the aquatic representatives of the Subclass Euthyneura in Kansas. These families are of the Order Pulmonata and Suborder Basommatophora. Characteristics common to the Order Pulmonata are: visceral nerve commissures not crossed, but forming simple loop; radula multiserial with many teeth in each transverse row; sexes united in same individual (hermaphroditic); gill cavity transformed into lung for breathing free air (some with pseudobranch in addition); without an operculum (Figs. 14, 18, 19). Members of the Suborder Basommatophora are characterized by having one pair of tentacles, flattened and triangular or subcylindrical, contractile but not eversible; eyes at base of tentacles; shell spiral, cup-shaped, or discoid. The terrestrial gastropods of the Suborder Stylommatophora are characterized by having two pairs of eversible tentacles, with the eyes situated at the tips of the longer pair (Fig. 14).

Some of the species of the families Physidae, Lymnaeidae, and Planorbidae are highly tolerant of changes in environmental conditions, such as chemistry of the water, temperature, and drought. Many species of *Lymnaea* live entirely out of water in mid-summer.

The Physidae and *Helisoma trivolvis lentum* are occasionally seen out of the water crawling on moist surfaces. Experiments indicate that these animals have the ability to take in dissolved oxygen through the skin while under water. However, they depend to a great extent on free air, as they frequently come to the surface and fill the pulmonary cavity with air. When streams or pools dry up some aquatic pulmonates burrow into the mud and secrete a thin epiphragm across the aperture of the shell, thus preventing loss of moisture from the body, and remain dormant in aestivation until the recurrence of water which softens the mud and dissolves the epiphragm. In winter they remain in water and may be active and come to the surface for air even though the water is freezing at the surface. It is doubtful that they burrow in winter unless the formation of ice above them forces them to do so (Jones, 1935, pp. 140-142).

Species of the family Ancylidae are less tolerant of variable environmental conditions and are never seen out of the water except occasionally in aquaria where they may suffer for lack of oxygen. They are provided with a relatively large pseudobranch and are also said to have a pulmonary cavity (Baker, 1928, p. 388).

General activity, reproduction, and growth among the aquatic gastropods is most pronounced during spring and early summer. Egg-laying begins as early as February and March and continues until late fall in some species. The egg masses of *Physa*, *Helisoma*, and *Lymnaea* are more frequently observed in March, April and May.

Aquatic gastropods are saprophytic and omnivorous and feed upon a wide variety of dead or living plant and animal substances. Baker (1911, p. 42) lists a number of living and dead animals that have been observed serving as food for species of *Lymnaea*. They are known to feed also on large amounts of diatoms, desmids, spirogyra, and other algae and have been observed consuming the softer parts of dead leaves and stems of plants in large quantities.

Economic Importance

The aquatic gastropods are among the most common fresh water animals in all bodies of water throughout the state and are utilized as food by vertebrate and invertebrate animals.

Perhaps their greatest economic importance is indirectly that of constituting food for game fish. Baker (1928, p. 5) states, "About 20 per cent of the species of freshwater fish feed more or less upon mollusks, largely gastropods; the quantity consumed, in compari-

son with other food, ranges from 1 to 100 per cent. The sheepshead, lake sturgeon, common red horse, spotted sucker, and pumpkinseed include from 50 to 100 per cent of mollusks in their food; and the common sucker, common bull head, and whitefish include more than 25 per cent." In reporting the food of the game fishes of Iowa, Harlan and Speaker (1951) include "small mollusks" as food for three species of trout, five species of catfish, nine species of the sucker family (Catostomidae), three species of the sunfish and bass family (Centrarchidae), two species of the perch family, and the Freshwater Drum (*Aplodinotus grunniens*). Aquatic gastropods are also commonly eaten by salamanders, turtles, wild ducks, shrews, muskrats, and raccoons. Among the invertebrates, leeches (*Glossiphonia*, *Placobdella*, *Haemopia*), as well as predaceous "water-bugs" (*Belostoma*, *Lethocerus*, *Nepa*) and the predaceous diving-beetle *Dytiscus*, both as larva and adult, prey heavily on snails.

Snails, as consumers of large amounts of vegetation, both dead and living, are an important "link" in the food chain of any aquatic community.

Scientific Importance

The fresh-water snails have been used by students, teachers, experimental biologists, and research workers as materials for study of embryology, physiology, ecology, and palaeontology. For the study of developmental processes students and teachers have found the translucent eggs to be readily obtainable and easily kept in aquaria. Embryos and young snails are easily seen within the eggs when the egg mass is placed in a small watch glass, fingerbowl, or on a slide, and observed under a microscope. The egg capsules of some smaller species such as those of the family Ancylidae are especially convenient as there are only a few eggs in each capsule and the order in which they were laid can be determined. During the laying of the eggs the animal rotates and the capsule becomes a spiral in which the terminal point overlaps the initial one. An arrangement may be made, using a shallow aquarium, whereby the animal is forced to lay its eggs directly on glass slides (Bondesen, 1950, pp. 603-605).

The fossilized shells of aquatic gastropods are used by palaeontologists and geologists in determining successions of deposits, and local physical and environmental conditions of past geologic times. Fossil specimens are compared with similar or identical living specimens and it may be inferred that the fossil species lived in condi-

tions of habitat similar to those of their living counterparts. Many species are restricted to certain kinds of habitats and may be dependent upon the limits of certain factors in the environment such as temperature, humidity, the seasonal presence of water, general topography, and kind and amount of vegetation in the local area.

The fresh-water mollusks are thought to have evolved from several different sources at different times during geologic time. The ancestral forms were probably all marine. Among the gastropods, the Ctenobranchiata have descended more or less directly from marine forms which became adapted to a fresh-water habitat through gradual change from marine through brackish to fresh water. These forms retain the ancestral gills, and, in some groups a lung has been added. The fresh-water pulmonates (Basommatophora) have supposedly descended from terrestrial mollusks through an adaptation to aquatic conditions. In some forms (Planorbidae) there is a secondary gill, or pseudobranch, which may exist with the lung, or the secondary gill may replace the lung almost entirely (Ancylidae) (Baker, 1928, introduction).

COLLECTION AND PRESERVATION OF AQUATIC GASTROPODS

Collecting

Aquatic snails are commonly found in the shallow water of lakes or streams. Generally collections can be made by hand-picking along the edge of the water. It is necessary also to inspect closely the bottom and objects in the water such as dead leaves, stems and stalks of dead plants, stones, and living aquatic plants. Most snails tend to be of the same general color and appearance as their surroundings in their respective habitats and may easily be overlooked. Some individuals are covered with ooze or may have algae growing on their shells, which causes them to resemble pebbles on the bottom. In summer, snails of the genus *Lymnaea* are more frequently found out of the water on mud or wet surfaces and often in shade provided by semiaquatic grasses and sedges. Aestivating snails can be taken from the mud of drying stream beds or pools in marshy areas. Species of *Amnicola* often burrow into mud at the bottom of quiet pools, and in winter other species seek deeper water and stay on or near the bottom. The bottom can be dredged with a bucket or a sturdy long-handled dipper. In collecting from mud, specimens can be found easily and in greater numbers if several handfuls of mud are put in a wire sieve having about 25 meshes

per inch and shaken or dipped in water several times so that the mud is washed through, leaving the snails.

The smaller species of the families, Planorbidae and Ancylidae, can be more easily found and obtained in larger numbers by placing a large mass of aquatic plants in a bucket of water, and allowing it to remain undisturbed for at least an hour. The snails often crawl off the vegetation and onto the sides of the bucket where they are easily seen, especially if the bucket is light colored within. In lakes, small planorbids often are on large pieces of driftwood either floating or washed up along the shore. Some species of *Ferrissia* are found only on hard smooth surfaces such as mussel shells, smooth stones, pieces of glass and metal objects in water. A knife with a sharp blade is best for removing these small snails. In collecting it is often advantageous to take samples of the water and living and dead plants together with the snails. Under magnification the egg capsules of the snails and different kinds of small animals and plants living in association in the habitat may be observed and studied. For transport the specimens may be placed in loosely covered containers of water if they are to be kept alive, or they may be immediately preserved in alcohol.

For scientific purposes a small tag or card bearing an assigned field number, the date of the collection, precise locality data, and the name of the collector is put into a container with each lot of specimens. A field notebook is kept in which the corresponding field number, date, locality, and name of the collector is entered. Observations of the ecological conditions of the habitat, general environmental situation in which the specimens were living, and pertinent aspects of their behavior should be recorded here. All data and field numbers on the field tag and in the field notebook are written in permanent black ink.

Preservation

If both the animal and its shell are to be preserved intact, 60 to 75 per cent alcohol is sufficient. If it is desired to remove the animal from the shell for study of the anatomy the snail should be killed by putting it into boiling water for a few seconds. The animal may then be removed carefully with a pin or small forceps and preserved in alcohol or dissected at once. The shell of small specimens can be broken away from the underlying parts or dissolved in diluted hydrochloric acid.

To prepare the shell for storage, encrustations of debris, algae, or mineral deposits may be removed by light scrubbing with a stiff

toothbrush. It is also desirable to wash out the interior of the shell by means of a small syringe in order to remove parts of the animal and thus avoid offensive odors and infestation by insects such as ants and dermestids. Small specimens should be kept in a 70 per cent alcohol solution for a day or two, then allowed to dry. Small shells as well as opercula may be cleaned in dilute oxalic acid. Opercula of large Ctenobranchiate shells may be glued to a piece of cotton that plugs the aperture of the shell.

IDENTIFICATION OF SPECIES

In most colonies of aquatic snails, the assemblage includes various ages and sizes. For accuracy in the identification of a species it is important to have at least several specimens of any one kind from a single locality. Typical and mature individuals should be selected for observation and determination of the characteristics of the species. Mature snails are naturally larger and have more solid and durable shells, whereas those of immature individuals are thinner and more translucent. The shell is especially thin in the region of the peristome in rapidly growing young individuals. Also, the shells of immature snails do not have so many whorls as those of adults. Published descriptions of species generally refer to mature animals.

The key to the shells of aquatic gastropods (see below) is intended for use in identifying aquatic snails that occur in Kansas. It should not be used alone but in connection with the descriptions of the species. Accurate identification depends upon a study of the descriptions, plates, and figures as well as use of the key. It is necessary to use a microscope in counting the whorls of most shells and to observe the sculpture and form of small shells. Measurements should be made by means of calipers or some similar device. Measurements are conventionally recorded in millimeters.

In using the key it will be noted that statements concerning characters of the shell are in couplets, each with a corresponding number to the left. Each statement of a couplet is in opposition or at least distinctly different from the other. One should always begin with the first couplet. Read both statements and decide which of the two fits the specimen to be identified. The number to the right following the fitting statement refers to another couplet which also has a fitting statement. It will again be necessary to read both statements before deciding which one fits the specimen. This statement will be followed either by the name of the species or by the number of another couplet. One should continue this procedure until the

statement is found which is followed by the name of the species. If any part of any statement does not fit the characters of the shell the other statement of the couplet should.

KEY TO THE SHELLS OF THE AQUATIC GASTROPODS OF KANSAS

1. A. Shell having spiral whorls 4
   B. Shell patelliform 2
2. A. Shell exceeding 5.5 mm. in length . . . . *Ferrissia kirklandi*, p. 67
   B. Shell not exceeding 3.5 mm. in length 3
3. A. Height of shell generally less than ⅓ of length; some shells septate . . . . *Gundlachia meekiana*, p. 73
   B. Height of shell generally more than ⅓ of length; shell never septate . . . . *Ferrissia shimekii*, p. 69
4. A. Spire elevated above body whorl 5
   B. Spire depressed below level of body whorl 7
5. A. Whorl sinistrally spiraled 6
   B. Whorls dextrally spiraled 12
6. A. Shell fusiform; spire generally more than ⅓ of length. . . . . *Physa hawnii*, p. 43
   B. Shell inflated; broadly elliptical; spire generally less than ⅓ of length . . . . *Physa anatina*, p.
7. A. Spire in a funicular depression; whorls carinate above or below or both . . . . *Helisoma antrosa*, p.
   B. Spire not in a funicular depression 8
8. A. Shell generally more than 12 mm. in diameter; sculpture of coarse transverse striae . . . . *Helisoma trivolvis lentum*, p. 57
   B. Shell generally less than 6 mm. in diameter 9
9. A. Umbilical region large, round and deep. . . . . *Promenetus umbilicatellus*, p. 65
   B. Umbilical region a shallow depression 10
10. A. Periphery of shell keeled . . . . *Promenetus exacuous*, p. 66
    B. Periphery of shell rounded 11
11. A. Whorls not more than 3½; body whorl rapidly enlarging. . . . . *Gyraulus parvus*, p. 60
    B. Whorls 4; body whorl not rapidly enlarging. . . . . *Gyraulus circumstriatus*, p. 64
12. A. Shell imperforate or having peristome continuous; aperture in living shell closed by an operculum 13
    B. Shell neither imperforate nor having peristome continuous; lacking an operculum in living shells 18
13. A. Shell imperforate, generally more than 15 mm. in diameter; whorls of spire shouldered . . . . *Campeloma subsolidum*, p. 31
    B. Shell perforate or imperforate; generally less than 10 mm. in diameter; whorls of spire rounded or flat 14
14. A. Shell imperforate; diameter ½ or more of length; whorls flat or slightly swollen, usually 7 or less. . . . . *Goniobasis potosiensis plebeius*, p. 41

B. Shell either imperforate or with umbilicus open; whorls more or less than 7 15

15. A. Shell imperforate, elongate; whorls flat, usually more than 7 *Pleurocera acuta*, p. 37

B. Umbilicus open but reduced to small chink; peristome continuous 16

16. A. Diameter less than ½ length; whorls 7; color dark chestnut. *Pomatiopsis lapidaria*, p. 35

B. Diameter more than ½ length; whorls 6 or less; color gray or green *Amnicola integra*, p. 33

17. A. Whorls 6; body whorl greatly inflated; spire acutely conic. *Lymnaea bulimoides techella*, p. 48

B. Whorls fewer than 6 18

18. A. Spire short and broad; whorls 4½; body whorl globose. *Lymnaea bulimoides cockerelli*, p. 50

B. Spire elongate, acute, or turreted 19

19. A. Diameter of shell more than 4.5 mm.; whorls 5½. *Lymnaea obrussa*, p. 51

B. Diameter of shell less than 4.6 mm.; whorls 5 or 5½ 20

20. A. Spire long, narrow, extremely acute; umbilical chink nearly closed; whorls 5 to 5½ *Lymnaea humilis rustica*, p. 53

B. Spire turreted; whorls 5 to 5½ 21

21. A. Diameter of shell generally not less than 2.5 mm.; aperture roundly elliptical; whorls 5 to 5½ *Lymnaea parva*, p. 4

B. Diameter of shell generally not more than 2.5 mm.; aperture narrowly elliptical; whorls 5 to 5½, shouldered. *Lymnaea dalli*, p. 56

ACCOUNTS OF SPECIES

Introduction

The first attempt at a survey of the aquatic gastropods of Kansas was made by R. Ellsworth Call during the years 1884-1887, under the direction of F. W. Cragin of the Washburn Biological Survey of Kansas. The species of aquatic gastropods were listed together with general indications of the stations of occurrence in a series of reports published in the Bulletin of the Washburn Laboratory of Natural Science (1885a, p. 51; 1885b, p. 115; 1886, p. 177; 1887, p. 14). Specimens were obtained by collecting on the part of Call himself and from collections sent to him by other persons. Little data concerning the ecology and distribution of species appeared in these reports.

G. Dallas Hanna (1909, pp. 81, 94) listed the Mollusca of Douglas County, based on two years collecting. Some of the specimens were collected from drift along the Kaw River and may have

been carried downstream for many miles, and several reported species are now known to have been fossils washed down from Pleistocene deposits farther west. It is sometimes difficult to distinguish fossil gastropod shells from those of recently living animals (Franzen and Leonard, 1943, p. 427).

Later reports of Mollusca in Kansas, including aquatic gastropods, contained more precise locality data and descriptions of habitats of species within the respective areas studied. Franzen and Leonard (1942, pp. 334-343) reported the results of a survey of the Mollusca of Kingman County. Alice E. Leonard (1943, pp. 226-240) published a list of the Mollusca of Meade and Clark counties together with associated flora. Franzen and Leonard (1943, pp. 363-439) reported on a study of the molluscan fauna of the Wakarusa Valley in northeastern Kansas; and Franzen (1944, pp. 261-273) listed new records of aquatic and terrestrial gastropods in Kansas. Leonard and Leonard (1946, pp. 115-122) reported pelecypods and aquatic and terrestrial gastropods found in watercourses in Greenwood County. Leonard and Goble (1952, pp. 1013-1055) published an ecological study of the Mollusca of the University of Kansas Natural History Reservation in Douglas County, but only three species of aquatic gastropods are known to occur on the Reservation.

Kansas has a wide variety of habitats suitable for aquatic gastropods. The deciduous forest-grassland ecotone occupies the extreme eastern part of the state, and includes at the southeast corner, a small part of the Ozarkian region. Franzen (1944, pp. 261-262) has given a descriptive account of this general area. Next to it to the west are the Flint Hills, characterized by grass-covered hills having frequent outcrops of limestone and occasional small valleys with sparsely wooded streams. Central and western Kansas is occupied by the more elevated grassland plains area. There are many small streams and rivers throughout the state all draining generally eastward toward the Mississippi. Artificial ponds and lakes are fairly abundant and well distributed. There are in the state a few natural marshy areas, some maintained by artesian water and others dependent upon precipitation.

Localities, unless otherwise indicated, are in Kansas. Catalogue numbers, unless otherwise indicated, refer to the collections of the University of Kansas.

Phylum MOLLUSCA
Class GASTROPODA
Subclass STREPTONEURA Spengel
Order CTENOBRANCHIATA Scheigger
Family VIVIPARIDAE Gill

The shells of the species in this family are moderately large, sometimes an inch or more in length, perforate to subperforate, and provided with a corneous, convex, concentric operculum; whorls convex, in some species carinate; aperture entire, subcircular to angular above in general outline.

The members of this family are widely distributed over the northern hemisphere, although in the United States, no species are known from west of the Rocky Mountains. Viviparids inhabit a variety of types of streams, lakes and ponds, but generally avoid silted waters.

Genus *Campeloma* Rafinesque

Campeloma subsolidum (Anthony)

Pl. 1, fig. 13; text fig. 20

Paludina subsolida Anthony, 1860, Proc. Philadelphia Acad. Sci., p. 71.

Campeloma subsolidum, Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 2, p. 51; ———, 1886, *op. cit.*, vol. 1, No. 4, p. 177; ———, 1887, *op. cit.*, vol. 2, No. 8, p. 17; Baker, 1902, Chicago Acad. Sci., Bull. No. 3, Nat. Hist. Survey, pt. 2, pp. 361-362, pl. 36, figs. 8-12; Hanna, 1909, Nautilus, vol. 23, No. 7, pp. 81-82, 94-96; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, No. 9, p. 404, pl. 30, fig. 9.

Shell: Conispiral, dextral, elongate, solid, more or less malleated; color horn or light green; surface polished, smooth except for somewhat elevated crowded growth lines; shell beneath epidermis chalky white; apex small but prominent; spire elevated, elongate, conic; sutures deeply impressed; whorls 6-7 in fully adult specimens, rather flat sided, sloping near sutures where they are almost angular; body whorl occupies ¾ length of shell, periphery perceptibly flattened; aperture broadly ovate, rounded below and contracted above, white or bluish white within; peristome thin, acute; terminations of peristome connected by rather heavy columellar callus, reflected over umbilicus; base rounded, imperforate, somewhat wrinkled.

Measurements

Length	Width	Length of aperture	Width of aperture
36.0 mm.	22.3 mm.	18.9 mm.	11.6 mm.
31.1	19.5	16.7	10.3
24.0	15.5	13.4	7.9

Soft Part of Animal: Operculate; bluish white, spotted with salmon, undersurface of foot pale bluish-white; head small, distinct; rostrum small, cylindrical;

tentacles long and tapering, eyes on outside of enlargement of tentacles one-third of distance from base; in males, right tentacle modified, forming verge; foot large, broad, produced in front, and much in advance of head and tentacles. Operculum corneous, longer than wide, convex.

Radula bearing broad central tooth having simple distal reflection without denticulations; three elongate fanglike teeth on each side of central tooth.

Females of this family are ovoviviparous; that is to say, the eggs are retained within the body of the mother where they hatch and the young are able to crawl about immediately after they are born.

General Distribution: "Massachusetts to Illinois and Michigan, south to central Ohio [and southwest Kansas]" (Baker, 1902, p. 362).

Occurrence in Kansas: The specimens most recently found in the state were two "dead" shells from the Wakarusa River in Douglas County (Franzen and Leonard, 1943, p. 404). More than fifty years ago, however, Call reported this species from the Nemaha and Blue rivers and from Silver Lake in Shawnee County (1885a, p. 54), from the Missouri and Kansas rivers in Wyandotte County (1886, p. 177), from the Marmaton River at Fort Scott and from the Delaware River in northeastern Kansas (1887, p. 17). Later Hanna (1909, p. 96) reported both *C. subsolidum* and *C. decisum* living abundantly in the Wakarusa River in Douglas County.

Campeloma seems now to be extinct in Kansas.

Ecology: Campeloma is generally found in streams and lakes in shallow quiet water with mud bottom where it may be seen crawling on the bottom or more often burrowed in the mud. Baker (1902, p. 361) states that "They seem to prefer large bodies of water."

Family AMNICOLIDAE Gill

The shells of the members of this family are small, in many species not more than a few millimeters in length, spiral, conical or elongate conical, perforate or imperforate, and without color patterns. The aperture is entire and its lip is simple. The operculum is corneous, and concentric or spiral.

Amnicolids are widely distributed over the earth, where they live in a great variety of aquatic habitats, although some species prefer damp earth not actually under water. Amnicolids were abundant in Kansas during parts of Pleistocene time, but are now rare, and locally distributed in the State.

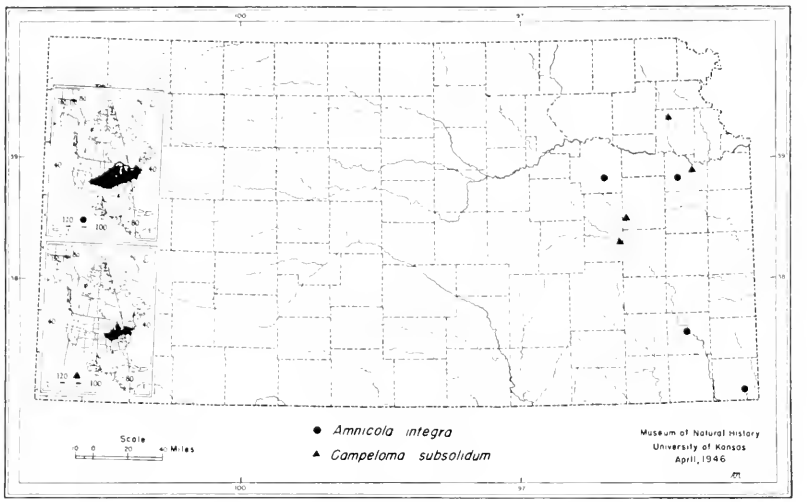


FIG. 20. Distribution of *Amnicola integra* and *Campeloma subsolidum* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Genus *Amnicola* Gould and Haldeman

Amnicola integra (Say)

Pl. 1, fig. 1; text fig. 20

Paludina integra Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 174.

Amnicola integra, Berry, 1943, Misc. Publ. Mus. Zool. Univ. Michigan, No. 7, pp. 32-36, pl. 1, fig. 7, pl. 3, fig. 4, pl. 6, fig. 1.

Amnicola cincinnatiensis, Call, 1885b, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 115.

Cincinnatia cincinnatiensis, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 122-124, pl. 6, figs. 40-41, pl. 7, figs. 15-17.

Shell: Conispiral, dextral, heavy, wide; color gray to yellowish brown; whorls 5-6; spire broadly conic elevated, whorl of protoconch elevated above other whorls; second, third, and fourth whorls shouldered, body whorl round; aperture roundly ovate, angled above, white within; peristome continuous, generally attached to body whorl from angle of umbilicus, may be completely separate from body whorl in old individuals; umbilicus wide and deep.

Measurements

Length	Width	Length of aperture	Width of aperture
6.2 mm.	4.5 mm.	2.6 mm.	2.4 mm.
5.5	4.2	2.6	2.2
5.2	3.9	2.7	2.3

Soft Part of Animal: Operculate; sexes separate; gill pectinate; body generally whitish or pinkish and translucent; streak of dark brown extending down side of tentacles, patch of brown between eyes, and black and brown markings on rostrum; foot short, about three times as long as wide, rounded behind, broad before and somewhat concave in middle of sides; rostrum short, broad, emarginate in middle of anterior end; tenacles slender, not tapering, about two-thirds as long as extended foot, blunt at tips; eyes at inner bases of tentacles on anterior side of a small swelling; mantle simple along its edge.

Males can be distinguished from females by the presence of a verge situated within the mantle cavity dorsal, posterior, and slightly to the right of the head. The verge is a flat white rectangular lobe having the small penis on the right margin.

General Distribution: "New York and eastern Penn., west to Utah, Wisconsin south to Texas." (Baker, 1928, p. 124.)

Occurrence in Kansas: Shoal Creek in Cherokee County, Lone Star Lake in Douglas County, Neosho River at Humbolt in Allen County, and in Wabaunsee County.

Ecology: In Lone Star Lake, *A. integra* was found living on mud bottom in quiet shallow water near the mouth of a small creek emptying into the lake. In this habitat the water was somewhat turbid and contained large masses of floating and partly submerged algae. In Shoal Creek it was found living on ooze-covered gravel bottom in clear quiet water about one foot deep. Microscopic examination of sections through the intestine indicate that the food of *integra* consists chiefly of diatoms (Berry, 1943, p. 35).

The reproductive season of *integra* probably begins early in the spring and continues throughout the summer. Egg capsules of *A. limosa*, a closely related species, have been observed in April, May, July, and August. In regard to *limosa* Baker (1928, p. 96) states that a single egg is laid in a semilenticular corneous capsule, somewhat longer than broad, attached to objects by what may be termed the base. Each capsule is attached separately to some object, as on the shell of a neighboring *Ammicola* or on vegetation or other object, and contains the egg or embryo which floats in the fluid contained in the capsule. As many as five capsules have been counted on a single shell of *Ammicola*. Females are more numerous than males, the ratio sometimes being 10 to 1.

Family POMATIOPSIDAE Stimpson

The shells of the animals of this family are small, but range up to nearly a half inch in length, elongately conical, turreted, umbilicate; peristome continuous, simple; operculum corneous, subspiral. As is the case with amnicolids, the shells are not reliable criteria

for determination of species, and recourse must be had to a study of the soft anatomy.

The family is probably restricted to North America, but there is uncertainty about the relationships of some Old World snails that may belong with the pomatiopsids.

Pomatiopsids are sometimes spoken of as "amphibious" because of their habit of wandering away from water, or living on damp earth.

Genus *Pomatiopsis* Tryon

Pomatiopsis lapidaria (Say)

Pl. 1, fig. 4; text fig. 21

Cyclostoma lapidaria Say, 1817, Journ. Philadelphia Acad. Sci., vol. 1, p. 13.

Pomatiopsis lapidaria, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 162-168, pl. 7, figs. 42-45; Franzen, 1944, Trans. Kansas Acad. Sci., vol. 47, No. 2, pp. 264-265, pl. 1, fig. 9.

Shell: Conispiral, dextral, elongated, turreted; color dark brownish horn or chestnut; surface dull to shining, lines of growth crowded, slightly wrinkled in some specimens, rather fine; apex rounded, flattened, depressed; nuclear whorl not emergent, partly embraced by second whorl, sculpture finely granulated or almost smooth; whorls 7, well rounded, slowly and regularly increasing in diameter; sutures deeply impressed; spire acute, about three times as long as aperture; aperture elongate ovate, somewhat narrowed and angled above, rounded below, slightly expanded, somewhat brownish or purplish within; peristome simple or slightly thickened within; upper terminations connected on parietal wall by callus; umbilicus distinct, emargined by inner lip that is slightly reflected over umbilical region; base rounded.

Measurements

Length	Width	Length of aperture	Width of aperture
8.0 mm.	3.9 mm.	2.4 mm.	1.9 mm.
6.8	3.6	2.3	1.8
6.3	3.1	2.1	1.6

Soft Part of Animal: Operculate; sexes separate; gill pectinate; foot short, broad, broadly rounded before, rounded behind, having three sinuses, one of which separates foot into anterior and posterior parts; above this sinus, another at right angles to it separates foot from body; rostrum blunt, longer than tentacles, wrinkled transversely, except when fully extended; tentacles short, pointed, tapering; verge, in males, large, simple, long, somewhat sickle-shaped, and tapering gradually to point, situated some distance behind right tentacle a little to right of center of neck and concealed within branchial cavity. General color of animal pale yellowish or horn.

Central tooth of radula broader than high, its curved ventral margin bearing two large basal denticulations pointed inward; distal reflection broad bearing three large, wide cusps, center cusp about twice as large as either side cusp; lateral tooth 5-cuspid, second medial cusp about twice as large as either side cusp; marginal teeth multi-cuspid.

General Distribution: "New York to [northeastern Kansas and] Iowa, Michigan and Wisconsin south to Missouri, Alabama, and Georgia." (Baker, 1928, p. 166.)

Occurrence in Kansas: P. lapidaria is known only from Atchison County.

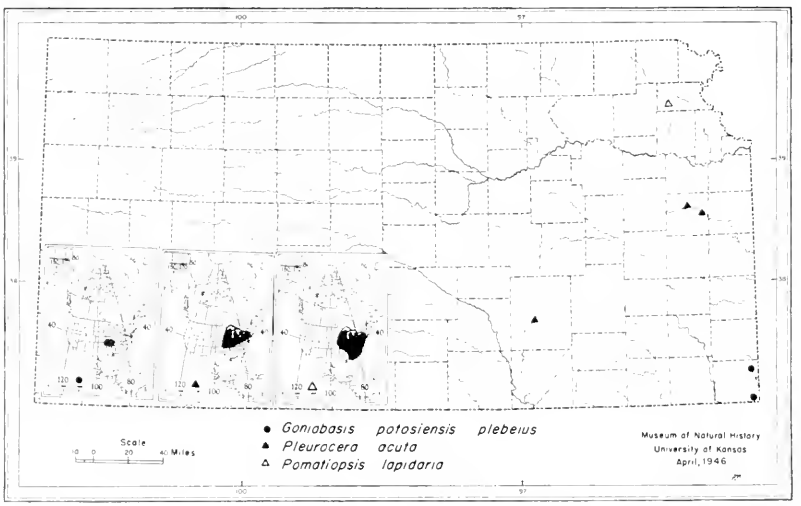


FIG. 21. Distribution of *Goniobasis potosiensis plebeius*, *Pleurocera acuta* and *Pomatiopsis lapidaria* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ecology: P. lapidaria is more or less amphibious. In Atchison County it lives in an isolated marshy area of some forty acres in extent, one and one-half miles south of Muscotah. In this habitat it has been found living on moist or wet ground and low on the stems and leaves of sedges, reeds, and cattails. Associated with it here (Franzen, 1944, p. 264) were the three terrestrial snails, *Oxyloma retusa* (Lea), *Triodopsis multilineata algonquinensis* Nason and, *Stenotrema leai aliciae* (Pilsbry). Berry (1943, p. 60) states that in Kentucky *lapidaria* was collected from a mountain side more than 500 feet from water but that it has been kept alive submerged in a wire screen trap in a creek from February to May. In states bordering the Great Lakes *lapidaria* seems to be commonest near streams and on river banks. Baker (1928, p. 166) states that it seemingly prefers wet ground to actual immersion in water and that it has been found in many places under leaves and on damp or wet

mud in places more or less subject to overflow from streams and rivers.

Out of water, *lapidaria* has a peculiar manner of progression by stepping, using the rostrum and posterior part of the foot together for securing one stance and then moving the anterior part of the foot forward to support its weight while it moves the rostrum and posterior part forward in the second phase of the step. When in water it "glides along with a somewhat hesitating motion" (Baker, 1928, pp. 167-168).

Family PLEUROCERIDAE Fisher

Among the members of this family, the shells are elongately conical to subglobose, moderately large, in some species an inch or more in length, thick and solid. The aperture is entire, or canaliculate below. The operculum is corneous, and subspiral.

The family is restricted to North America, where the greatest concentration of species occurs in the southeastern part of the United States, and in the region of the Great Lakes. Like other branchiate snails, the members of this family inhabit permanent bodies of water; they are sensitive to pollution and siltation of their habitats.

Genus *Pleurocera* Rafinesque

Pleurocera acuta Rafinesque

Pl. 1, fig. 7; text fig. 21

Pleurocera acuta Rafinesque, 1813, Enumeration and Account, p. 3; Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 171-179, pl. 9, fig. 14; Franzen, 1944, Trans. Kansas Acad. Sci., vol. 47, No. 2, pp. 263-264, pl. 1, fig. 10.

Shell: Conispiral, dextral, elevated, acute, imperforate; color greenish yellow to pale brown, or dark chestnut, sometimes with a yellowish band encircling whorls immediately below suture; nuclear whorls 1½ to 2, smooth, rounded, rapidly increasing in diameter, apex bent inward; surface dull to shining, lines of growth oblique, crowded, here and there elevated; sculpture of fine incised spiral lines, which are more deeply impressed on upper carinated whorls than elsewhere; whorls 13 in perfect specimens, 7-10 usually represented, flatsided, regularly increasing in diameter, upper 7-11 carinated immediately above suture, last four either without carina or with slight ridge immediately above suture; body whorl distinctly angulated, sharply defined carina, and some specimens having one or more small carinae encircling base of body whorl; aperture subrhomboid, narrowed above, white, bluish-white or purple within, spiral ridges on base sometimes showing through as white lines; produced and canaliculate below near columella, purplish spot near columella in some specimens; peristome acute, smooth, thick; columella bluish-white, twisted, terminations of peristome and columella joined by thick, sometimes spreading, callus.

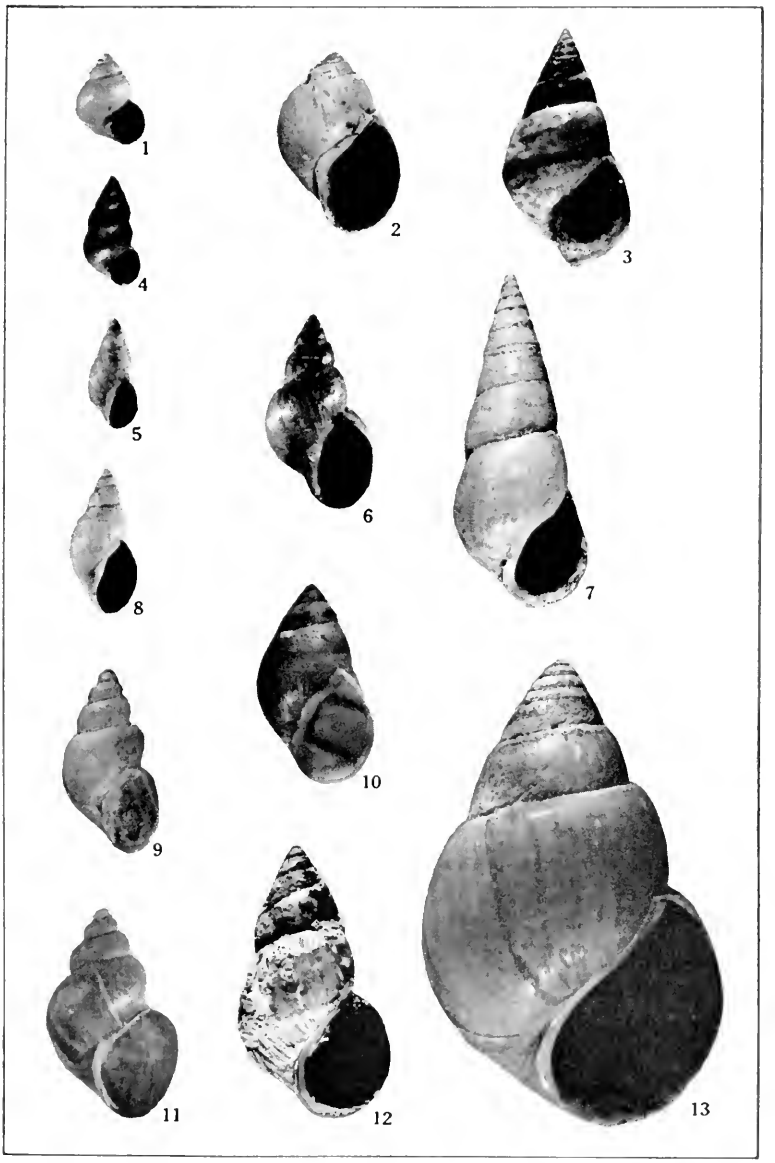
PLATE I

Shells of Aquatic Gastropods in Kansas

Figures 9 and 11 enlarged approximately 6 times, and all other figures enlarged approximately 2 times, natural size.

1. *Amnicola integra* (Say), Lone Star Lake, N ½ sec. 25, T. 12 S, R. 18 E, Douglas County, Kansas. Collected by L. D. Fairbanks, 23 April 1954. Catalogue number 9810.
2. *Lymnaea bulimoides cockerelli* (Pilsbry and Ferriss), Lakeview School pond, 8 mi. E Meade, Meade County, Kansas. Collected by A. B. and A. E. Leonard, 17 August 1941. Catalogue number 955.
3. *Goniobasis potosiensis plebeius* (Anthony), 5 mi. E. Baxter Springs, Cherokee County, Kansas. Collected by A. B. and A. E. Leonard, 17 April 1943. Catalogue number 1313.
4. *Pomatiopsis lapidaria* (Say), 1½ mi. S Muscotah, Atchison County, Kansas. Collected by L. D. Fairbanks, 15 May 1954. Catalogue number 9819.
5. *Lymnaea humilis rustica* Lea, 1½ mi. S Lawrence, Douglas County, Kansas. Collected by G. D. Hanna, 10 May 1909. Catalogue number 2496.
6. *Lymnaea bulimoides techella* (Haldeman), 9 mi. E Cunningham, Kingman County, Kansas. Collected by D. S. Franzen, 10 September 1940. Catalogue number 1042.
7. *Pleurocera acuta* Rafinesque, ½ mi. S bridge on Marais des Cygnes River, near La Cygne, Linn County, Kansas. Collected by A. B. Leonard, 15 September 1943.
8. *Lymnaea obrussa* Say, 1 mi. E, 1½ mi. S Lawrence, Douglas County, Kansas. Collected by G. D. Hanna, 10 January 1909. Catalogue number 2466.
9. *Lymnaea dalli* Baker, Meade County State Park, Meade County, Kansas. Collected by A. B. Leonard, 30 August 1941. Catalogue number 958.
10. *Goniobasis potosiensis plebeius* (Anthony), ¼ mi. S mouth of 5-Mile Creek, 5 mi. E Baxter Springs, Cherokee County, Kansas. Collected by L. D. Fairbanks, 31 May 1955. Catalogue number 9850.
11. *Lymnaea parva* Lea, Atchison County Lake, sec. 12, T. 5 S, R. 18 E, Atchison County, Kansas. Collected by L. D. Fairbanks, 10 May 1955. Catalogue number 9821.
12. *Goniobasis potosiensis plebeius* (Anthony), See Figure 10.
13. *Campeloma subsolidum* (Anthony), Wakarusa Creek, 2 mi. S Lawrence, Douglas County, Kansas. Collected by G. D. Hanna, 11 April 1909. Catalogue number 2785.

PLATE I



Measurements

Length	Width	Length of aperture	Width of aperture
22.0 mm.	8.6 mm.	7.8 mm.	4.2 mm.
19.1	7.6	6.7	3.9
13.0	5.5	4.9	2.9

Soft Part of Animal: Operculate; foot wide, short, thick, truncated before and rounded behind; blackish above, yellowish below; top of rostrum marked by black transverse bands or spots; side of body and foot streaked with black; mouth dark gray or blackish; opereuligerous lobe conspicuous; head prominent, having large, somewhat elongated, proboscis or rostrum, subconical in form, capable of considerable extension when the animal is in motion; mouth at tip of rostrum, disklike, a long longitudinal slit dividing end of rostrum into double disk; radula plainly seen in mouth when animal is feeding; tentacles long, tapering, narrow; eyes black, on swelling at outer base of tentacles; mantle simple, folded on right side to form respiratory cavity; impressed line along right side of body curves to margin of foot behind right tentacle; gills within mantle cavity, primary gill being narrow. Sexes separate, no external verge in male; female distinguished by presence of pit or sinus on neck between right tentacle and opereuligerous lobe. Rachidian tooth large, broader than long, rounded below, 7-9 cuspid, central cusp large; laterals subrhomboidal, 4-6 cuspid, one cusp large; marginal teeth elongated, more or less sole-shaped, multicuspid (Baker, 1928, pp. 174-176).

General Distribution: Baker (1928, p. 178) proposes separating the river form and small lake-form of *acuta* from the "Great Lake" form and assigns the name *P. a. tracta*, to the river-form with the distribution, "Western New York, to Great Lakes Region south to Ohio River drainage." The species from Kansas, however, has been referred to *Pleurocera acuta* Rafinesque by Goodrich (Franzen, 1944, p. 264).

Occurrence in Kansas: In 1941 A. B. Leonard found a few dead shells along the Marais des Cygnes River within three miles of Rantoul in Franklin County. In 1948 shells of recent origin were found along the Marais des Cygnes River at Ottawa in Franklin County.

Ecology: Baker (1928, p. 178) records the species in Wisconsin from the following habitats: boulder and gravel bottom on exposed shores of lakes in water 1.5 to 2.5 m. deep, and in streams and rivers on bottoms of gravel, rock, and "rock ledge" in moderately swift current. The depths at which *P. acuta* was taken from the streams varied from 0.3 to 0.6 m. The rocks in some of these stream habitats were covered with algae. Other vegetation present included *Potamogeton* and *Elodea*.

"This *Pleurocera* appears to be rare on sand and mud bottom in slow current, but common and abundant on rocky shores subject

to violent wave action. It is decidedly a shallow water form, becoming rare in water deeper than 0.5 m." (Baker, 1928, p. 178).

Remarks: The rocky stream bed of the Marais des Cygnes River in eastern Kansas was in former years probably a more satisfactory habitat for *P. acuta* than at present. The rarity of living examples there is probably owing to the effects of flooding and accompanying siltation in recent years, especially since the cultivation of land has become more extensive.

Genus *Goniobasis* Lea

Goniobasis potosiensis plebeius (Anthony)

Pl. 1, figs. 3, 10, 11; text fig. 21

Melania plebeius Anthony, 1850, Proc. Boston Soc. Nat. Hist., vol. 3, p. 362.

Goniobasis potosiensis plebeius, Goodrich, 1939, Occ. Papers, Mus. Zool. Univ. Michigan, No. 406, p. 3; Franzen, 1944, Trans. Kansas Acad. Sci., vol. 47, No. 2, p. 263, pl. 1, fig. 4.

Shell: Dextral, sharply conic above periphery of body whorl, subovate below; color, yellow to pale green or olivaceous; whorls variable in number, scarcely inflated, slightly shouldered, increasing regularly in size from apex to carina on periphery of ultimate whorl, carina frequently paralleled by secondary ridges above and below; aperture ovate, slightly longer than height of spire; lip simple.

Goodrich (1939, p. 3) states, "*G. p. plebeius* varies from pyramidal, tightly coiled, flat-whorled forms to elongate, loosely coiled, striate and keeled phases."

Measurements

Length	Width	Length of aperture	Width of aperture
13.0 mm.	7.0 mm.	6.5 mm.	3.5 mm.
16.0	9.0	8.0	4.5
18.0	11.0	9.0	5.5

Soft Part of Animal: Much like that of *Pleurocera acuta*, rounded foot marked by reticulate black streaks on background of red, but yellow or gold along sides; undersurface of foot white; proboscis having transverse black wrinkles across dorsal surface; sides yellow or red; ventral side and mouth bluish-white; tentacles long, cylindrical with transverse alternating bands of black and yellow or red; eyes black, situated at outer bases of tentacles; operculum dark chestnut.

General Distribution: "Common in rivers and creeks of the Ozarkian area of Missouri and Arkansas and in Oklahoma counties bordering Missouri. Probably in parts of southeast Kansas." (Goodrich, 1939a, p. 3.)

Occurrence in Kansas: Two records from the southeastern part of Cherokee County.

Ecology: Franzen (1944, p. 263) states, "*G. potosiensis plebeius* was discovered, in the spring of 1943, by Hibbard, living in large numbers in a small, clear stream which was flowing below timbered hills in the Ozarkian region, six miles east of Baxter Springs, Kansas. . . . This stream, a small tributary of Shoal Creek, has a bed of gravel or shingle, without the silt so characteristic of most Kansas streams. Later in the autumn of the year, our field party found that severe floods had washed the snails toward Shoal Creek. They were found near the mouth of the small stream but in small numbers. They had at that time not worked their way back upstream to their former habitat."

In Cass County, Missouri, *G. p. plebeius* lives in clear swiftly flowing rocky streams where it may be found adhering to ooze-covered rocks on the bottom. The species is more readily observed in quiet water approximately one foot deep near the main current of the stream. The shells are often covered with algae and ooze and bear a strong resemblance to the smaller stones and gravel on the bottom. Their locomotion is so slow as to be almost imperceptible.

The eggs of *Goniobasis* are laid on rocks in a linear series of two or three or singly. The significance of the pit situated at the base of the right tentacle of the female is not known. Males are known to free spermatophores into the water. "Although fertilization is probably internal the lack of specialized intromittent organs often leads to the loss of some of the spermatophores into the water. It has not yet been possible to determine how the spermatophores are deposited or whether they enter the female pit of the uterus directly." (Jewell, 1931, p. 115-118.)

Subclass EUTHYNEURA Spengel

Order PULMONATA Cuvier

Suborder BASOMMATOPHORA Schmidt

Family PHYSIDAE Dall

The family Physidae and the remaining families of aquatic gastropods considered in this handbook, belong to the Order Pulmonata. The snails of that order have lost their gills and have a cavity, in the mantle chamber, acting as a lung for respiratory purposes. Such snails are referred to as pulmonate. This group of families is also spoken of as *basommatophorous,* because the eyes are not stalked, but occur at the base of the tentacles.

In the family Physidae, the shells of the animals are sinistral, conical, with a spire of variable length, and simple aperture, and like most other Pulmonata, lack an operculum. These animals live

in ponds, lakes or streams, and thrive in bodies of water that may be heavily silted, or choked with algae.

Genus *Physa* Draparnaud

The current classification of the species of *Physa* is imperfect. Baker (1928, pp. 418-419) has pointed out that, "The study of the Genus *Physa* is attended with great difficulty; the species are very variable in form and structure; and as well, often in sculpture. . . . The early authors, Say, Lea, Tryon, frequently described a species from one or two examples and several names have been given to the extremes in variation of a single species for this reason." Call (1887, p. 17), in regard to the species of *Physa*, states, "In every pond and pool in which undoubted specimens of one occurs there also may be found typical examples of the other."

The physae are highly tolerant of the extremes of limiting environmental conditions and may occur where no other aquatic snails are to be found. Consequently they are subject to the effects of depauperization. Goodrich (1939b, p. 124) states, "Depauperization as it is understood by malacologists is the outward manifestation of disease, accident, or malnutrition or a reaction of inimical environment." According to this author the effects of the latter are found in individual mollusks fairly frequently and sometimes involve whole colonies or even all animals in a wide area. Dwarfing is seen for example, in colonies living in sandy areas, or in a habitat subjected to dry periods, or rapid run-off of water. Long periods of imposed hibernation or aestivation certainly bring about a reduction in size. A local example is a colony of dwarfed *Physa* living in a large spring near the Scott County State Lake in western Kansas.

The classification here adopted for species of *Physa* is tentative and must remain so until non-heritable differences are distinguished from those that are heritable.

Physa hawnii Lea

Pl. 3, figs. 7, 8, 13; text fig. 22

Physa hawnii Lea, 1869, Journ. Acad. Nat. Sci. Philadelphia, vol. 6, 2nd ser., pp. 165-166, pl. 24, fig. 84; Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 2, p. 53; ——, 1885b, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 125; ——, 1887, Bull. Washburn Lab. Nat. Hist., vol. 2, No. 8, p. 14; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, pt. 2, No. 9, pl. 30, fig. 11, p. 408; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., vol. 24, pt. 2, No. 16, pl. C, fig. 2, pp. 1027-1028.

Shell: Conispiral, sinistral, fusiform, imperforate, generally thick and solid in large specimens; color variable from whitish and amber to brown and black, often with one or a few white bands paralleling growth lines, indica-

tive of dormant periods; spire exserted and obtuse; sutures impressed but shallow; whorls 5 to 6, convex, the last greatly swollen, occupying approximately ¾ of total length; aperture elongate oval, often with reddish-brown stripe or varix within paralleling outer margin of peristome; outer lip thin and simple, terminations connected by a prominent callus across parietal wall; columellar plait thickened and scarcely folded; sculpture of fine, or sometimes coarse irregular vertical striations crossed by exceedingly fine spiral lines giving surface glossy texture.

Measurements

Length	Width	Length of aperture	Width of aperture
20.1 mm.	10.1 mm.	11.9 mm.	4.8 mm.
17.6	9.0	11.2	4.5
13.6	6.9	9.8	3.4

Soft Part of Animal: Blackish or yellowish gray, dotted or flecked with white or yellow; foot long, narrow, acutely pointed behind and rounded before where it is produced into two lateral lobes (vela); mantle reflected over part of shell from columellar side and produced into two series of digitations; tentacles long, slender, cylindrical, situated at outer angles of head; eyes at inner base of tentacles; pulmonary, excretory, and genital orifices on left side; lacking pseudobranch; jaw single, arched, having vertical process on upper margin; radula bearing teeth arranged in oblique rows, center tooth with lateral projections, multicuspid; lateral and marginal teeth comblike, approximately 120 on each side of central tooth, usually with large cusps alternating with smaller denticulations, and with lobe or process at upper inner angle of tooth.

General Distribution: Eastern Kansas, and probably southern Missouri, northern Arkansas, and northeastern Oklahoma.

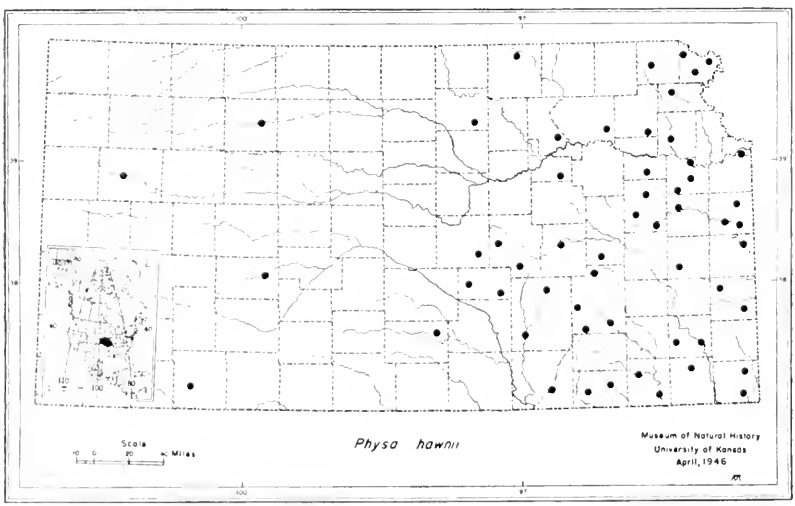


FIG. 22. Distribution of *Physa hawnii* in Kansas. Locality records are shown in symbols. Inset map shows approximate distribution of this species in North America.

Occurrence in Kansas: Generally confined to the eastern one third of the state including the Flint Hills.

Ecology: This species is abundant in small ponds, road-side ditches, streams, lakes and large rivers. It is one of the most common aquatic gastropods in eastern Kansas. It is often seen crawling on dead and living vegetation or on rock or mud bottom in shallow water. Occasionally individuals are found out of the water creeping on moist surfaces of dead leaves, sticks, stones, and mud. They seem to have a high tolerance for a wide variety of environmental conditions and are easily kept in aquaria. Small forms have been found in ephemeral pools and streams that repeatedly dry up and are replenished with water after the next rain. The largest forms occur in southeastern Kansas where the streams flow throughout the year. Large populations thrive in some streams polluted by sewage.

In bodies of water that dry up *Physa* is compelled to aestivate and does so by burrowing into cracks in the mud or into the mud itself, closing the aperture with mud attached to the mucous of the foot. Individuals remain dormant until the next occurrence of water.

The reproductive period begins usually in February and continues into the fall. Marked individuals in aquaria have been observed acting alternately as male and female in copulation within a period of four days. The individual acting as male crawls upon the body whorl of the individual acting as female and faces in the same direction as the latter. The penis is everted and extended vertically passing the outer lip of the shell of the "female" partner and is inserted in the female aperture. The acting female may remain stationary or crawl about as usual with the acting male riding. So far as is known mutual copulation wherein each individual acts as male to the other, as has been observed in the *Lymnaea* and some terrestrial pulmonates, has not been observed in the *Physa*.

The egg capsules are elongate, reniform, transparent, and gelatinous. Size is variable and may be as large as 20 mm. by 5 mm.; masses contain a variable number of eggs, sometimes as many as 200. The eggs are laid on almost any object in water and frequently on the underside of stone, on exposed surfaces of the bottom, or on any kind of vegetation in water, often on the undersides of dead leaves. Several weeks are usually required for hatching. The newly hatched snails are about the same size as the individual eggs, approximately .45 mm. in diameter.

Locomotion of the *Physa* is relatively rapid. It glides about on

stones, vegetation, and the undersurface of the water where the characteristic rippling movements of the ventral surface of the foot are easily observed. In crawling on the undersurface of the water (surface film) in an inverted position the mucous secretion of the foot accumulates a filmy mass of small floating debris that is moved to the terminal end of the foot. The animal frequently turns its head around to meet the flexed posterior end of the foot and devours the entire accumulation.

When the animal is on the bottom it can ascend to the surface by simply raising the anterior end of the foot and rising from the substrate leaving a mucous thread attached to the bottom; the animal continues "spinning" in proceeding to the surface. On reaching the surface the snail turns over into the inverted position, opens the pneumostome, takes in air for a moment and crawls along the surface film. To descend to the bottom it may find the same mucous thread or one left by another snail; the snail crawls downward in a tilted position on the thread at the same rate that it crawls on any other surface.

The mucous thread is, of course, invisible in the water but it can be easily observed by moving a stick through the water in back of the descending snail and lifting the thread above the surface where the thread will be seen with small droplets of water clinging to it. In so doing the snail will be pulled back toward the surface. This so-called "thread-spinning" has also been observed in *Lymnaea*.

Physa anatina Lea

Pl. 3, figs. 14, 18; text fig. 23

Physa anatina Lea, 1869, Journ. Acad. Nat. Science Philadelphia, vol. 6, 2nd ser., pp. 171-172, pl. 24, fig. 94; Call, 1885b, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 123; ——, 1886, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 184; ——, 1887, Bull. Washburn Lab. Nat. Hist., vol. 2, No. 8, p. 14; Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 2, fig. 21; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, pt. 2, No. 9, p. 408, pl. 30, fig. 10.

Shell: Conispiral, sinistral, subfusiform, somewhat inflated, imperforate, thin to heavy; color amber to light brown; spire usually short, exserted, pointed; sutures shallow or sometimes impressed; whorls, 5 to 6, somewhat convex, and last one large; aperture elongate oval, often having narrow reddish stripe on white callus paralleling peristome within outer lip; outer lip slightly expanded, terminations connected by thin callus across parietal wall; columellar plait similar to that of *haweni*, often impressed in middle, and twisted; lines of sculpture generally fine, giving shell glossy or silky texture.

Measurements

Length	Width	Length of aperture	Width of aperture
12.5 mm.	7.2 mm.	7.8 mm.	3.8 mm.
9.1	5.6	8.0	2.9
7.5	4.5	5.2	2.3

Soft Part of Animal: Resembles *P. hawnii.*

General Distribution: Probably, from Nebraska to central Texas and from eastern Kansas to New Mexico and Colorado.

Occurrence in Kansas: Common throughout the state except in the extreme southeastern part.

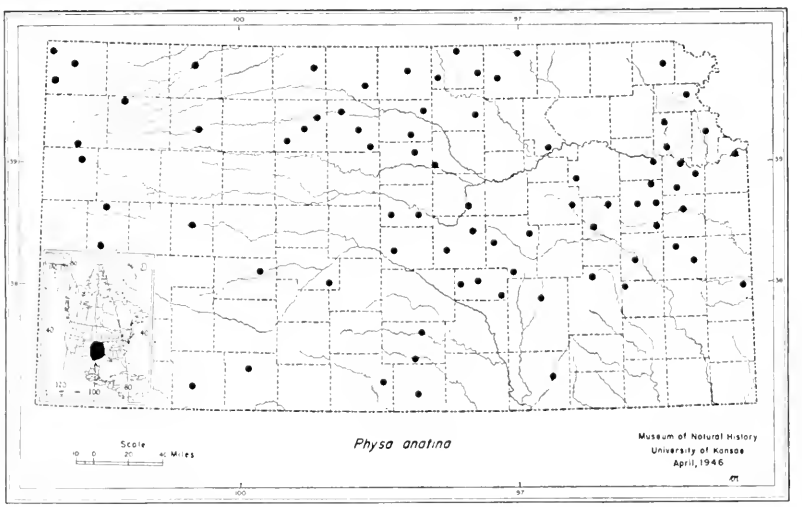


FIG. 23. Distribution of *Physa anatina* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Ecology: P. anatina is found in much the same variety of habitats as is *hawnii*, and habits and life cycle are not known to differ significantly in the two species. In western Kansas, however, *P. anatina* inhabits small creeks and rivers, ephemeral pools, ditches, irrigation reservoirs, pasture streams and isolated water tanks for cattle.

Family LYMNAEIDAE Broderip

Shells in the numerous species of this family are normally dextral, and ovate to elongately spiral. The columella is thickened and twisted. The peristome is simple and thin. The shell is covered with

a corneous epicostracum or epidermis. Lymnaeids are world-wide in distribution, but the greatest number of species occurs in the north-temperate zone. Geologically speaking, the family is an ancient one that had its greatest development in Tertiary time.

The animals of this family live in a wide variety of aquatic habitats, and certain species live on damp earth near water rather than in the water itself. In Kansas, species are more numerous than those of the Physidae, but local populations are generally less abundant.

Baker (1928) and others have recognized several genera in the family, but since the shells of these are difficult to distinguish, a conservative approach is here taken, and all members of the family in Kansas are referred to the genus *Lymnaea*.

Genus *Lymnaea* Lamarck

Lymnaea bulimoides techella (Haldeman)

Pl. 1, fig. 6; text fig. 24

Lymnaea techella Haldeman, 1867, American Journ. Conch., vol. 3, p. 194, pl. 6, fig. 4.

Lymnaea bulimoides techella, Pilsbry and Ferriss, 1906, Proc. Philadelphia Acad. Sci., p. 163, figs. 20-23; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 2, fig. 25; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 234, pl. 1, fig. 21; Franzen and Leonard, 1943, Univ. of Kansas Sci. Bull., vol. 29, pt. 2, No. 9, p. 405, pl. 30, fig. 5; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118.

Galba bulimoides techella, Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 214-217.

Lymnaea techella, Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96.

Shell: Conispiral, dextral, varying from obtuse to subfusiform; periostracum yellowish to grayish brown; surface dull to shining, growth lines rather coarse, with faint indications of spiral lines; body whorl frequently malleated; whorls of protoconch 1¼, wide and low, with surface sculpture resembling satin finish; whorls 6, convex, usually somewhat shouldered; last whorl large, generally ventricose; spire more or less acutely conic, of variable length; sutures well impressed; aperture roundly ovate, from ½ to ⅗ length of entire shell; inner lip broadly and flatly expanded and reflected; anterior end of aperture produced or effuse; umbilical chink large, rather widely open; outer lip simple, sharp; axis consisting of series of smooth round, hourglass-shaped columns.

There is considerable variation in the form of the shell of *techella*. The spire is variable in height and the last whorl may be either simply convex or disproportionately swollen.

Measurements

Length	Width	Length of aperture	Width of aperture
11.3 mm.	7.4 mm.	6.2 mm.	4.0 mm.
9.8	6.3	5.4	3.7
9.0	5.0	4.5	3.0

Soft Part of Animal: Foot short, wide, rounded; exposed parts of animal gray with white and black flecks; head having bilobed area of the vela; tentacles flattened, triangular; eyes on inner base of tentacles; jaw in three parts, a large superior and two smaller, narrow, lateral parts; central tooth unicuspid, having small ectocone at left; lateral teeth bi- or tri-cuspid; marginals serrated.

General Distribution: "Southern United States from Kansas, Missouri and Colorado to southern Texas; Alabama west to southern California and northern Mexico." (Baker, 1911, p. 215.)

Occurrence in Kansas: L. b. techella is found generally throughout the state, but is more common in the eastern half of Kansas than in western Kansas.

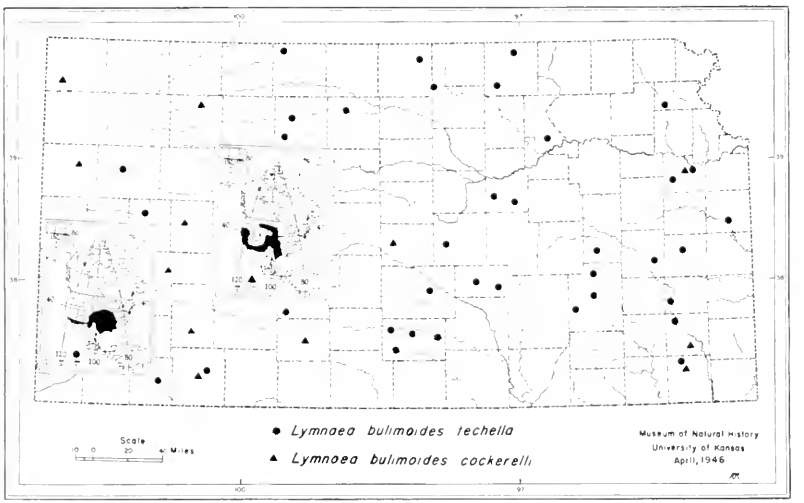


FIG. 24. Distribution of *Lymnaea bulimoides techella* and *Lymnaea bulimoides cockerelli* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ecology: L. b. techella commonly lives in shallow water with mud or ooze-covered bottom and on exposed areas in associations of semi-aquatic plants near shores of streams, lakes, ponds, and transient pools. In Franklin County it was found living in a large rock quarry at the edges of several shallow pools where large numbers of individuals were crawling on exposed rocks covered with algae, dead leaves of cattail (*Typha*), and in the water on ooze-covered bottom. Many were also observed crawling up the stems and leaves of *Typha, Juncus,* and *Scirpus,* which were growing in clumps at the edge of the water. Other snails living in association

with *techella* were *Physa hawnii* and the terrestrial snails *Bulimulus* and *Succinea*.

Alice Leonard (1943, p. 234) states that *L. b. techella* is common among the sinkhole ponds of Clark and Meade counties. "It is able to survive periods of drought and sometimes appears in great numbers in a pond that has been dry the previous season."

In March, individuals of *techella* of many different sizes were living entirely submerged in the water of a small roadside ditch near Muscotah, in Atchison County. The sides of the ditch and bottom of the pool were covered with dead terrestrial grasses on which the snails were actively crawling about. The air temperature was 38 degrees Fahrenheit. Like many of the species of *Lymnaea*, *L. b. techella* probably migrates from deep to shallow water and out of the water onto the shore according to the seasonal change of temperature from late winter to mid-summer. Also, the breeding season probably begins in early spring before the animals leave the water. Specimens of *techella* kept in aquaria in the laboratory laid eggs in April and were seldom seen out of the water until late in the month after several egg masses were laid.

The eggs are laid in an elongate, cylindrical, translucent, and gelatinous mass approximately 11 by 4 mm., containing a variable number of eggs, generally 25 to 50. The egg mass may often have a long "tail" of gelatinous material continuing from one end. It is generally half the diameter of the egg mass and just as long. The eggs may be laid directly on the bottom, but more often on dead vegetation in the water.

Lymnaea bulimoides cockerelli (Pilsbry and Ferriss)

Pl. 1, fig. 2; text fig. 24

Lymnaea bulimoides cockerelli Pilsbry, 1906, Nautilus, vol. 19, p. 30; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 234, pl. 1, fig. 20.

Galba bulimoides cockerelli, Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 217-221.

Limnophysa bulimoides, Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 118.

Shell: Conispiral, dextral, subglobose, rather thick; color pale horn; surface dull to shining; growth lines fine, coarser on last whorl, which is sometimes malleated near aperture; protoconch small, rounded; whorls 4½, convex, rapidly enlarging; spire short and broad; last whorl large, globose; sutures impressed; aperture varying from ovate to roundly ovate, occupying from two-thirds to two-fifths of length of shell; inner lip broadly expanded, arched over umbilical chink, which is widely open.

Measurements

Length	Width	Length of aperture	Width of aperture
10.3 mm.	7.8 mm.	6.2 mm.	3.3 mm.
9.6	7.5	6.2	3.2
7.0	5.0	4.2	3.0

Soft Part of Animal: Resembles *L. b. techella.*

General Distribution: "Montana south to southern Texas; South Dakota and eastern Texas west to California." (Baker, 1911, p. 218.)

Occurrence in Kansas: Western half.

Ecology: In Kansas *cockerelli* lives in or near transient pools that frequently dry up during summer and fall. Alice Leonard (1943, p. 234) collected *L. b. cockerelli* in Meade County from "a sinkhole pond that is dry in arid periods. While it was not found in large numbers, it seems to persist here from season to season, in spite of the ephemeral condition of the pond." Other areas in western Kansas from which *cockerelli* has been collected indicate that it has a high tolerance for drought conditions.

Lymnaea obrussa Say

Pl. 1, fig. 8; text fig. 25

Lymneus obrussus Say, 1825, Journ. Philadelphia Acad. Sci., vol. 5, p. 123.

Lymnaea obrussa, Baker, 1909, Nautilus, vol. 23, No. 7, p. 94; Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 2, fig. 23; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, pt. 2, No. 9, p. 406, pl. 30, fig. 7.

Galba obrussa, Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 270-283, pl. 26, figs. 8-13, pl. 31, figs. 20-37.

Limnophysa desidiosa, Call, 1885b, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 4, p. 118.

Shell: Dextral, subconic, pointed, oblong, frequently somewhat inflated; periostracum generally light yellowish (horn color); surface having numerous coarse lines of growth; fine spiral lines often visible under strong lens; whorls 5½, rounded, somewhat shouldered, shoulder near suture; last whorl large, half length of entire shell, generally compressed but quite obese in some specimens; spire acute, sharply conical; whorls of protoconch 1¼; sutures deeply indented; aperture elongate-ovate, somewhat produced anteriorly; peristome thin acute; inner lip reflected over umbilical chink and forming thin narrow expansion usually appressed to umbilical region, giving axis slight twist; parietal callus thin; umbilical chink varying from distinctly open to scarcely observable; surface of shell frequently malleated.

Measurements

Length	Width	Length of aperture	Width of aperture
17.7 mm.	7.7 mm.	9.0 mm.	5.0 mm.
12.0	5.5	6.2	3.2
8.0	4.5	4.0	2.0

Soft Part of Animal: Resembling that of *L. b. techella.*

General Distribution: "From the Atlantic to the Pacific oceans, and from Mackenzie Territory and Quebec south to Arizona and northern Mexico" (Baker, 1911, pp. 277-279).

Occurrence in Kansas: Generally state-wide excepting the two westernmost tiers of counties.

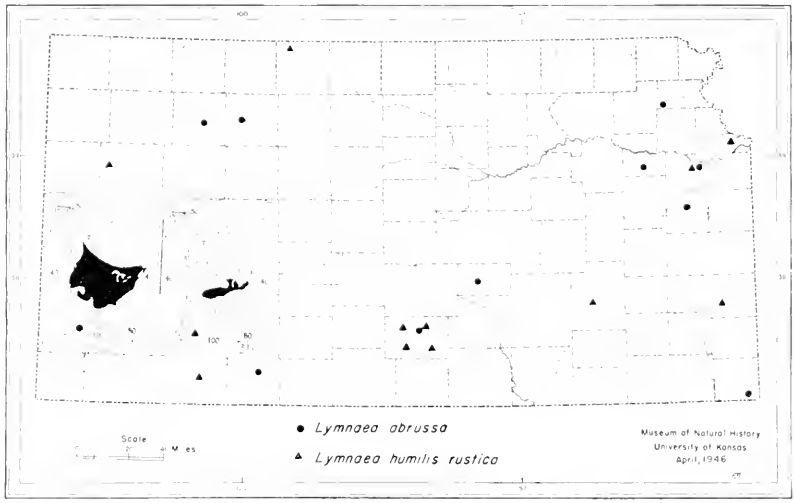


FIG. 25. Distribution of *Lymnaea obrussa* and *Lymnaea humilis rustica* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ecology: In Graham County, *L. obrussa* lived in shallow water having a mud bottom and on exposed mud flats at the edge of the County Lake. Clumps of sedges, cattail, and *Saggitaria* were common along the muddy shore.

In Shoal Creek in Cherokee County a colony of *obrussa* was found at the edge of a quiet pool on an ooze-covered gravel bar scarcely covered with water. The egg masses of this colony were elongate and cylindrical measuring 2-3 mm. by 6-8 mm. Egg masses are translucent and the opaque white eggs are visible within. Eggs are laid on the undersurfaces of leaves, sticks, and small stones in shallow water a few centimeters deep.

A "humching" method of locomotion is common to *obrussa* and *parva* (Baker, 1911, p. 33). By this method the animal moves forward by muscular contractions of the foot and then pulls the shell after it with a jerk. This variety of locomotion is most noticeable when the animal is out of water, which is normal for species of *Lymnaea* in summer.

Lymnaea humilis rustica Lea

Pl. 1, fig. 5; text fig. 25

Lymnaea rustica Lea, 1841, Proc. American Phil. Soc., vol. 2, p. 33.

Galba humilis rustica, Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 268-270, pl. 31, figs. 10-14.

Lymnaea humilis rustica, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 2, fig. 22; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 234, pl. 1, fig. 19; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118.

Shell: Conispiral, dextral, small, elongate, subfusiform; periostracum light yellowish horn, darker in some specimens; growth lines coarse, spiral lines absent or faint; whorls 5 to 5½, convex, rather gradually increasing in diameter, body whorl abruptly enlarging; spire long, acute, generally a trifle longer than aperture; sutures impressed; aperture usually narrowly elliptical; outer lip thin sometimes with varix; inner lip narrow, reflected, lower part turned up, upper part at its junction with the parietal wall impressed and flattened, forming slight plait; umbilical chink usually narrow, in some specimens nearly closed; axis hourglass-shaped.

Measurements

Length	Width	Length of aperture	Width of aperture
10.5 mm.	4.7 mm.	5.5 mm.	2.5 mm.
9.7	4.7	4.9	2.2
7.5	4.0	3.7	1.5

Soft Part of Animal: Resembling *L. b. techella* externally; color light brownish or blackish, paler on the foot.

General Distribution: "New York west to Utah, Nebraska south to New Mexico." (Baker, 1911, p. 269.)

Occurrence in Kansas: Sparingly throughout the state.

Ecology: In Kingman County, *rustica* was found on moist ground at the edges of shallow streams with "wide, sandy, and sandy loam flood plains." Tree flora was sparse and consisted mainly of cottonwood and willow. (Franzen and Leonard, 1942, p. 335.) Alice Leonard (1943, p. 234) noted that in Meade County, "This species is found sparingly in grassy pools, and in the moist meadows around marshes. Occasional specimens may be found in brooks." In Greenwood County, Leonard and Leonard (1946, p. 116) found *rustica* along a creek in a well-drained ravine with slopes having outcrops of limestone "and bearing a fair stand of oak, hickory, elm and sycamore trees." In Logan County, *rustica* was found on exposed mud bottom of a shallow stream bed. The only available shade was provided by sedges, semiaquatic grasses, and prairie grasses growing at the edge of the stream bed.

Lymnaea parva Lea

Pl. 1, fig. 11; text fig. 26

Lymnaea parva Lea, 1841, Proc. American Phil. Soc., vol. 2, p. 33.

Lymnaea parva, Wheatley, 1845, Cat. United States Shells, p. 23; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 234; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, pt. 2, No. 9, p. 406, pl. 30, fig. 6; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., vol. 34, pt. 2, No. 16, p. 1029, pl. C, fig. 8a.

Galba parva, Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 243-248, pl. 29, figs. 5-14, pl. 30, figs. 9-12.

Shell: Conispiral, dextral, small, rather solid, turreted, translucent; periostracum light horn or yellowish white, pellucid; surface shining, growth lines close set and well marked, sometimes so elevated as to roughen surface of last whorl; spiral lines fine or absent; whorls 5-5½, convex, regularly increasing in size; protoconch of 1¼ whorls, smooth with satin-finish sculpture; protoconch rounded in outline, first whorl large; sculpture beginning abruptly; spire elevated, forming acute pyramid, generally longer than aperture; sutures deeply impressed; aperture roundly and regularly elliptical, continuous in many specimens, a trifle effusive at lower end; outer lip thin, sometimes developing white deposit or varix short distance from edge; inner lip markedly and broadly reflected over umbilicus, forming broad even expansion; parietal callus well marked, thick; umbilical chink, well-marked, open; axis straight, not twisted, thickened by shelly deposit.

Measurements

Length	Width	Length of aperture	Width of aperture
5.7 mm.	3.2 mm.	2.6 mm.	1.7 mm.
5.0	3.0	2.3	1.6
4.7	2.7	2.6	1.6

Soft Part of Animal: Resembling that of *L. b. techella.*

General Distribution: "Connecticut west to Idaho; James Bay and Montana south to Maryland, Kentucky, Oklahoma, southern New Mexico and Arizona" (Baker, 1911, p. 245).

Occurrence in Kansas: Principally eastern half; rare in west.

Ecology: In summer, *L. parva* is often found out of water on sticks, stones, or mud flats at edge of streams, on exposed mud bottoms of transient pools, and on moist drift along stream banks.

According to Hoff (1936, pp. 259, 262; 1937, pp. 303-306), *parva,* in Illinois, lived almost entirely in the water from December to March. During winter as the surface water freezes in small streams the snails migrate to deeper water and then back to shallow water during periods of partial thaws. Snails were taken from bottom mud in pools the surfaces of which were frozen continuously for a month. There was little feeding or growing during January and February. Early in March *parva* migrated to shallow areas, but

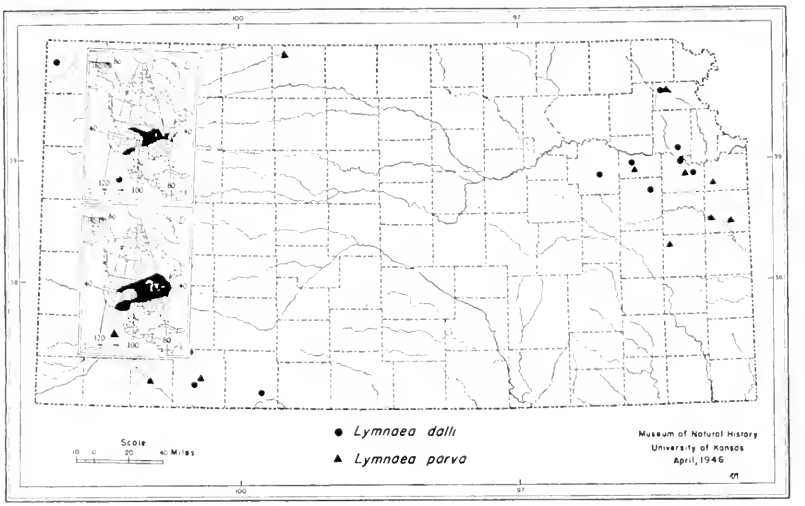


FIG. 26. Distribution of *Lymnaea dalli* and *Lymnaea parva* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

was not found out of water unless the air temperature was above 40 degrees Fahrenheit. They were found in the water if the temperature was below 40 degrees. *L. parva* in a small pool near the Atchison County Lake on March 16, 1955, were crawling on submerged dead stalks and stems of weeds in water 56 degrees Fahrenheit while the air temperature was 38 degrees. The large number of individuals there were remarkably uniform in size.

Hoff states further that migration from water to land and *vice versa* is often a daily occurrence in the last two weeks of March and most of April. After the middle of May snails of this species almost without exception remain on bare mud flats near the stream. In damp weather they can be found 10 feet from water. Growth of individuals is rapid during migration to and from water in spring and continues until death which generally occurs with the drying up of the mud flats in June. Egg-laying begins about the first of April and continues for approximately one month. Hatching occurs in May and early June. Wet weather seems to retard egg-laying and the appearance of the young, whereas dry weather seems to speed up reproduction; it begins earlier and is of shorter duration.

Each generation produces but a single brood. Young snails aestivate in mud of drying pools and are found more frequently in

aestivation in shaded areas than elsewhere. If mud is placed in a beaker of water any snails present eventually crawl out of the mud and up to the surface of the water. The recurrence of water in the fall or winter revives the snails at which time they again become aquatic.

Lymnaea dalli Baker

Pl. 1, fig. 9; text fig. 26

Lymnaea dalli Baker, 1906, Bull. Illinois State Lab. Nat. Hist., vol. 7, p. 104; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 235, pl. 1, fig. 17.

Galba dalli Baker, 1911, Special Publ. No. 3, Chicago Acad. Sci., pp. 251-254, pl. 30, figs. 13-18.

Shell: Small, thin ovate conic, turreted; greenish or whitish horn; surface dull to shining; marked by heavy, crowded growth lines elevated into distinct ridges in some specimens; protoconch small, flatly rounded, light horn colored, rounded in outline, first whorl large; whorls 4½-5, rounded and distinctly shouldered; spire generally obtusely conic, turreted, trifle longer than aperture; sutures deeply impressed; aperture elongate ovate or elliptical, continuous in many specimens; outer lip acute; inner lip forming rather flat erect extension over umbilical region, leaving pronounced chink; lower part of aperture somewhat effusive; columellar extension of inner lip sometimes so appressed at its junction with parietal wall as to form pseudo-plait.

Measurements

Length	Width	Length of aperture	Width of aperture
5.6 mm.	3.4 mm.	2.6 mm.	1.6 mm.
4.0	2.5	2.0	1.2
4.0	2.4	2.0	1.2

Soft Part of Animal: Resembling *parva* and other species of *Lymnaea* but often more darkly pigmented.

General Distribution: "Ohio to northern Michigan and Montana, south to Kansas and Arizona." (Baker, 1911, p. 252.)

Occurrence in Kansas: Probably state-wide although unevenly distributed.

Ecology: Similar to that of *parva*. In Meade County State Park *dalli* was found among sedges and grasses on marshy ground around ponds, living in association with *Lymnaea parva* and terrestrial snails, *Succinea concordialis* and *Vertigo ovata*.

L. dalli is often found either in moist shaded places or a few centimeters away from the edge of water on wet surfaces of mud, stones, or sticks. Small size makes *dalli* highly susceptible to dessication. It is the smallest species of *Lymnaea* in Kansas.

Family PLANORBIDAE Adams

In this family, the shells are discoidal; that is to say, the turns of the spiral are all in the same plane, or nearly so. The shells are either dextral or sinistral, but this is difficult to determine in many cases. In one subgroup of the family, the shells are physoid, but none of the members of this group occurs in Kansas. The family, which is world-wide in distribution, was being revised by Baker when his death unfortunately interrupted his studies. Part of his work was published posthumously (Baker, 1945).

Planorbids live in a wide variety of aquatic habitats, some species thriving in ephermeral pools and small streams. Some are minute and easily overlooked by the casual observer, but in Kansas, *Helisoma* is represented by species with rather large shells that generally are associated with *Physa*.

Genus *Helisoma* Swainson

Helisoma trivolvis lentum (Say)

Pl. 2, figs. 15, 16; text fig. 27

Planorbis trivolvis Say, 1817, Nicholson's Encyc., 1st American Ed., vol. 2, (no pagination), pl. 2, fig. 2.

Helisoma trivolvis lentum, Baker, 1945, The Molluscan Family Planorbidae, p. 149, p. 294, pl. 29, figs. 7-13, p. 414, pl. 89, figs. 1-4; Leonard and Gobel, 1952, Univ. Kansas Sci. Bull., vol. 34, pt. 2, No. 16, pp. 1028-1029, pl. C, fig. 9.

Helisoma trivolvis, Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 2, p. 53; ——, 1885b, *op. cit.*, vol. 1, No. 4, p. 123; ——, 1886, *op. cit.*, vol. 1, No. 4, p. 177; ——, 1887, *op. cit.*, vol. 2, No. 8, p. 14; Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96; Baker, 1909, Nautilus, vol. 23, No. 7, p. 93; Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 330-334, pl. 20, figs. 1-13, 22, 23; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342; Franzen and Leonard, 1943; Univ. Kansas Sci. Bull., vol. 29, pt. 2, No. 9, pp. 407-408, pl. 30, fig. 2; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 235, pl. 2, fig. 30; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118.

Shell: Discoid, sinistral, flat, sometimes carinate above, rounded below; color yellowish, greenish or most often brownish; sculpture of coarse oblique, raised, more or less equidistant lines of growth; immature shell of three whorls having distinct spiral impressed lines disappearing on last whorl; whorls 4, discoidal, rounded on periphery; spire flat, in young perfectly flat, but in adult sunk below level of last whorl; spire always exhibiting all volutions; protoconch small, of about one-half turn; sutures deep, v-shaped; base of shell indented, showing from two to three volutions; aperture broadly lunate, somewhat expanded below and with v-shaped angle above; aperture exact height of last part of body whorl; outer lip acute, thin, rounded, often a little thickened on inside in mature forms; parietal wall with thin callus; interior of aperture bluish-white or horn-colored; umbilicus narrow, deep, funnel-shaped.

Measurements

Length	Width	Length of aperture	Width of aperture
19.5 mm.	32.0 mm.	14.0 mm.	10.2 mm.
11.0	25.0	10.5	7.0
6.2	10.4	6.0	3.0

Soft Part of Animal: Darkly pigmented, generally brown; sinistral, having pulmonary, genital, and excretory orifices on left side; tentacles long and slender, cylindrical; eyes placed at inner base of tentacles; head large and auriculate; secondary branchia (pseudo-branch) of left side, highly vascular; jaw in three segments, superior large, each of two lateral segments narrow and long; radula with comparatively small number of teeth in straight, horizontal row; center tooth bicuspid, lateral teeth large and tricuspid, marginal teeth multicuspid, generally more than 20 teeth on each side of center tooth; blood of Planorbidae unique in containing haemoglobin, red colored.

General Distribution: "Atlantic coast and Mississippi River drainages, northward to Arctic British American and Alaska and southward to Tennessee and Missouri. The southern distribution is not clear owing to mixing with related species" (Baker, 1928, p. 332).

Occurrence in Kansas: Commonly occurs in rivers, small streams, lakes, ponds and road-side ditches throughout the state.

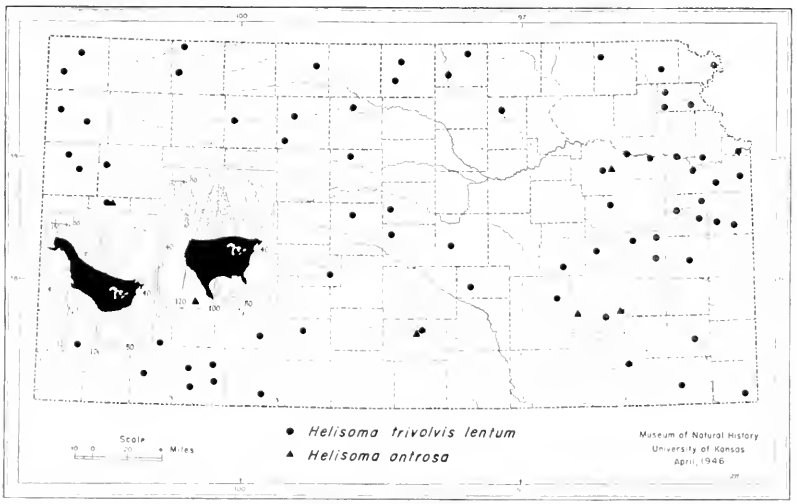


FIG. 27. Distribution of *Helisoma trivolvis lentum* and *Helisoma antrosa* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ecology: H. trivolvis is generally an inhabitant of quiet waters. It is most often found in shallow water one foot or less deep on ooze-covered bottoms, rocks covered with algae, and dead leaves

and stems of plants. Occasionally *trivolvis* is found out of the water on wet vegetation of rocks moistened by wave action. In central and western Kansas *trivolvis* is not uncommon in transient pools and streams and even in water tanks for cattle.

The size of the shell varies considerably according to the habitat. In western Kansas where many streams and bodies of water are transient and not abundantly supplied with plant material the shells are uniformly smaller than those from eastern Kansas. In constantly flowing streams of the Ozarkian area in southeastern Kansas some shells attain larger size than any from other parts of the state.

The reproductive season begins early in March, if not before, and lasts through November or later, probably depending on the severity of cold temperatures. In Douglas County, egg cases have been found in ponds as late as November 20. The eggs are laid close together in single-layered clusters of 30, more or less, on smooth surfaces of leaves, sticks, stones, old boards, pieces of glass, and other objects in the water. Egg clusters have a covering of tough, closely applied, plastic membrane or encasement that is transparent and amber colored. An egg case ordinarily measures about 5 by 10 by 1 mm. but varies considerably in size. Individual eggs are approximately 1 mm. in diameter. Shortly after hatching the young break through the case enclosing the egg cluster which splits uniformly around the edge and near its basal attachment. After each newly hatched snail pushes out of the egg case the covering springs back into place so that the split edges are almost imperceptible unless the covering is moved again by other emerging young. Some eggs hatch 48 hours or even more after the first young have emerged from the case.

Helisoma antrosa (Conrad)

Pl. 2, figs. 10, 11; text fig. 27

Planorbis antrosus Conrad, 1834, American Journ. Sci., vol. 25, No. 1, p. 343.
Helisoma antrosa, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 317-320; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 2, fig. 26; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., vol. 31, pt. 1, No. 6, p. 118.
Planorbis bicarinatus, Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96.

Shell: Sinistral, discoidal, more or less angulated; color yellowish or brownish horn, sometimes dark brown, reddish or greenish; surface shining; sculpture of irregular transverse, strong, sometimes elevated lines of growth; protoconch small but visible at base of funicular depression forming spire, of about one turn; whorls 3½, more or less angulated above and below, periphery rounded or flattened; spire exhibiting all volutions; sutures impressed; base of

shell having deep umbilical depression that exhibits all volutions; aperture lunately ovate, bluntly rounded or v-shaped above, usually v-shaped below where it extends below body whorl, whitish within; aperture usually forming more or less bell-shaped enlargement, higher than wide in fully mature individuals; outer lip expanded.

Measurements

Length	Width	Length of aperture	Width of aperture
3.1 mm.	4.1 mm.	2.7 mm.	1.2 mm.
6.1	11.1	5.7	4.2
7.0	12.0	6.5	4.0

Soft Part of Animal: Having wide foot, rounded before and behind; tentacles long and filiform, as long as or longer than foot; head rounded and not so much auriculated as in *trivolvis;* color blackish, flecked with white.

General Distribution: "From Maine to Oregon and from Hudson Bay south to western Mexico." (Baker, 1928, p. 319.)

Occurrence in Kansas: Specimens of relatively recent origin have been found in Greenwood, Kingman, Wabaunsee, and Wichita counties. The sparsity of records indicate that it is rare in the state.

Ecology: Its habitat in Greenwood County is recorded as a well-drained ravine with outcrops of limestone along its slopes. This was in an area having a "fair stand" of oak, hickory, elm, and sycamore trees. *H. antrosa* was found less commonly than *H. trivolvis* "apparently because of a closer restriction to habitat. It prefers clean running water." (Leonard and Leonard, 1946, pp. 116-118.) In Kingman County, the habitat has been recorded as shallow streams with wide, sandy and sandy-loam flood plains, the tree flora consisting mainly of cottonwood and willow (Franzen and Leonard, 1942, p. 335).

Conrad recorded *antrosa* living in a creek adhering to limestone rocks (Baker, 1928, p. 319).

Genus *Gyraulus* Charpentier

Gyraulus parvus (Say)

Pl. 2, figs. 1, 3; text fig. 28

Planorbis parvus Say, 1817, Nicholson's Encyc., pt. 2, vol. 1 (no pagination), pl. 1, fig. 5; Hanna, 1909, Nautilus, vol. 23, No. 7, p. 96.

Gyraulus parvus, Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 2, p. 54; ——, 1887, *op. cit.*, vol. 2, No. 8, p. 16; Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 374-378, pl. 23, figs. 27-31, 39; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., vol. 45, p. 342, pl. 1, fig. 17; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 235, pl. 1, fig. 4.

Shell: Discoidal, ultra-dextral, small, depressed, with rounded periphery; color bright horn to jet black, often pearly; surface shining in light-colored

specimens, dull in dark examples; lines of growth transverse, crowded, fine, frequently crossed on base by several fine spiral lines; protoconch small rounded, sculpture of distinct spiral striae; whorls about 3½, rapidly enlarging; rounded below periphery and somewhat flattened above on body whorl and flattened above on all whorls of spire; spire flat, first two whorls sunken below body whorl; sutures deeply impressed; base slightly concave, body whorl flattended, umbilical region wide, shallow, exhibiting all volutions; aperture long ovate, nearly in same plane as body whorl in most specimens, but oblique in some examples; outer lip acute, thin, simple, superior margin produced considerably over inferior margin; parietal wall with thin wash of callus; interior of aperture yellowish-white or white.

Measurements

Length	Width	Length of aperture	Width of aperture
1.4 mm.	5.0 mm.	1.5 mm.	1.8 mm.
1.5	4.1	1.2	1.5
1.3	3.5	1.0	1.2

Soft Part of Animal: Dark brown, lighter below; foot short, rounded; tentacles whitish, with dark line on center of dorsal surface; pseudobranch long, narrow, white; jaw composed of 28 plates of varying size placed on horseshoe-shaped cartilage; central tooth of radula bicuspid; 17 teeth on each side of the central tooth, those nearest center being tricuspid; marginal teeth multicuspid.

General Distribution: "Eastern North America east of the Rocky Mountains from Florida northward to Alaska and northern British America" (Baker, 1928, p. 377).

Occurrence in Kansas: Wyandotte County west to Wallace County, north to Decatur County and south to Meade County. We have no records of *G. parvus* from southeastern Kansas although it may occur there.

Ecology: G. parvus in Kansas is common in natural and artificial lakes and occasionally in quiet pools in stream beds in the western part of the state. The species is frequent on or among aquatic plants such as *Chara*, *Typha*, *Spirogyra*, and duckweed, and occurs on submerged blades of living and dead grasses or on dead tree leaves in water. *G. parvus* is often found in the larger lakes on floating, partly water-logged pieces of driftwood that have been washed up along shore.

Egg capsules are generally laid on small stems and leaves of dead and living vegetation in water. Usually six to nine eggs are laid close together in a single layer and are covered by a closely applied tough, translucent, pale amber membrane. The entire capsule is approximately 1.5 mm. in diameter. Eggs laid in aquaria in the laboratory hatched within ten days. The young push out of the capsule in a manner like that of the young of *Helisoma*.

PLATE 2

Shells of Planorbidae in Kansas

Figures 10 and 11, and 15 and 16, enlarged approximately 2 times, and remaining figures enlarged approximately 7 times, natural size.

1, 2, 3. *Gyraulus parvus* (Say), 1 mi. W Kingman, Kingman County, Kansas. Collected by D. S. Franzen, 2 September 1940. Catalogue number 1036.

4, 5, 6. *Gyraulus circumstriatus* (Tryon), Miami County Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by L. D. Fairbanks, 30 March 1955. Catalogue number 9888.

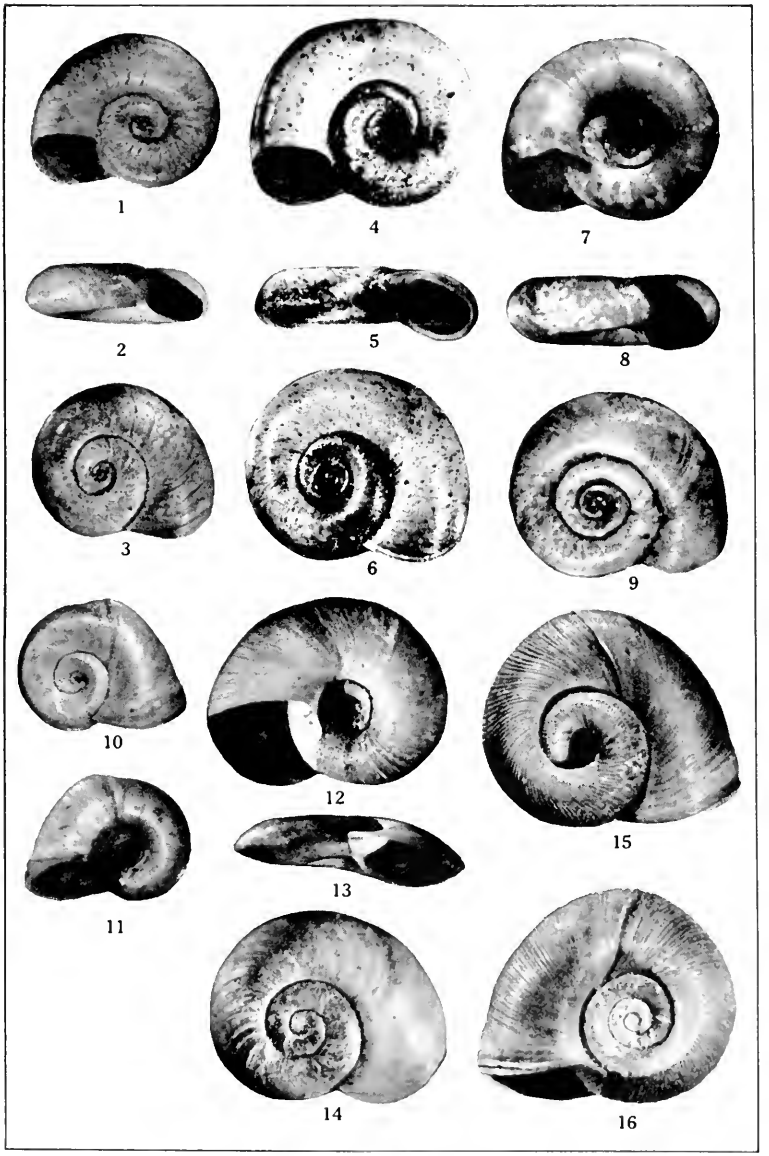
7, 8, 9. *Promenetus umbilicatellus* (Cockerell), Miami County Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by D. S. Franzen, 6 June 1942. Catalogue number 7321.

10, 11. *Helisoma antrosa* (Conrad), 5½ mi. W, 4 mi. S Kingman, Kingman County, Kansas. Collected by D. S. Franzen, 10 October 1940. Catalogue number 1026.

12, 13, 14. *Promenetus exacuous* (Say), Fish Hatchery Pond, Meade County State Park, 8 mi. S, 5 mi. W Meade, Meade County, Kansas. Collected by A. B. and A. E. Leonard, 9 September 1940. Catalogue number 960.

15, 16. *Helisoma trivolvis lentum* (Say), Miami County Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by A. B. Leonard, 7 September 1943.

PLATE 2



Gyraulus circumstriatus (Tryon)

Pl. 2, figs. 4, 6; text fig. 28

Planorbis circumstriatus Tryon, 1866, American Journ. Conch., pt. 2, p. 113, pl. 10, Figs. 6-8.

Gyraulus circumstriatus, Baker, 1928, Wisconsin Geol. and Nat. Hist. Survey, Bull. 70, pt. 1, pp. 378-379, fig. 162.

Shell: Discoidal, dextral, periphery rounded, body whorl slightly flattened above, obtusely subangulate below; sculpture of rather coarse distinct lines of growth; frequently having raised spiral lines on base; color pearly white or amber; whorls about 4½, slowly and regularly increasing in diameter, all usually in same plane; sutures deeply impressed; whorls of spire rounded; aperture roundly ovate.

Measurements

Length	Width	Length of aperture	Width of aperture
1.43 mm.	4.43 mm.	1.43 mm.	1.43 mm.
1.43	4.20	1.43	1.43
1.20	3.75	1.20	1.20

Soft Part of Animal: Resembling that of *G. parvus*.

General Distribution: "Connecticut west to Wisconsin. Exact limits, especially north and south, not known. Confused with *parvus*" (Baker, 1928, p. 379).

Occurrence in Kansas: Miami County State Lake, Atchison County State Lake, and in artesian-fed ponds in Meade County State Park. Occurrence in Kansas not previously recorded.

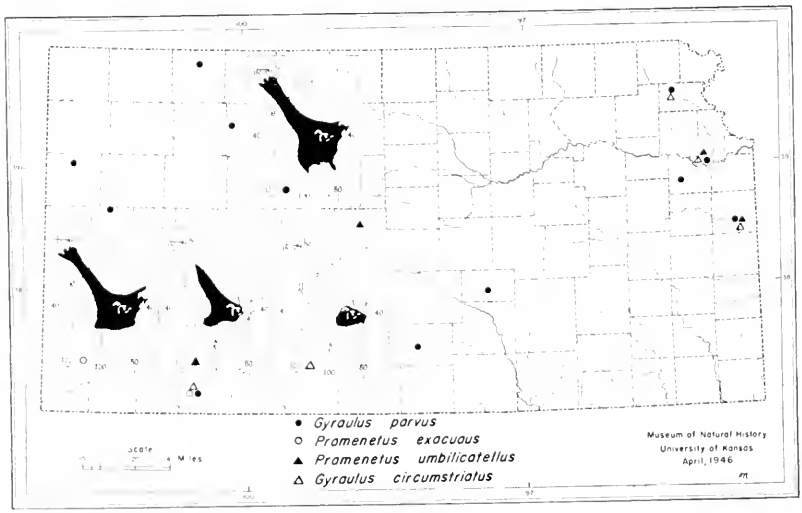


FIG. 28. Distribution of *Gyraulus parvus*, *Promenetus exacuous*, *Promenetus umbilicatellus* and *Gyraulus circumstriatus* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ecology: In Kansas, *G. circumstriatus* has been found on dead and living vegetation in shallow water of natural and artificial lakes, usually in quiet nooks or inlets near tree-lined shores. In these situations it frequently lives in association with *G. parvus*, *Gundlachia meekiana*, *Helisoma trivolvis lentum* and *Physa*. Vegetation in the water includes dead leaves of trees, grasses, cattail, *Chara*, and filamentous green algae. Egg masses are almost identical to those of *G. parvus*.

Genus *Promenetus* Baker

Promenetus umbilicatellus (Cockerell)

Pl. 2, fig. 7, 8, 9; fig. 28

Planorbis umbilicatellus Cockerell, 1887, Conch. Exch., vol. 2, No., p. 68.
Promenetus umbilicatellus, Baker, 1935, Nautilus, vol. 49, No. 2, p. 48.
Gyraulus umbilicatellus, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 383-385, pl. 22, figs. 18-21.

Shell: Ultra-dextral, discoidal, depressed; color light corneous or yellowish to brownish; surface shining; sculpture of distinct but fine transverse lines of growth crossed by fine crossed spiral lines; protoconch striated in sculpture; whorls 4½, rounded, regularly increasing in diameter, last part of body whorl somewhat expanded near aperture; spire flat, all volutions in same plane or first two whorls slightly sunken below plane; sutures distinctly impressed but not channeled; base of body whorl flatly rounded, umbilical region large, round, and deep, but exhibiting all whorls to apex; aperture elongate-lunate or roundly triangular, narrowing toward peripheral part of outer lip; upper part of aperture curved, lower part deeply rounded, concave; outer lip simple, sharp, thin; parietal wall with thin callus.

Measurements

Length	Width	Length of aperture	Width of aperture
2.0 mm.	6.0 mm.	1.8 mm.	2.4 mm.
1.9	5.3	1.5	2.3
1.5	4.1	1.1	1.3

Soft Part of Animal: Similar to that of *Gyraulus parvus* but more darkly pigmented.

General Distribution: From New Mexico northward to northwestern Canada; occurs in states of Illinois, Michigan, Iowa, Minnesota, Colorado, Montana, the Dakotas, and Wisconsin.

Occurrence in Kansas: P. umbilicatellus has been found only in Miami County State Lake and in the Cheyenne Bottoms east of Hoisington in Barton County. Occurrence in Kansas not previously recorded.

Ecology: Judging from the localities in Kansas in which this species is found, it prefers shallow marshy lakes with considerable vegetation of varied kinds. The water level in the Miami County

State Lake fluctuates seasonally. Parts of the lake bed often are exposed in late summer and terrestrial and semiaquatic grasses and herbaceous plants grow readily in these areas. Other parts of the lake are deeper, especially along the east side where well wooded slopes extend down to the edge of the lake. The trees in this area are mostly oak, elm and hickory. Dead leaves of trees, dead grasses and leaves and stems of other plants may be floating and submerged in the water. Living plants in the water include cattail (*Typha*), *Chara*, and filamentous green algae.

The Cheyenne Bottoms east of Hoisington in Barton County consist of gentle depressions in a generally flat surrounding area of grassland. The water level fluctuates seasonally and annually. Water often covers growing grasses and there are small grass-covered islets throughout the area. *Helisoma trivolvis lentum* and large *Physa anatina* live in association there with *P. umbilicatellus*.

Baker (1928, p. 384) states that all specimens in Wisconsin were found in "swales".

Promenetus exacuous (Say)

Pl. 2, figs. 12-14; text fig. 28

Planorbis exacuous Say, 1821, Journ. Philadelphia Acad. Sci., vol. 2, p. 168.

Promenetus exacuous, Baker, 1935, Nautilus, vol. 49, No. 2, p. 48.

Menetus exacuous, Call, 1885a, Bull. Washburn Lab. Nat. Hist., vol. 1, No. 2, p. 54; Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 361-363; Leonard, 1943, Trans. Kansas Acad. Sci., vol. 46, p. 235, pl. 1, fig. 2.

Shell: Discoidal, ultra-dextral, much depressed, with acute periphery; light horn to brownish; surface shining; sculpture of fine lines of growth, often slightly elevated, crossed by fine spiral lines under corneous epidermis; protoconch small rounded, sculptured with fine spiral lines; whorls 4, rapidly increasing in diameter, sloping in flatly rounded curve to acutely keeled periphery; spire flat, all whorls in same plane, or apical whorls slightly sunken below plane; sutures well impressed; base flatly convex; umbilicus rather narrow, deep, exhibiting all volutions to apex; aperture obliquely, obtusely triangular; outer lip thin, acute, superior part much produced beyond inferior part and expanded near periphery; parietal wall having thin wash of callus.

Measurements

Length	Width	Length of aperture	Width of aperture
2.5 mm.	8.3 mm.	2.5 mm.	3.7 mm.
2.0	6.0	1.6	2.4
1.4	4.7	1.5	2.1

Soft Part of Animal: Color blackish; foot short, rounded.

General Distribution: "United States east of Rocky Mountains, north to Alaska and the Mackenzie River, south to New Mexico." (Baker, 1928, p. 363.)

Occurrence in Kansas: The most recent record of *P. exacuous* in Kansas is that from a brooder fish hatchery in Meade County State Park (Alice Leonard, 1943, p. 235).

Ecology: In Meade County *P. exacuous* was found living only among the vegetation in the cool water of a brooder pond (Alice Leonard, *loc. cit.*) where *Gyraulus parvus* was living in association with it. The vegetation was *Potamogeton, Spirodela, Riccia, Mimulus, Eleocharis,* and *Scirpus.*

Baker (1928, pp. 262-263) found this species in Wisconsin living on logs in sloughs in water .3 to .6 meters in depth. The bottom was of soft sticky mud. It was found also near Lake Superior living on mud flats at the edge of a small stream of clear cold water.

Family ANCYLIDAE Menke

In this family the shells are extremely variable in form, but in all the species that occur in Kansas, the shells are patelliform. The family is world-wide in distribution, but the genera *Ferrissia* and *Gundlachia* are the only ones widely dispersed, the others being more or less local. In general the shells are small to minute, and this is true of the members of the family represented in Kansas; because of their small size they have been generally overlooked, and probably are much more wide-spread in the State than records indicate.

Species of *Ferrissia* and *Gundlachia* prefer quiet waters in ponds or at the margins of streams, where the animals creep about on dead leaves, smooth stones, stems of sedges or grasses, or on smooth objects, such as metal or glass containers that may have been thrown into the water. Colonies of *Ferrissia* frequently appear in lily ponds in private gardens, where the snails have been unknowingly transported with the stocks of lilies or other aquatic vegetation.

Genus *Ferrissia* Walker

Ferrissia kirklandi (Walker)

Pl. 3, figs. 19-21; text fig. 29

Ancylus kirklandi Walker, 1903, Nautilus, vol. 17, p. 29, pl. 2, figs. 1-12.
Ferrissia kirklandi, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 406-407.

Shell: Patelliform, large for genus, thin, translucent, horn-colored; broadly oval or obovate, sides nearly equally curved, ends broadly rounded; much elevated; apex nonstriate, subacute, behind and to right of middle, and decidedly turned to right; posterior and right slopes straight or slightly concave; anterior slope notably convex; left slope decidedly convex; surface

having growth lines regular and distinct, more or less rippled by transverse wrinkles, tending to form feeble irregular radial riblets in many specimens.

Measurements

Length	Width	Height
7.9 mm.	5.0 mm.	2.3 mm.
6.9	4.0	2.1
5.8	4.0	1.8

Soft Part of Animal: Sinistral, attached to shell by three muscles (columellar), two anterior, and one posterior on left side, and by continuous band of muscle marking free edge of mantle; foot large, long and wide; head wide, short, auriculate as in *Lymnaea;* mouth in center of head on ventral surface between two lateral lobes; tentacles cylindrical, rather short, bluntly pointed, slightly tapering; eyes on inner base of tentacles, which are much widened at this point; gill or pseudobranch large, conical, made up of several folds, on left side; male and female apertures on left side; male aperture in front of left attachment muscle and behind left tentacle; female aperture behind muscle and immediately below shorter part of pseudobranch.

General Distribution: "New Jersey and D. C., west to Arkansas [and Kansas] north to Michigan and Wisconsin." (Baker, 1928, p. 407.)

Occurrence in Kansas: Southeastern Kansas in Montgomery and Cherokee counties. Occurrence in Kansas not previously recorded.

Ecology: In Elk River in the northwestern part of Montgomery County *F. kirklandi* was found living on smooth surfaces of dead sycamore leaves in clear running water about eight inches deep. In the Verdigris River in southeast Montgomery County it was living on mussel shells and smooth stones, also in clear running water. One specimen was found on the telson of a crayfish. The most noticeable vegetation living in the water in both streams was filamentous green algae adhering to stones and sticks. Both streams are well wooded along the banks with elm, sycamore, cottonwood, ash, hickory and pecan.

In Shoal Creek in eastern Cherokee County examples were living on smooth surfaces of stones and on the sides of non-rusted metal cans in a clear quiet pool with gravel and rock bottom. This pool was to the side of the main bed of the stream which was clear and flowing considerably. Shoal Creek also is well wooded along its banks being definitely in the Ozarkian region of southeastern Kansas. Other species of aquatic gastropods living in the pool were *Physa hawnii*, *Helisoma trivolvis lentum*, *Lymnaea obrussa*, and *Amnicola integra*.

Little is known about the eggs and egg-laying habits of the Ancylidae. Baker (1928, p. 392) states that the egg case of *F.*

fusca, a species smaller than *kirklandi* but considerably larger than *F. shimekii*, measures 2.5 mm. in diameter and 1 mm. in height. Each egg case contains from one to nine capsules (seven being the usual number); the capsules are filled with a transparent, colorless, viscous liquid. Each capsule usually contains one egg; however, some may contain four or more. Complete development requires 18 to 21 days, 18 days being normal.

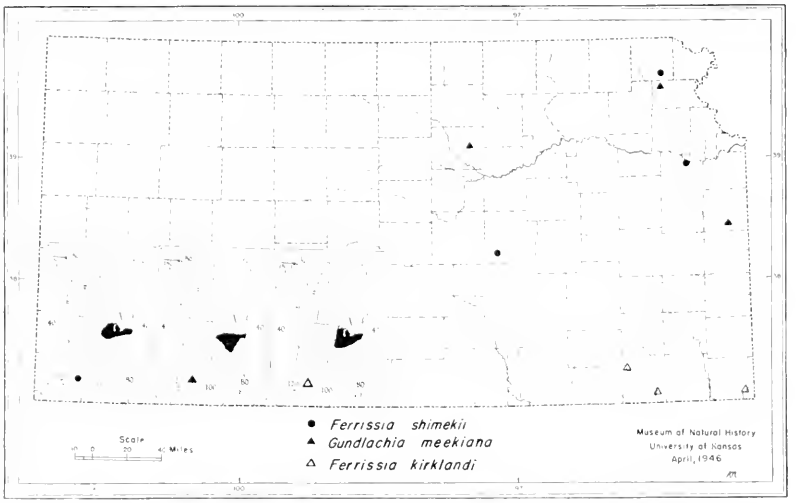


FIG. 29. Distribution of *Ferrissia shimekii*, *Gundlachia meekiana* and *Ferrissia kirklandi* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Ferrissia shimekii (Pilsbry)

Pl. 3, figs. 1, 3; text fig. 29

Ancylus shimekii Pilsbry, 1890, Nautilus, vol. 4, p. 48.

Ferrissia shimekii, Baker, 1928, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 1, pp. 402-403.

Shell: Patelliform, elevated, thin, transparent, horn-colored with a yellowish-brown periostracum; aperture ovate, conspicuously wider anteriorly, in many (especially young) specimens slightly reniform by a barely perceptible incurving of right margin; anterior, left and posterior margins regularly rounded, but right slightly incurved, straight or only slightly convex; apex striate, acute, elevated, strongly depressed posteriorly and to right, curved downward, in most specimens actually overhanging posterior right margin of shell; apical half or more of shell strongly compressed, laterally, and obliquely, a character making young seem proportionally much narrower than adults; anterior slope of shell long and strongly convex, posterior slope being short and concave;

PLATE 3

Shells of Physidae and Ancylidae in Kansas

1, 2, 3. *Ferrissia shimekii* (Pilsbry), Fig. 1, posterior profile; Fig. 2, right profile; Fig. 3, dorsal view. Pool beneath railway bridge, 1 mi. N Lawrence, Douglas County, Kansas. Collected by L. D. Fairbanks, 26 March 1954. Catalogue number 9790. Figures enlarged approximately 7 times.

4, 5, 6. *Gundlachia meekiana* Stimpson, non-septate form, Fig. 4, posterior profile; Fig. 5, right profile; Fig. 6, dorsal view. Miami County Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by L. D. Fairbanks, 30 March 1955. Catalogue number 9839. Figures enlarged approximately 7 times.

7. *Physa hawnii* Lea, roadside pool, South Mound, Neosho County, Kansas. Collected by G. D. Hanna, 11 July 1909. Catalogue number 1730. Figure enlarged approximately 2 times.

8. *Physa hawnii* Lea, School Creek, 3 mi. E, 1 mi N Baxter Springs, Cherokee County, Kansas. Collected by L. D. Fairbanks, 11 April 1954. Catalogue number 9814. Figure enlarged approximately 2 times.

9, 10, 11. *Gundlachia meekiana* Stimpson, septate form. Fig. 9, right profile; Figure 10, ventral view, showing septum and aperture; Fig. 11, dorsal view. Ottawa County Lake, 6 mi. E, 1 mi. S, Minneapolis, Ottawa County, Kansas. Collected by L. D. Fairbanks, 29 July 1955. Catalogue number 9889. Figures enlarged approximately 12 times.

12, 15, 16, 17. *Gundlachia meekiana* Stimpson, septate form with secondary growth. Fig. 12, right profile; Fig. 15, apertural view; Figs. 16, 17, dorsal views of two specimens. Miami County Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by L. D. Fairbanks, 30 March 1955. Catalogue number 9839. Figures enlarged approximately 8 times.

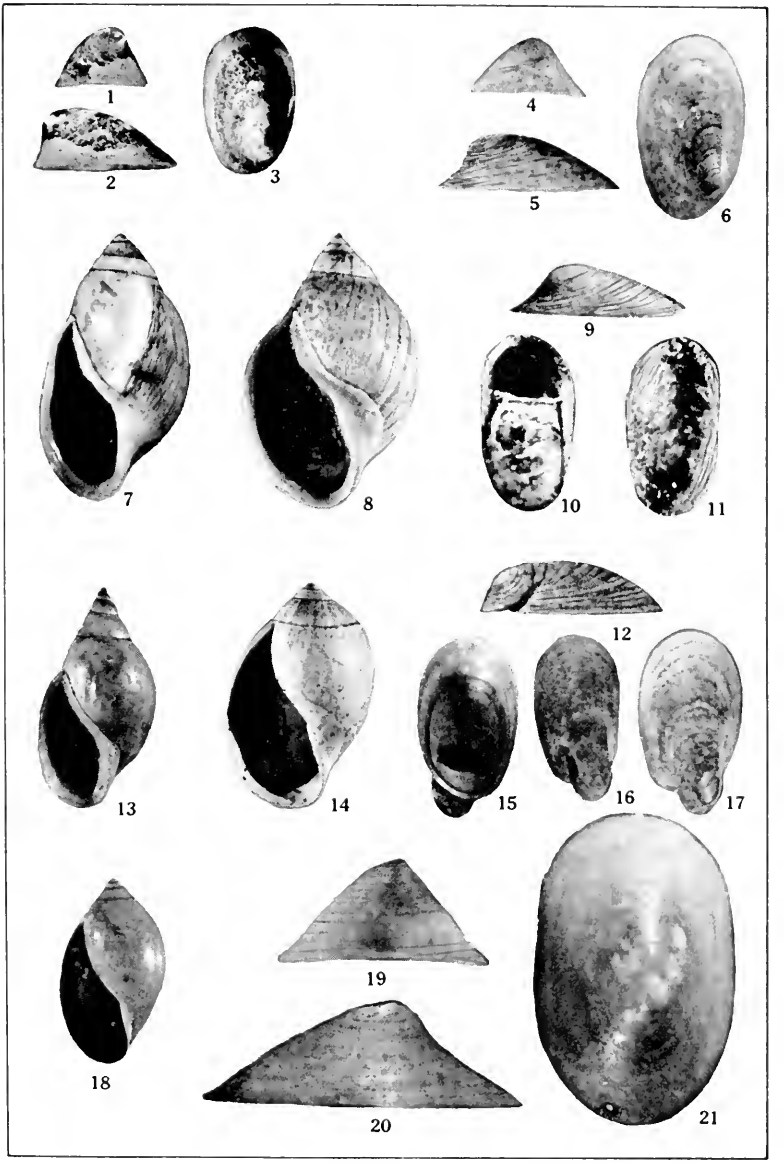
13. *Physa hawnii* Lea, 1 mi. S, 2 mi. W Olathe, Johnson County, Kansas. Collected by L. D. Fairbanks, 22 July 1954. Catalogue number 9868. Figure enlarged approximately 2 times.

14. *Physa anatina* Lea, 6 mi. E, 3 mi. S Hoisington, Barton County, Kansas. Collected by L. D. Fairbanks, 31 July 1954. Catalogue number 9849. Figure enlarged approximately 2 times.

18. *Physa anatina* Lea, Nemaha County Lake, 4 mi. S, 1 mi. E Seneca, Nemaha County, Kansas. Collected by L. D. Fairbanks, 6 July 1954. Catalogue number 9887. Figure enlarged approximately 2 times.

19, 20, 21. *Ferrissia kirklandi* (Walker). Fig. 19, posterior profile; Fig. 20, left profile; Fig. 21, dorsal view. School Creek, 3 mi. E, 1 mi. N Baxter Springs, Cherokee County, Kansas. Collected by L. D. Fairbanks, 11 April 1954. Catalogue number 9808. Figures enlarged approximately 7 times.

PLATE 3



surface marked by fine lines of growth; cross-section of shell shows right slope to be concave and left slope convex, with apex well over on right side.

Measurements

Length	Width	Height
3.5 mm.	1.8 mm.	1.2 mm.
2.7	1.7	1.2
2.5	1.5	1.0

Soft Part of Animal: Uniform bluish-white; foot ovate, wider anteriorly, and rather narrow; otherwise like that of *F. kirklandi;* dental formula, 12-1-12.

General Distribution: "Nebraska; Delaware River, Pa.; Wisconsin. The records indicate a wide geographic range." (Baker, 1928, p. 403.)

Occurrence in Kansas: Mission Lake, Brown County; small permanent pool two miles north of Lawrence, Douglas County; artificial pool, Hillsboro, Kansas. Occurrence in Kansas not previously recorded.

Ecology: F. shimekii seems to prefer quiet permanent bodies of water. In the Mission Lake it was found on smooth stones and broken pieces of glass two to six feet from shore in water about one foot deep. The water was slightly turbid, the bottom was rocky, and there was a noticeable lack of observable living plants and dead vegetation in the water. Living in association with *shimekii* were *Helisoma trivolvis lentum* and *Physa anatina.* Several other places along the lake shore were investigated for the presence of *shimekii,* but none was found elsewhere.

In a small deep pool beside a railroad bridge one mile north of Lawrence, Kansas, *F. shimekii* was found near the edge of the water on smooth stones, sticks, pieces of glass, an old automobile tire, a piece of sheet metal, metal cans and smooth-surfaced cardboard. The bottom was of rock and gravel and the water turbid. *Physa anatina* was also living here as well as water beetles of the family Gyrinidae and giant water bugs of the family Belostomatidae. There were no noticeable aquatic plants in the water and the only dead vegetation observed was a large cottonwood tree trunk that had fallen, or been pushed, into the water. There were no living trees near the pool.

Baker (1928, p. 393) states that some species of *Ferrissia* prefer certain habitats. It is apparent that *shimekii* does not prefer running water nor an abundance of vegetation.

The egg cases of *F. shimekii* in Kansas have not been observed although it is supposed that their eggs and egg-laying habits resemble those of *Gundlachia meekiana.*

Genus *Gundlachia* Pfeiffer

Gundlachia meekiana Stimpson

Pl. 3, figs. 4-6, 9-12, 15-17; text fig. 29

Gundlachia meekiana Stimpson, 1863, Proc. Boston Soc. Nat. Hist., p. 249, fig. 1; Binney, 1865, Smithsonian Misc. Col. 143, pt. 2, p. 150-151, fig. 2.

Shell: Patelliform, color opaque black, sometimes light straw or chestnut; dimorphic, sometimes septate with secondary growth of shell arising from restricted aperture, or septate only, or completely without septum; oblong, broader anteriorly, anterior margin roundly truncate, right posterior margin obliquely truncate; apex obtuse, radially striate, situated in posterior ⅓ of length; anterior slope strongly convex, some individuals having radiating riblets crossing growth lines; posterior slope concave, left slope slightly convex, right slope nearly straight; septate form with secondary growth convex in dorsal outline, primary or apical part situated obliquely and to right upon posterior end of back of larger growth of shell; apical part often extending posteriorly beyond periphery of secondary growth; secondary growth, thin, translucent toward periphery; opening of apical part semilunar, greater diameter coincident with external width; septum of septate form without secondary growth, thin translucent, lines of growth convex, generally covering posterior ⅔ of aperture, sloping upward anteriorly within aperture, reflected ventrally at anterior margin.

Measurements: Non-septate Form (pl. 3, figs. 4, 5, 6)

Length	Width	Height
2.55 mm.	1.50 mm.	.82 mm.
3.30	1.80	1.20
3.75	2.17	1.12

Septate Form With Secondary Growth (pl. 3, figs. 12, 15, 16, 17)

Length	Width	Height
2.85 mm.	1.65 mm.	.75 mm.
3.00	1.57	1.05
3.00	1.80	.97

Septate Form Without Secondary Growth (pl. 3, figs. 9, 10, 11)

Length	Width	Height
1.80 mm.	.97 mm.	.52 mm.
2.25	1.27	.90

Soft Part of Animal: Externally same as in *Ferrissia*. In septate forms having secondary growth of shell, a small part of digestive gland lies within apical or primary and septate part of shell; jaw and radula of both septate and non-septate forms identical in respect to these parts; jaw appears to be composed of three horny parts of which all are thin, narrow, translucent and light straw-colored; entire jaw has appearance of narrow doubled ribbon; compared to jaw of species of *Ferrissia*, that of *G. meekiana* almost imperceptible owing to narrowness and pallor; jaw usually broken off and frequently lost in process of preparing radula for study.

The radula has approximately 112 transverse rows of teeth. In each row there is a single-cuspid central tooth and 16 multicuspid lateral teeth on either side. The characteristics of the teeth agree well with Stimpson's figure (Binney, 1865, p. 151).

General Distribution: G. meekiana was first found in the Potomac River. Subsequent records are few and indefinite. Undetermined species of *Gundlachia* which may have been *meekiana* are recorded from New York, Ohio, Illinois, and Nebraska (Hedley and Pilsbry, 1895, pp. 62-63). It has been reported from Alabama in recent years (Goodrich, 1944, p. 14).

Occurrence in Kansas: Ottawa County State Lake, Atchison County State Lake, and Miami County State Lake. Occurrence in Kansas not previously recorded.

Ecology: G. meekiana is among the smallest of the aquatic gastropods in Kansas. Its small size and habit of clinging tenaciously to the vegetation on which it lives may easily cause it to be overlooked. Its shell frequently has the same general shade of color as the vegetation on which it is found. In the Ottawa County State Lake it was living on the undersides of dead floating lilypad leaves. The shells of the animals were black matching the blackness of the dead leaves. The habitat here was at the west edge of the lake in water approximately one foot deep. The bottom was sandy and the water slightly turbid. The only apparent living plants in the water were lily-pads, the leaves of many of which stood four feet above the water. Dead leaves were floating on the partly shaded surface beneath. The shells of the animals found here were all of the non-septate form, with the exception of one that was septate without a secondary growth.

In the Atchison County Lake these little snails were in quiet water approximately one foot deep at the edge of a narrow inlet at the northeast end of the lake. Living plants in the water included cattail (*Typha*), duckweed, and large amounts of green filamentous algae. Dead vegetation in the water was chiefly leaves of *Typha*, oak, and a terrestrial grass (*Triodea*). The water was clear and the bottom was of black mud, probably containing a high percentage of decomposing vegetation. More specimens were found on the *Triodea* than on the other vegetation. Collections were made in July and October of 1954 and in March 1955. No individuals with septate shells having secondary growths were found in July or October, although they may have been there. But in March 1955, two specimens, each with septa and secondary growths, were found along with several individuals having non-septate shells. Other aquatic snails living in association with the *meekiana* in the Atchison County Lake were *Helisoma trivolvis lentum*, *Gyraulus parvus*,

Gyraulus circumstriatus, and *Physa anatina*. Egg masses of these species were on the dead vegetation in the habitat. Other animals living in association here were mayfly larvae, flat worms (*Planaria*), leeches (*Glossophonia*), green *Hydra*, and several kinds of protozoa.

On March 30, 1955, *G. meekiana* was found in the Miami County State Lake. It was living near the shore on dead leaves of oak, elm, and terrestrial grasses submerged in water approximately one foot deep. Living in association with it here were *Helisoma trivolvis lentum*, *Gyraulus parvus*, *G. circumstriatus*, *Physa anatina*, and *Lymnaea parva*. Many specimens of *meekiana* were also taken from branches of *Chara*, which were floating in masses entangled by filamentous green algae and dead stems of herbaceous terrestrial plants. These masses were approximately thirty feet from the shore. Aquatic snails also living in these masses were *Physa anatina*, *G. parvus*, *G. circumstriatus*, and *Promenetus umbilicatellus;* other animals included mayfly larvae, pink *Hydra*, and bryzoa (*Plumatella*). Of 28 specimens taken from the Miami County State Lake, 21 were non-septate, six were septate with secondary growths, and one was septate without a secondary growth. The septum of the latter individual appeared to be not quite complete as the anterior margin was not yet reflected ventrally. The shells of the *meekiana* in the Miami County State Lake have a jet black periostracum while those in the Atchison County Lake have a dark chestnut colored periostracum matching the vegetation on which they live.

Several specimens of *meekiana* were kept alive in small finger-bowl aquaria where they were provided with dead leaves of oak, elm, and grasses (*Scirpus* and *Triodea*). A few grams of powdered calcium carbonate were added to the water in the aquaria. They were observed to exude a relatively large mass of mucous when disturbed, especially when an attempt was made to separate them from the substrate and turn them over for observation. This amounted to an obstacle to the latter and an aid in righting them after they had been turned upside down. The mucous is so viscous, sticky, and relatively prodigous that it makes a direct connection between the foot of the animal and the substrate, enabling the animal to pull itself back to the normal position. The mucous may also serve the animal to some extent as a protective device. The body and sides of the foot are well ciliated and keep a constant current of water passing from anterior to posterior under the shell and throughout the mantle cavity at all times except when the animal is quiescent

and the shell is pulled down tightly against the substrate. The current may be seen carrying out faecal pellets and particles of suspended debris.

The individuals kept in the aquaria laid eggs a few days after they were brought into the laboratory in March. The eggs were laid singly usually on dead leaves in the aquarium. They are oval, hemispherical, slightly flattened, and translucent; they measure about .45 mm. in diameter. The developing embryo may easily be seen within the closely applied egg case. Eggs laid in the aquaria hatched within ten days; the air temperature in the laboratory was maintained at approximately 75 to 80 degrees Fahrenheit. The newly hatched young are oval in outline, flattened, whitish and translucent, otherwise quite like the adult non-septate form.

Remarks: In the past the validity of the Genus *Gundlachia* has been doubted. Dall (1904, p. 97) believed *Gundlachia* to be an *Ancylus* (*Ferrissia*), "which has under favorable circumstances been able to form a calcareous epiphragm and survive the winter, which ordinarily kills the great mass of individuals, and, while retaining the shell of the first year, to secrete an enlarged and somewhat discrepant shell during its second summer." Dall postulated that the formation of a septum may also be advantageous during a dry season.

Hedley and Pilsbry (1895, p. 68) stated that *Gundlachia* differs from *Ancylus* (*Ferrissia*) by a distinct pattern of radula and conchologically by its compound shell, and that "from an *Ancylus* (*Ferrissia*) of the same size the subcentral nucleus and regular elliptical outline distinguish young *Gundlachia*."

After studying shells from the type lot of *G. stimpsoniana* Smith, a closely related species, Walker (1907, pp. 16-17) was of the opinion that at least some of the non-septate shells in the collection had clearly marked secondary growths and were otherwise identical with the septate forms with secondary growths, excepting the small apical septate part. This appears to be true of many of the non-septate forms in Kansas.

Dr. H. A. Pilsbry (correspondence, March 25, 1955) considers *Gundlachia* to be a group of generic value. "It is certain that while many individuals do not form the special cap, yet numerous other ancylid species never form it; and the differences in the teeth are significant." Also, "the septate stage has been surmised to be a resting stage, not formed when growth has been continuous. The considerable variation in size of the 'cap' in shells of one population recommends this view."

GEOGRAPHIC RELATIONSHIPS IN NORTH AMERICA

In general the Great Lakes region seems to be the center of distribution of the aquatic gastropods represented in Kansas, although the Viviparidae are most numerous in the southern Appalachians. The distributions of the Ctenobranchiates, although somewhat limited in comparison with the pulmonates, includes the Great Lakes region and areas to the north, east, and southeast of Kansas. The species of aquatic pulmonates in Kansas have centers of distribution to the north, and east including the Great Lakes region. Two exceptions, however, are *Lymnaea bulimoides cockerelli* and *L. b. techella* that are more common south and west of Kansas. *Physa* and the larger planorbids (*Helisoma*) that occur throughout Kansas generally have more extensive distributions throughout North America, while the smaller species of the Family Planorbidae have extensive distributions to the north, east, and northwest. The species of *Lymnaea* in Kansas, with the exception of *L. obrussa*, are typically western species. However, the distributions of the smaller species of *Lymnaea* include parts of the Great Lakes region. The Ancylidae occur more commonly to the east and north of Kansas, including parts of the Great Lakes region.

TERRESTRIAL GASTROPODS

Terrestrial gastropods are, for the most part, non-operculate, pulmonate animals, that live a truly terrestrial existence, although they require a great deal of moisture, and some may be found in water on occasion, or crawling about on reeds, sedges and other vegetation that projects from water. Most terrestrial gastropods are herbivorous, and it is said that the mycelia of fungus forms a large part of their diet; however, at least in captivity, terrestrial gastropods will readily eat fresh vegetables, such as lettuce, or fresh fruit, such as apples or bananas. A few terrestrial gastropods, such as *Haplotrema concavum*, are predaceous and prey on other snails. Some terrestrial gastropods are adapted to living in very dry habitats, where they take advantage of occasional rainy periods for reproduction and growth of the young. Most live on the ground or even in it, but some are arboreal, but this is true of none of the species living in Kansas. The size of the animal varies greatly; some have shells more than an inch in diameter and the larger slugs may extend themselves to several inches in length, while some terrestrial gastropods are less than 2 millimeters in length or diameter.

Collecting: Most terrestrial gastropods are nocturnal in habit,

and during the day are generally in hiding beneath leaves, logs, grasses, or stones, but on heavily overcast, or rainy days, many kinds are active and may be seen crawling about. They may be collected then by the simple procedure of picking them up. Under usual circumstances, however, terrestrial gastropods must be searched for under stones, in leaf litter, under logs, or beneath the started bark of dead trees. A few minute kinds live in moss, where they are found with difficulty; it is usually most convenient to bring the moss into the laboratory, and patiently search through it for gastropods. Other minute gastropods live in leaf litter, where it is almost impossible to see them under field conditions. The leaf litter may be brought into the laboratory, passed over a coarse screen to remove large sticks and leaves, and the finer litter examined with the aid of a microscope. Great patience and some skill is required to isolate minute kinds of gastropods such as *Carychium* or *Punctum* from such material.

Preservation: When it is desirable to dissect gastropods, such as the succineids, in order to classify them, it is best to work with fresh material. The animals may be killed by a few seconds exposure to boiling water. With firm, but gentle pressure, the body can be pulled from the shell without damage. If, however, it is not possible to work with fresh animals, dissection may be performed on preserved specimens. The animals should be relaxed and killed by drowning. Place the animals in a small, tightly-covered jar filled with water, and with no air-space at the top. Depending upon the size of the animals and the temperature, the animals will die in a relaxed state within two to five hours. The animals may then be preserved in 70 per cent alcohol, which should be renewed after the first twenty-four hours. After several days in the second alcohol, transfer the animals to 70 per cent alcohol to which has been added 5 per cent glycerine by volume. In this state, gastropods can be preserved for long periods, even years.

Ordinarily, only the shells are desired. Small species may be dropped in alcohol or formalin, which will kill the animals with the soft parts withdrawn into the shell. After a few days, wash the snails in running water for an hour, and dry them carefully. The shells can then be placed in a collection without causing undesirable odors. This procedure has the advantage that later, if necessary, the body of the animal can be recovered for a study of the radula, or, with sufficient care, even other anatomical parts.

Larger gastropods must have the bodies removed from the shells before the latter are placed in a collection. The live animals are

dropped in boiling water for a few minutes, drained, cooled, and bodies withdrawn by the use of a pin or needle with a hooked point. Care must be taken that all parts are withdrawn, including the digestive gland at the apex of the shell. A jet of water sometimes is useful to remove last remnants of the body. The shells may then be dried, and placed in the collection.

KEY TO THE FAMILIES OF TERRESTRIAL GASTROPODS OF KANSAS

1.	Animal with an external shell	2	
	Animal without an external shell	13	
2.	Parietal wall of shell with plaits extending far back into body whorl, and with one or two plaits emerging from aperture	Strobilopsidae, p.	165
	Parietal wall not as above	3	
3.	Shell broader than high	4	
	Shell higher than broad	9	
4.	Lip of shell reflected	5	
	Lip of shell not reflected	6	
	(NOTE: Hirsute specimens are juvenile Polygyridae)		
5.	Adult shell 3 mm. or less in diameter	Valloniidae, p.	188
	Adult shell 6 mm. or more in diameter	Polygyridae, p.	80
6.	Shell with either transverse or longitudinal ribs	Endodontidae, p.	127
	Shell without ribs	7	
7.	Shell more than 10 mm. in diameter	8	
	Shell less than 10 mm. in diameter	Endodontidae, p.	127
		Zonitidae, p.	108
8.	Diameter of umbilicus contained 3 to 4 times in shell diameter	Haplotrematidae, p.	105
	Diameter of umbilicus contained at least 8 times in shell diameter	Zonitidae, p.	108
9.	Aperture occupying one-half or more of length of shell	10	
	Aperture occupying not more than one-third of length of shell	11	
10.	Shell coloration not uniform, brown or grayish markings present; shell not fragile	Bulimulidae, p.	103
	Shell coloration uniform; thin, very fragile	Succineidae, p.	139
	(NOTE: In living specimens the color of the mantle may be visible through shell)		
11.	Aperture elongate; edentate or only a single parietal plait	12	
	Aperture not elongate; usually dentate, or if not, with reflected lip	Pupillidae, p.	167
12.	Parietal wall with a single plait	Carychiidae, p.	191
	Edentate	Cionellidae, p.	189
13.	Mantle covering only the anterior part of body	Limacidae, p.	125
	Mantle covering nearly the entire body	Philomycidae, p.	137

Suborder STYLOMMATOPHORA Schmidt

Family POLYGYRIDAE Pilsbry

The shells in this family are large to medium sized, and are usually monocolored yellow or brown, but a few, such as *Allogona profunda* may be banded, and some, as, for example, *Triodopsis multilineata* have numerous bands of darker color on the shell. As in most other terrestrial gastropods, polygyrids are stylomatophorous; that is to say, the eyes are borne on long, tentaclelike stalks. The shells are globose-conic to lens-shaped; the aperture has a reflected lip, and is often provided with "teeth" or whitish excrescences.

Most polygyrids are animals of humid countries, except that the genus *Ashmunella* occurs in arid regions in the southwestern part of the United States. The family is widespread in North America, from Mexico to latitude 13° north, but has its principal development in temperate climates. In Kansas, polygyrids are rare west of the Flint Hills, and only *Stenotrema leai* occurs in the western two thirds of the State. This has been true, so far as known, at least since the beginning of Pleistocene time.

The shells of polygyrids are unreliable as characters for identification since the same type of shell occurs in several genera. Therefore the keys to the species in Kansas are purely artificial, and insofar as they are reliable, will apply only to the species listed in this handbook.

KEY TO SPECIES OF THE POLYGYRIDAE IN KANSAS

1. Peristome simply reflected, lacking sinuses or denticles . . 2
   Peristome having sinuses or denticles, never simple . . 13
2. Peristome having tooth on parietal wall . . 10
   Peristome lacking tooth on parietal wall . . 3
3. Shell monocolored, yellow to light brown . . 6
   Shell bearing one or more darkly colored, spiral bands . . 4
4. Color bands limited to one broad, brownish stripe above periphery, some specimens having fine, faint lines, below or only one such fine, faint line below . . *Allogona profunda*, p. 101
   Color bands narrow, more than one both above and below periphery . . 5
5. Greater diameter of shell more than 20 mm.; umbilicus usually rimate . . *Triodopsis multilineata multilineata*, p. 99
   Greater diameter of shell less than 20 mm.; umbilicus usually imperforate . . *Triodopsis multilineata algonquinensis*, p. 100
6. Umbilicus imperforate . . 9
   Umbilicus perforate, widely open or narrowly rimate . . 7
7. Umbilicus widely open . . *Allogona profunda*, p. 101
   Umbilicus, if open, narrowly rimate . . 8

8. Bosslike denticle usually present on parietal wall; greater diameter more than 17 mm. *Mesodon thyroidus*, p. 87
   No denticle on parietal wall; greater diameter usually less than 17 mm. *Mesodon clausus*, p. 91
9. Greater diameter of shell more than 20 mm. *Triodopsis albolabris alleni*, p. 97
   Greater diameter of shell less than 20 mm. *Triodopsis divesta*, p. 101
10. Having parietal tooth and simple peristome 11
    Having parietal tooth, but peristome not simple 13
11. Parietal tooth small and bosslike, never elongate. *Mesodon thyroidus*, p. 87
    Parietal tooth large and elongate, never small and bosslike 12
12. Umbilicus narrowly open; surface of shell smooth. *Stenotrema leai aliciae*, p. 86
    Umbilicus imperforate; surface of shell hirsute or pitted. *Stenotrema hirsutum*, p. 85
13. Umbilicus imperforate *Stenotrema stenotrema*, p. 84
14. Parietal tooth elongate; umbilicus rimate. *Mesodon inflectus inflectus*, p. 94
    Parietal tooth not elongate, or, if somewhat elongate, umbilicus widely open 15
15. Parietal tooth somewhat elongate, never upright, never squarish *Triodopsis cragini*, p. 96
    Parietal tooth upright, squarish 16
16. Less than one-half of penultimate whorl visible in umbilical view of shell *Polygyra jacksoni jacksoni*, p. 83
    More than one-half of penultimate whorl visible in umbilical view of shell 17
17. All whorls visible in umbilical view of shell *Polygyra neglecta*, p. 94
    All whorls not visible in umbilical view of shell 18
18. Diameter of umbilicus equal to less than one-third that of greater diameter of shell *Polygyra dorfeuilliana dorfeuilliana*, p. 81
    Diameter of umbilicus equal to one-third or more that of greater diameter of shell *Polygyra dorfeuilliana sampsoni*, p. 82

Genus *Polygyra* Say

Polygyra dorfeuilliana dorfeuilliana Lea

Pl. 4, figs. 10, 11, 12; text fig. 30

Polygyra dorfeuilliana Lea, 1838, Trans. Amer. Phil. Soc., 6:107, Pl. 24, fig. 118, type locality "Ohio, Mr. Dorfeuille, Cincinnati" (see discussion in Pilsbry, 1940:634); Call, 1886, Bull. Washburn Coll. Lab. Nat Hist., 1:205; Hanna, 1909, Nautilus, 23:82; Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. I, pt. 2, p. 634, fig. 398 (upper four figs.).

Range: Central United States, largely west of the Mississippi River, from Illinois and Kansas south to Louisiana and Texas, in Kansas limited to the southeastern part of the state, except that no records exist in the Ozarkian province in Kansas.

Description: Shell between ¼ and ⅜ inches in diameter (7-9 mm.); discoidal, spire slightly elevated; light brown, translucent; last whorl coarsely

but weakly ribbed, subobsolete on base; whorls 6, rounded; sutures impressed; umbilicus deep, small, contained about 3¾ times in diameter; aperture oval, with three denticles, the large squarish parietal being the most prominent; lip white, thickened, reflected.

Measurements of Figured Specimens (Pl. 4)

Height, 3.8 mm.; greater diameter, 9.1 mm.; number whorls, 5¾

Recognition Characters: The large, squarish parietal tooth will distinguish this shell from all other Kansas forms. It differs from the subspecies *P. d. sampsoni* in being generally larger (7.8-9.1 mm.), having spire less elevated, having striation on base of the shell less pronounced, and having narrower umbilicus (see pl. 4, figs. 3, 12).

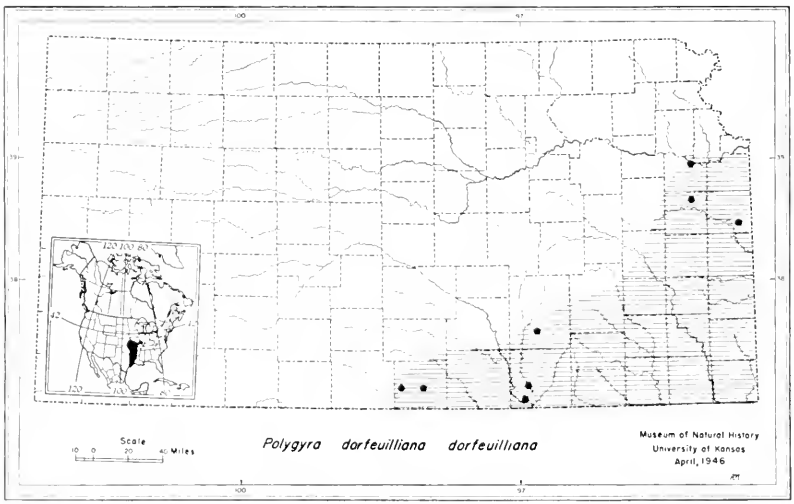


FIG. 30. Distribution of *Polygyra dorfeuilliana dorfeuilliana* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Habitat: Polygyra dorfeuilliana inhabits rocky, wooded slopes, in well-drained situations, and may be found under stones, and less frequently beneath decaying logs and in leaf litter.

Polygyra dorfeuilliana sampsoni (Wetherby)

Pl. 4, figs. 1, 2, 3; text fig. 31

P. [olygyra] sampsoni Wetherby, 1881, Jour. Cincinnati Soc. Nat. Hist., 4:332, type locality Eureka Springs, Arkansas. Lectotype A. N. S. P. # 11029.

Polygyra dorfeuilliana sampsoni, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2, p. 636, fig. 398 (lower left and middle figs.); Franzen, 1944, Trans. Kansas Acad. Sci., 47:269, pl. 1, fig. 11.

Range: Ozarkian faunal province, Arkansas, Missouri, Oklahoma, and Kansas, and also Texas. In Kansas, known only from Miami and Cherokee counties.

Description: Shell between ¼ and ⅜ inches in diameter (7-9 mm.); discoidal, spire slightly elevated; light brown, glossy; sculpture of coarse striae subobsolete on base of shell; whorls 6, rounded, increasing regularly in size, last constricted behind aperture; sutures impressed; umbilicus small; aperture oval, having three denticles, the large, squarish parietal being the most prominent; lip white, thickened, reflected.

Measurements of Figured Specimen (Pl. 4)

Height, 4.3 mm.; greater diameter, 8.7 mm.; number of whorls, 5½

Recognition Characters: Distinguished from the subspecies *P. d. dorfeuilliana* in being generally smaller (7.2-8.5 mm.), spire more elevated, the striation on the base of the shell more pronounced, and the umbilicus broader.

Habitat: Franzen (1944:270) has recorded this snail from both Miami and Cherokee counties, where it occurs on rocky, forested slopes.

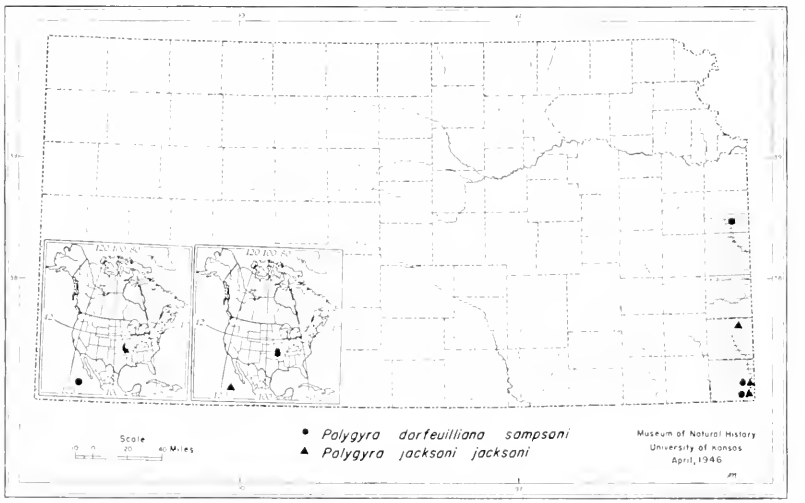


FIG. 31. Distribution of *Polygyra dorfeuilliana sampsoni* and *Polygyra jacksoni jacksoni* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Polygyra jacksoni jacksoni (Bland)

Pl. 4, figs. 19, 20, 21; text fig. 31

Helix jacksoni Bland, 1866, Amer. Jour. Conch., 2:371, pl. 21, fig. 8, type locality Fort Gibson, Muskogee Co., Oklahoma. Type M. C. Z. # 1806.

Polygyra jacksoni, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2, p. 631, fig. 397:10,11; Franzen, 1944, Trans. Kansas Acad. Sci., 47:270, Pl. 1, fig. 8.

Range: Restricted to the Ozarkian faunal province, southeastern Missouri, southeastern Kansas, northwestern Arkansas, northeastern Oklahoma.

In Kansas, known only from Cherokee and Crawford counties.

Description: Shell about ¼ inch in diameter (5-7 mm.); heliciform, depressed; brownish, upper surface striated, fine striations below; whorls 6, slightly convex, gradually increasing, last constricted above; sutures impressed; umbilicate, opening very small; aperture oblique, lunate-circular, having three teeth the most prominent of which is the white, linguiform, bicrural parietal; lip thickened, reflected, pale in color.

Measurements of Figured Specimen (Pl. 4)

Height, 3.1 mm.; greater diameter, 6.4 mm.; number whorls, 5⅛

Recognition Characters: The only other small snail in the State having a similar shell is *P. dorfeuilliana*, from which *P. j. jacksoni* differs in being smaller and in having a linguiform parietal.

Habitat: In Kansas this snail inhabits rocky, wooded slopes in association with *P. d. sampsoni* (Franzen, 1944:270).

Genus *Stenotrema* Rafinesque

Stenotrema stenotrema (Pfeiffer)

Pl. 4, figs. 13, 14, 15; text fig. 32

Helix stenotrema Pfeiffer, 1842, Symbolae ad Hist. Hel., 2:39, type locality "Indiana."

Stenotrema stenostrema, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2, p. 655, fig. 409 a-e; Franzen, 1944, Trans. Kansas Acad. Sci., 47:271, pl. 1, fig. 12.

Range: Eastern United States, from Virginia and South Carolina west to Kansas and Louisiana.

In Kansas, this species is known only from Cherokee County.

Description: Shell about ½ inch in diameter (9-13 mm.); globose-depressed, spire low, conoid, base strongly convex; color brownish; sculpture of irregular striae set with papillae bearing short "hairs"; whorls 5-6, convex, periphery rounded; sutures impressed; imperforate; aperture narrow, transversely linear, almost completely covered by parietal tooth in apertural view; basal lip with a small but pronounced notch; lip thickened, reflected.

Measurements of the Figured Specimen (Pl. 4)

Height, 6.9 mm.; greater diameter, 11 mm.; number whorls, 5¾

Recognition Characters: Only two snails in the State have the basal lip notched, *S. stenotrema* and *S. hirsutum*. From the latter *S. stenotrema* differs in larger size, narrower aperture, higher parietal tooth, wider basal lip, and narrower and deeper notch.

Habitat and Habits: This snail is solitary; only one or two individuals are usually found together under chips, bark, logs, and similar debris. *Stenotrema stenotrema* in Kansas is restricted, so far as known, to the forested Ozarkian province which enters only slightly into the southeastern corner of the State.

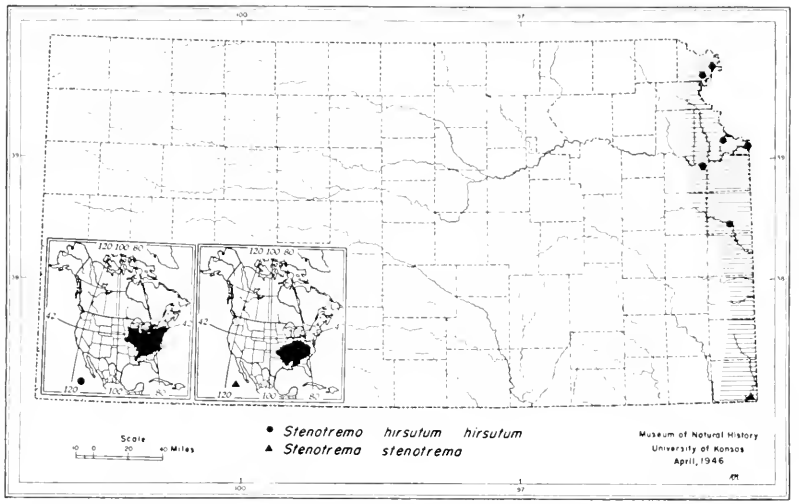


FIG. 32. Distribution of *Stenotrema hirsutum hirsutum* and *Stenotrema stenotrema* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Stenotrema hirsutum hirsutum (Say)

Pl. 4, figs. 22, 23, 24; text fig. 32

Helix hirsuta Say, 1817, Jour. Acad. Nat. Sci. Philadelphia, 1:17; 2:161, type locality "Philadelphia" (Wissahickon Creek, Germantown, Philadelphia selected by Pilsbry, 1940:664). Type A. N. S. P. # 11396.

Stenotrema hirsutum, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:202; Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2:662, fig. 412.

Range: Eastern North America, Massachusetts west to Minnesota and Kansas, south to Georgia and Mississippi; absent from Ozarks and southern Appalachians in the coastal plain south to North Carolina.

In Kansas, this snail is limited to the northeastern section of the state.

Description: Shell about ¼ inch in diameter (6-10 mm.); depressed-globose; spire low, conoid; brownish, granulated texture; short, moderately stiff "hairs" arranged in an oblique series; whorls 5, rounded, periphery subangular, last whorl deflected and constricted behind aperture; base strongly convex; sutures impressed; imperforate; aperture transversely elongate, parietal tooth almost covering opening but not basal tip in apertural view; sinus in basal lip broadly rounded, lip reflected.

The animal is whitish, having the head, eye-peduncles and tentacles slate gray; the foot is long, narrow, blunt in front, pointed behind.

Measurements of Figured Specimen (Pl. 4)

Height, 4.4 mm.; greater diameter, 7.1 mm.; number whorls, $5\frac{1}{5}$

Recognition Characters: This snail may be distinguished from *S. stenotrema* in being smaller, more globular, "hairy," and with the parietal tooth smaller.

Habitat and Habits: This is a forest snail, being found under stones, old logs and other forest debris. *Stenotrema hirsutum* is a characteristic snail of humid, forested regions, and in eastern Kansas, is at the extreme western limits of its range.

Stenotrema leai aliciae (Pilsbry)

Pl. 4, figs. 25, 26, 27; text fig. 33

Helix monodon var. *aliciae* Pilsbry, 1893, Man. Conch., 8:152, type locality near Lake Charles, Calcasieu Parish, Louisiana, Type A. N. S. P. No. 76753.

Stenotrema monodon var. *fraterna,* Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:55.

Stenotrema leai, Call, 1886, Bull. Wash. College Lab. Nat. Hist., 1:202.

Stenotrema monodon, Call, 1886, Bull. Wash. College Lab. Nat. Hist., 1:206.

Polygyra monodon, Hanna, 1909, Nautilus, 23:82.

Polygyra fraterna, Hanna, 1909 Nautilus, 23:82.

Polygyra fraterna aliciae, Hanna, 1909, Nautilus, 23:82.

Polygyra fraterna friersoni, Hanna, 1909, Nautilus, 23:94.

Stenotrema monodon aliciae, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2, p. 679, fig. 421c.; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1039, pl. C, figs. 5, 6.

Stenotrema fraterna, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:338, pl. 2, fig. 18.

Stenotrema fraternum fraternum, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:410, pl. xxxi, fig. 18.

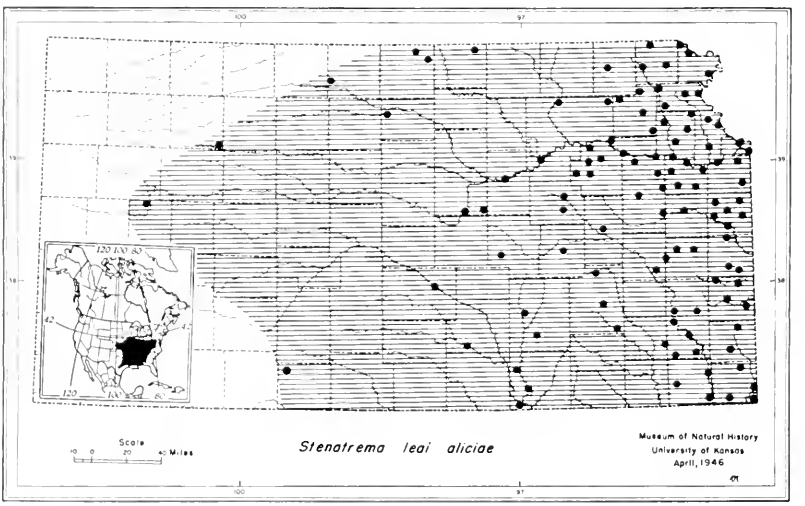


FIG. 33. Distribution of *Stenotrema leai aliciae* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Range: Eastern United States from Maryland and Alabama westernward to Kansas and Texas. In Kansas, abundant in eastern half of the State, with scattered colonies only in the Plains Border and High Plains geographic provinces.

Description: Shell about ¼ inch in diameter (7-8 mm.); heliciform, subglobose, spire elevated; brownish, surface covered with close-set, short hairs; whorls 5½ - 6, rounded, closely coiled, periphery high on body whorl; sutures impressed; narrowly perforate or imperforate; aperture tranverse, lip reflected, pale; dentition: a single prominent parietal tooth, no teeth on outer margin of peristome.

Measurements of the Figured Specimen (Pl. 4)

Height, 5.4 mm.; greater diameter, 8.4 mm.; number whorls, 5½

Recognition Characters: This species can be distinguished from the other species of *Stenotrema* in Kansas by the absence of a sinus in the outer peristome and the elongate, simple parietal tooth.

Habitat and Habits: The typical subspecies inhabits very humid areas. *Stenotrema l. aliciae* is found in Kansas both in the moist wooded areas of the eastern part of the State and in the more open situations of the central third, while occasional local populations are known in wooded areas associated with streams in the western third.

Genus *Mesodon* Rafinesque

Mesodon thyroidus thyroidus (Say)

Pl. 5, figs. 7, 8, 9; text fig. 34

Helix thyroidus Say, 1816, Nicholson's Encyclopedia, II, article Conchology, under *Helix albolabris* (no pagination), type locality not known. Neotype A. N. S. P., from Wissahickon Creek, Pa.

Mesodon thyroides, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Mesodon thyroidus, Franzen, 1944, Trans. Kansas Acad. Sci., 47(2):269; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31:119; Pilsbry, 1940, Land Mollusca of North America (North of Mexico), vol. 1, pt. 2, p. 706, fig. 432 a-e.

Range: Eastern North America, from Massachusetts and Ontario west to Minnesota, southwest through Iowa, eastern Nebraska and Kansas to Texas and northern Florida in the east.

In Kansas, this species is limited to the eastern third of the state.

Description: Shell large (greater diameter between 17.5 and 22.1 mm., about ¾ inches), globose-depressed (height diameter index ranges from about .64 to .82), thin; whorls 5½, sutures well impressed; shell light yellow to brownish yellow; peristome widely reflected, partly covering narrow umbilicus; surface glossy, having fine oblique striae; parietal wall of aperture of many individuals bearing an obliquely placed tooth (present in most Kansas specimens).

The animal is grayish or yellowish-white, dark on head and eye-peduncles, which are long and tapering. The foot is long, narrow, and dirty white.

PLATE 4

Shells of Polygyridae in Kansas

All figures enlarged approximately 2 times natural size.

1, 2, 3. *Polygyra dorfeuilliana sampsoni* Wetherby, shores of Pigeon Lake, Whiteford Ranch, 2½ mi. E, ½ mi. N Fontana, Miami County, Kansas. Collected by A. B. Leonard, 13 April 1943. Catalogue number 1319.

4, 5, 6. *Mesodon inflectus inflectus* (Say), 5 mi. E Baxter Springs, Cherokee County, Kansas. Collected by D. S. Franzen, 15 April 1943. Catalogue number 1326.

7, 8, 9. *Triodopsis cragini* Call, 1 mi. S, 1 mi. W Thayer, Neosho County, Kansas. Collected by E. J. Roscoe, 11 September 1950. Catalogue number 6552.

10, 11, 12. *Polygyra dorfeuilliana dorfeuilliana* Lea, Garnett, Anderson County, Kansas. Collected by E. H. Taylor, in the summer of 1910. Catalogue number 2148.

13, 14, 15. *Stenotrema stenotrema* (Pfeiffer), 1 mi. east of Baxter Springs, Cherokee County, Kansas. Collected by A. B. Leonard, 9 April 1943. Catalogue number 1314.

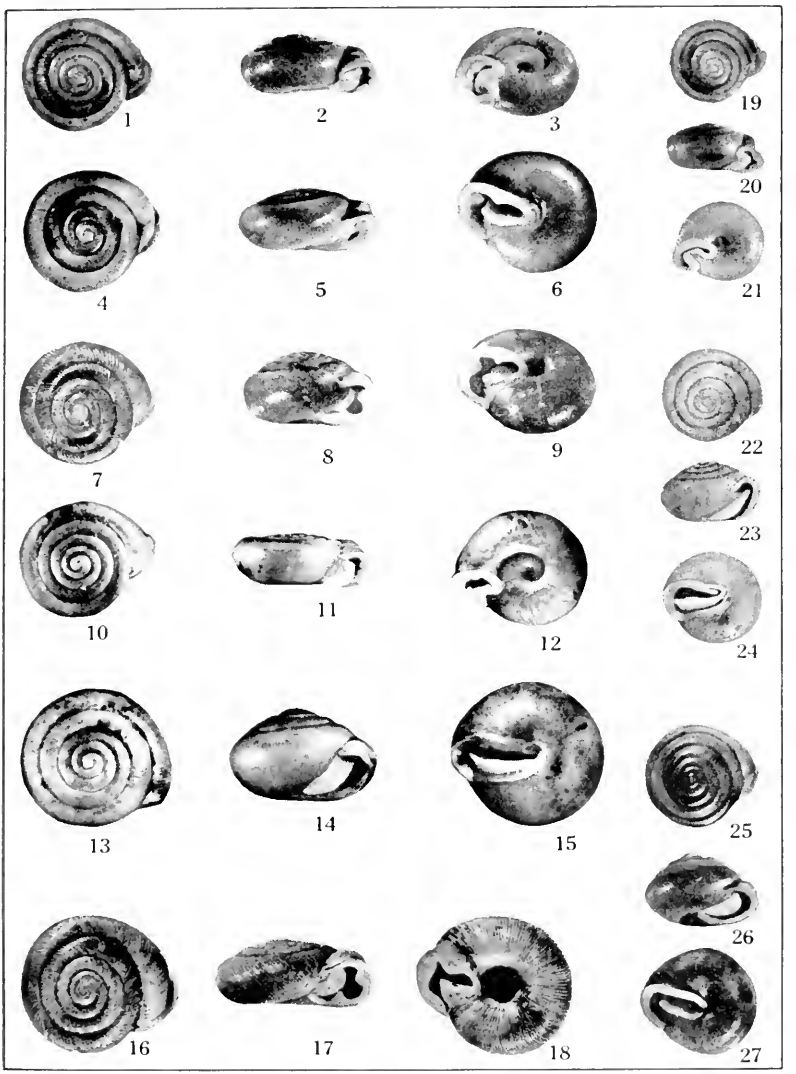
16, 17, 18. *Triodopsis neglecta* (Pilsbry), 2 mi. N Galena, Cherokee County, Kansas. Collected by E. L. Cockrum, 27 April 1947. Catalogue number 6920.

19, 20, 21. *Polygyra jacksoni* (Bland), 2 mi. N Galena, Cherokee County, Kansas. Collected by Dee Saunders, 28 April 1950. Catalogue number 6562.

22, 23, 24. *Stenotrema hirsutum* (Say), 3 mi. N Doniphan, Doniphan County, Kansas. Collected by D. S. Franzen, 16 October 1948. Catalogue number 5092.

25, 26, 27. *Stenotrema leai aliciae* (Pilsbry), 2 mi. W, 4½ mi. N Garnett, Anderson County, Kansas. Collected by E. J. Roscoe, 11 September 1951. Catalogue number 7908.

PLATE 4



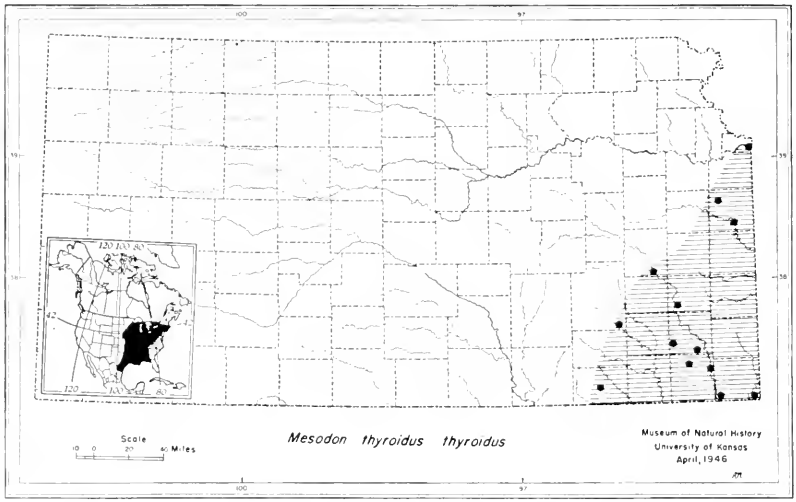


FIG. 34. Distribution of *Mesodon thyroidus thyroidus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Measurements of Figured Specimen (Pl. 5)

Height, 13.2 mm.; greater diameter, 20.1 mm.; number of whorls, 5¾

Recognition Characters: The combination of large size, shape, partly covered umbilicus and parietal tooth distinguish this snail from other Kansas polygyrids. Some small specimens may be confused with *Mesodon clausus* but the absence of the parietal tooth and generally higher spire in the latter will suffice to distinguish most specimens.

Habitat and Habits: This forest snail is found on and under rotten logs, smaller pieces of wood and in litter. This subspecies seems to be closely associated with floodplains and their margins in Kansas, but has been reported from drier situations in Indiana (Call, 1900:394) and Michigan (Goodrich, 1932:19). Call (*loc. cit.*) also records this snail from marshy areas, as well as on trees at heights of from 2 to 6 feet above ground. According to Goodrich and van der Schalie (1944:267) this species adapts itself well to open fields and gardens.

The species was recorded by Goodrich and van der Schalie (*loc. cit.*) as feeding on "mildews, slime molds and fungi." According to Pilsbry (1940:710), *Mesodon thyroidus* has been reported feeding chiefly on wood nettles (*Laportia canadensis*) in Illinois, whereas others, studying the species elsewhere, have reported the principal food to be fungi.

Mesodon clausus (Say)

Pl. 5, figs. 4, 5, 6; text fig. 35

Helix clausa Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:154, type locality unknown.

Mesodon clausa, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:201 (Kansas City, Mo.).

Polygyra clausa, Hanna, 1909, Nautilus, 23:82.

Mesodon clausus, Franzen, 1944, Trans. Kansas Acad. Sci., 47(2):269; Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2, p. 712, fig. 434 a, b.

Range: Central United States, Alabama to Michigan and southern Minnesota; west to eastern Kansas; south to Mississippi. In Kansas, limited to the two eastern tiers of counties.

Description: Shell moderately large (between 15 and 18 mm. in greater diameter; about ¾ inches), semi-globose (height diameter ratio varying from .75 to .85); color light yellow to greenish yellow; whorls 5 to 6½; sutures well impressed; surface with numerous oblique fine lines of growth; umbilicus narrow, partly covered by reflected peristome; aperture diagonally lunate, peristome reflected, white; no parietal tooth.

The animal is blackish on the dorsal surface of the body and head; the eye-peduncles are long and slender and blackish; the foot is long, narrow and its base yellowish-white.

Measurements of Figured Specimen (Pl. 5)

Height, 13.1 mm.; greater diameter, 18.5 mm.; number of whorls, 5¼

Recognition Characters: From *Mesodon thyroidus*, *Mesodon clausus* differs in smaller size, shape (higher h d index), and absence of a parietal tooth.

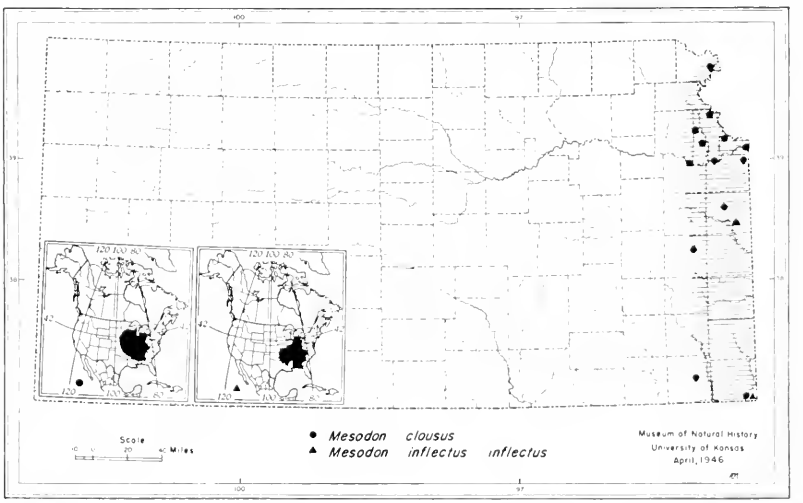


FIG. 35. Distribution of *Mesodon clausus* and *Mesodon inflectus inflectus* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

PLATE 5

Shells of Polygyridae in Kansas

All figures enlarged approximately 1.1 times natural size.

1, 2, 3. *Triodopsis multilineata algonquinensis* Nason, Muscotah Marsh, 1½ m. S Muscotah, Atchison County, Kansas. Collected by A. B. Leonard, 13 September 1943. Catalogue number 1312.

4, 5, 6. *Mesodon clausus* (Say), roadside park, ¼ mi. S Merriam, Johnson County, Kansas. Collected by E. J. Roscoe, 14 April 1951. Catalogue number 7243.

7, 8, 9. *Mesodon thyroidus thyroidus* (Say), shore of Pigeon Lake, Whiteford Ranch, 2½ mi. E, ½ mi. N Fontana, Miami County, Kansas. Collected by A. B. Leonard, 10 September 1943.

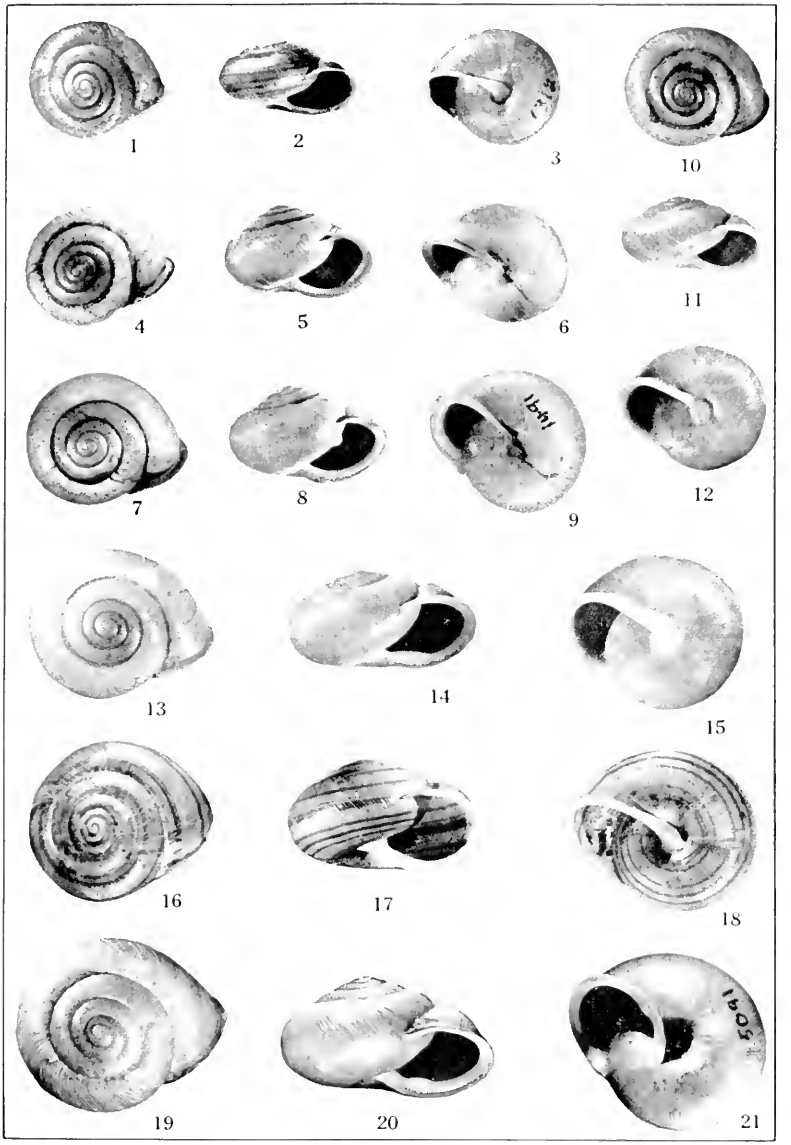
10, 11, 12. *Triodopsis divesta* (Gould), bank of Neosho River at Oswego, Labette County, Kansas. Collected by Mary Works, 24 April 1949. Catalogue number 9088.

13, 14, 15. *Triodopsis albilabris alleni* (Sampson), shore of Pigeon Lake, Whiteford Ranch, 2½ mi. E, 1 mi. N Fontana, Miami County, Kansas. Collected by A. B. Leonard, 10 September 1943. Catalogue number 1482.

16, 17, 18. *Triodopsis multilineata multilineata* (Say), shore of Kansas River, 8 mi. NW Lawrence, Douglas County, Kansas. Collected by G. D. Hanna, 2 May 1909. Catalogue number 211.

19, 20, 21. *Allogona profunda* (Say), loess hills, 3 mi. N Wathena, Doniphan County, Kansas. Collected by D. S. Franzen, 16 October 1948. Catalogue number 5091.

PLATE 5



Habitat and Habits: This is essentially a forest snail. It has been reported from prairie habitat by Baker (1939:57) in Illinois. Its distribution in Kansas (see fig. 35) would indicate that it does not succeed well in such situations farther west.

Baker (1902:159) records that the animal moves rapidly, is "most inquisitive," and will readily crawl over one's hand.

Mesodon inflectus inflectus (Say)

Pl. 5, figs. 4, 5, 6; text fig. 35

Helix inflecta Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:153, type locality "Lower Missouri." Type A. N. S. P. No. 11095.

Mesodon inflectus, Pilsbry, 1940, Land Mollusca of North America, vol. 1, pt. 2, p. 770, fig. 462 a-e; Franzen, 1944, Trans. Kansas Acad. Sci., 47:268, pl. 1, fig. 13.

Range: Eastern United States, from Louisiana and eastern Oklahoma and Kansas northward to southern Michigan; eastward to western Carolinas. This snail reaches only the eastern tier of counties in Kansas.

Description: Shell about ½ inch in diameter, solid, depressed; light brown; whorls 5, convex, rather closely coiled, the body whorl subangulate; surface of shell covered with fine periostracal processes; sutures impressed; imperforate; aperture contracted, armed with three denticles, a long, curved parietal tooth and two teeth on the outer lip.

This snail may be distinguished from others of similar size and shape (it bears a superficial resemblance to some species of *Polygyra* and *Triodopsis* in Kansas), by the closed umbilicus, the elongate parietal tooth, and the details of the outer peristome.

The animal is generally dark bluish or slate colored, blackish on the head and eye-peduncles, which are long and slender. The foot is long and narrow, rounded anteriorly and pointed posteriorly.

Measurements of Figured Specimen (Pl. 5)

Height, 6.9 mm.; greater diameter, 10.6 mm.; number of whorls, 4⅓

Habitat and Habits: This is a forest snail, apparently somewhat gregarious (Baker, 1939:47). It may be found in leaf litter, in rotting logs as well as on bare limestone cliffs.

Genus *Triodopsis* Rafinesque

Triodopsis neglecta (Pilsbry)

Pl. 4, figs. 16, 17, 18; text fig. 36

Triodopsis fallax Say, var. *minor* Wetherby, 1881, Jour. Cincinnati Soc. Nat. Hist., 4:333.

P. [olygyra] neglecta Pilsbry, 1899, Nautilus, 13:40; Pilsbry and Ferriss, 1907, Proc. Acad. Nat Sci., Philadelphia for 1906, p. 546, pl. 22, figs. 19-21, Type locality, Eureka Springs, Carroll Co., Arkansas. Type A. N. S. P. # 76283.

Triodopsis neglecta, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), Acad. Nat. Sci., Philadelphia Monographs no. 3, vol. 1, pt. 2, p. 807, fig. 479.

Range: South-central United States in Missouri, Kansas, Arkansas, Oklahoma. Limited to the southeastern portion of Kansas.

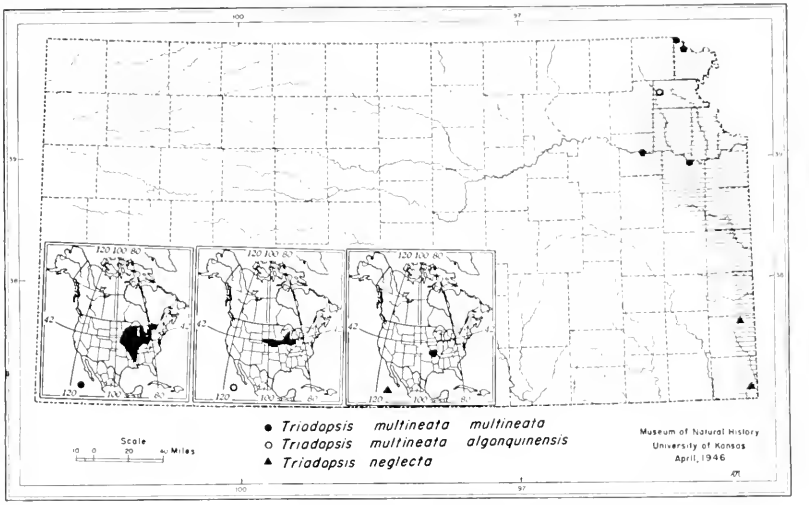


FIG. 36. Distribution of *Triodopsis multineata multineata*, *Triodopsis multineata algonquinensis* and *Triodopsis neglecta* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Description: Shell ½ to ¾ inches in diameter (10-12 mm.); strongly depressed; color dilute olive; glossy; whorls 5 to 5½, closely coiled, body whorl rounded at periphery, descending steeply to the aperture; strongly contracted behind outer and basal margins of lip; sutures impressed; surface with regular, fine, transverse striae; widely umbilicate, contained about four times in diameter of shell; lip white, reflected, aperture markedly trilobed; parietal tooth strongly curved, long, reaching to columella; squarish tooth on outer lip and tubercular tooth on basal lip.

Measurements of Figured Specimen (Pl. 4)

Height, 5.3 mm.; greater diameter, 11.5 mm.; number of whorls, 5

Recognition Characters: Triodopsis neglecta most closely resembles *T. cragini* among polygyrids in Kansas. From the latter, *T. neglecta* differs in larger size, relatively larger umbilical opening, more depressed spire, and larger and differently shaped parietal and basal denticles.

Habitat and Habits: Triodopsis neglecta has a restricted distribution in the forested Ozarkian uplift and its outliers; in Kansas the species is at the extreme periphery of its range. It may be found under stones, the trunks of fallen trees, and in leaf litter on the forest floor.

T. neglecta seems most closely related to *T. fraudulenta*, but the range of the latter in Virginia and West Virginia, is separated from that of *T. neglecta* by many hundreds of miles. If the two nominal species are actually one, the gross discontinuity in the range must be explained.

Triodopsis cragini (Call)

Pl. 4, figs. 7, 8, 9; text fig. 37

Triodopsis cragini Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:202, fig. 5, type locality, banks of Chetopa Creek, Neosho Co., Kansas. Type M. C. Z. # 3123; Pilsbry, 1940, Land Mollusca of North America, vol. 1, pt. 2, p. 821, fig. 484 g-i.

Polygyra cragini, Pilsbry and Ferriss, 1907, Proc. Acad. Nat. Sci. Philadelphia for 1906, p. 545.

Range: South-central United States in Kansas, Missouri, Arkansas, Oklahoma, Louisiana and Texas.

Known only from Neosho County in Kansas.

Description: Shell ¼ to ½ inch in diameter; depressed globose; reddish or reddish-brown, shiny, with yellow blotches; whorls 5, convex, spire increasing regularly in size, body whorl enlarging rapidly; surface of body whorl with numerous prominent sigmoid striae, obsolete on base of shell; tendency to subangulation of body whorl at junction of aperture only; sutures well impressed; deeply but narrowly umbilicate; aperture oblique, constricted by three teeth—a short straight parietal tooth, a heavy, white triangular tooth on outer edge of peristome and a short conical tooth on the basal margin; peristome reflected, white, thickened.

Measurements of Figured Specimen (Pl. 4)

Height, 4.8 mm.; greater diameter, 9.2 mm.; number of whorls, 4¾

Recognition Characters: Among polygyrids in Kansas, *Triodopsis cragini* most closely resembles *T. neglecta*, but differs in smaller size, smaller umbilical opening, differently shaped and more poorly developed apertural denticles, and obsolete basal striae.

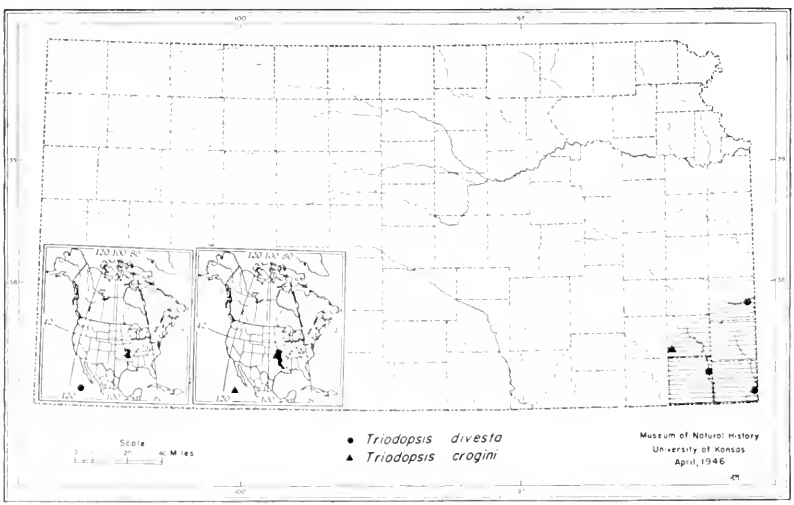


FIG. 37. Distribution of *Triodopsis divesta* and *Triodopsis cragini* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Habitat and Habits: Triodopsis cragini appears to be better adapted to arid situations than most other Polygyridae. In Kansas it occurs primarily in upland habitats in sandy areas where oak forest is the dominant vegetation. It has also been collected from under rocks and in the cracks and crevices of sandstone ledges. Pilsbry (1940:823) found it in Oklahoma "under stones and wood on a stony hillside with very little shade."

Triodopsis albolabris alleni (Sampson)

Pl. 5, figs. 13, 14, 15; text fig. 38

Mesodon albolabris and var. *minor* Wetherby, 1881, Jour. Cincinnati Soc. Nat. Hist., 4:332, non *Helix albolabris* var. *minor* Shuttleworth.

Mesodon albolabris var. *alleni* Wetherby, Sampson, 1883, Kansas City Rev. Sci., 6:24; Ann. Report Geol. Surv. Arkansas for 1891, 2:189, 190 (first description).

Mesodon albolabris, Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:55; Call, 1886, *ibid.*, 1:206.

Polygyra albolabris alleni, Pilsbry and Ferriss, 1907, Proc. Acad. Nat. Sci. Philadelphia for 1906, p. 552; Hanna, 1909, Nautilus 23:82.

Triodopsis albolabris alleni, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2:840, fig. 489, No. 10, 11, 11a; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:409, pl. xxxi, figs. 13, 17; Franzen, 1944, Trans. Kansas Acad. Sci., 47:269; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119.

Range: Central United States, mostly west of the Mississippi River: Minnesota, Iowa, Missouri, Kansas, Oklahoma, Arkansas, Illinois and Tennessee.

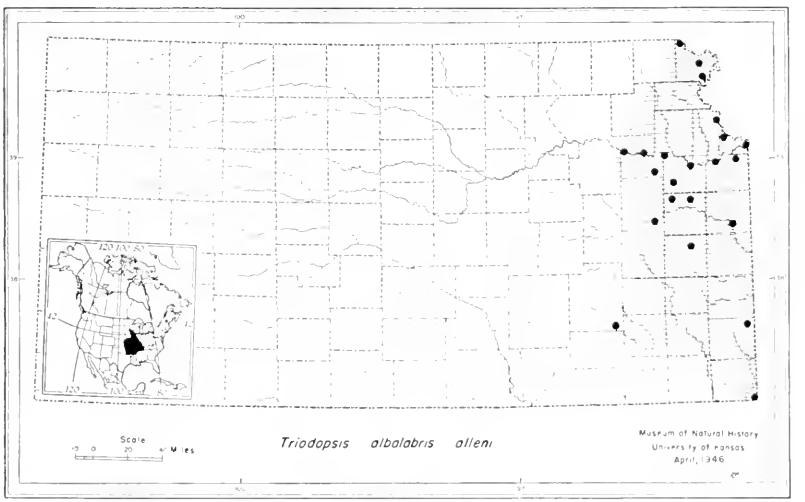


FIG. 38. Distribution of *Triodopsis albolabris alleni* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

In Kansas this species is distributed over the eastern one-fourth of the State, reaching its western limits along the Kaw Valley in Shawnee County, and in Butler County in the south.

Description: Shell about 1 inch in diameter (22-28 mm.); globose depressed (h/d index varies from .65 to .72); solid; yellowish-brown, sometimes darker, no color-bands; whorls 5-6, rounded, regularly increasing in size, spire but little elevated; sutures impressed; surface covered with fine, weak oblique striae; imperforate; aperture lunate, lip white, reflected, rounded, small callosity near columella present in some individuals; parietal tooth infrequent in individuals in Kansas.

Measurements of Figured Specimen (Pl. 5)

Height, 13.8 mm.; greater diameter, 26.0 mm.; number of whorls, 5¼

Recognition Characters: The large, imperforate shell of this snail makes it one of the most easily recognized kinds in the State. Smaller individuals can be distinguished from *T. multilineata* by the absence of color bands and from the larger *Mesodon* on the basis of shape, *T. a. alleni* being the higher in specimens of equal size.

Examination of all sets of *T. albolabris* in the University of Kansas collection has led to the conclusion that the typical subspecies does not occur in the State. *Triodopsis a. alleni* differs from *T. a. albolabris* as follows: more depressed, more glossy, sculpture weaker, lip narrower, its face rounded rather than flat, baso-columellar "tooth" often more pronounced. Although some Kansas specimens show intergradation in one or two characters, on the whole they are distinct. The Mississippi River marks the approximate boundary between the two subspecies.

Habitat and Habits: This is essentially a forest snail, typically found under and about old logs in woodlands and wooded hillsides. The species as a whole was in former times one of the most common forest snails in North America. The species shows a distinct adaptiveness to conditions brought about by deforestation, small individuals of *T. a. albolabris* being reported from grasslands and sandy areas in Michigan (Goodrich 1932:14), Indiana (Goodrich and van der Schalie 1944:269), and Ontario (Oughton, 1948:12). In the past such depauperized colonies were often given varietal names.

The foot of the animal is long and wide. The posterior part of the foot is flattened and acutely pointed, rising to meet a central dorsal keel. The body varies from whitish or cream through yellowish-brown to black. A dark stripe extends down the center of the neck and head to the shell. The short, cylindrical tentacles and unusually long eye-peduncles are almost black.

In locomotion the animal has been described by Baker (1902: 153) as ". . . slow in movement, but not at all timid, readily allowing itself to be handled without withdrawing into its shell. When crawling up the side of a glass jar the shell is so heavy that

it hangs almost to the extremity of the foot. The eye-peduncles are pointed straight ahead during locomotion, the shell is carried almost flat, and the tentacles are directed straight downwards." The rate of locomotion has been recorded (Baker, *op. cit.*:154) as 24 inches in 14 minutes, or a theoretical 16.6 miles per year (Oughton, *op. cit.*:128).

"When eating, the head is drawn partly in and the tentacles are laid back and half contracted." (Baker, 1902:153-4.)

Aestivation occurs under logs, but the animal does not burrow into the ground according to Call (1900:389). The large, cream-colored eggs are deposited under logs in moist situations in clusters of two or three dozen or more (Call, *loc. cit.*).

Because of its abundance and large size this snail has long been a favorite laboratory animal in elementary zoological classes. A detailed account of its anatomy can be found in the paper by Simpson (1901). Preserved specimens are regularly sold by biological supply houses, although frequently under the generic name *Polygyra*.

Triodopsis multilineata multilineata (Say)

Pl. 5, figs. 16, 17, 18; text fig. 36

Helix multilineata Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:150, type locality "Illinois and Missouri." Type A. N. S. P.

Mesodon multilineata, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:202.

Polygyra multilineata chadwicki Ferriss, 1907, Nautilus 21:37; Hanna, 1909, Nautilus 23:82.

Polygyra multilineata, Hanna, 1909, Nautilus 23:82.

Triodopsis multilineata, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2:847, fig. 493 a-c.

Range: Eastern North America, east of the Appalachians from southern Ontario to Minnesota; south to Arkansas and Mississippi; east to Ohio. Its western limits are reached in eastern Nebraska and Kansas.

In Kansas this snail is limited to the northeastern section of the State.

Description: Shell between ¾ and 1 inch in diameter (20-25 mm.); globose depressed (h/d index between .69-.75); thin; yellowish-horn with numerous reddish-brown spiral bands of variable width; glossy; whorls 5-6 rounded, regularly increasing in size, the last ventricose; spire depressed, sutures deeply impressed; sculpture of fine, oblique striae; imperforate; aperture broadly truncate; lip white, reflected; callus thin, typically plain but some shells having low oblique tooth.

Recognition Characters: The combination of a large imperforate shell and color bands will distinguish this from all other shells in the State that closely resemble that of *T. m. multilineata*. Juveniles are difficult to distinguish from *Allogona profunda*. In general, the color bands are more numerous in *T. multilineata*. *T. m. multilineata* is readily distinguished from *T. m. algon-*

quinensis by larger size (major diameter of shell 20 or more millimeters instead of less than 20).

Measurements of Figured Specimen (Pl. 5)

Height, 14.1 mm.; greater diameter, 24.5 mm.; number of whorls, 5½

The animal is similar in form to that of *Allogona profunda*, having a long and narrow foot, blackish in color but with lighter tubercles or granules. The eye-peduncles are long and tapering.

Habitat and Habits: This snail is characteristic of marshy woodlands and meadows. In Illinois (Baker, 1939:51) it has been recorded from damp woods of oak, hickory, box elder, tamarack, maple and cottonwood.

The animal is slow and timid and "is usually found crawling about, even in warm sunshine, and appears to withstand the summer's heat better than does the majority of helices." (Call, 1900:390.) It is apparently gregarious in winter, Goodrich and van der Schalie (1944:269) stating that "During the hibernating period, it buries itself in the soil or among the rotting leaves of marsh plants, and in such places as many as a hundred individuals have been found closely packed together."

Triodopsis multilineata algonquinensis (Nason)

Pl. 5, figs. 1, 2, 3; text fig. 36

Polygyra multilineata algonquinensis Nason, 1906, Nautilus, 19:141, type locality Algonquin, McHenry County, Illinois. Lectotype A. N. S. P. # 91193.

Triodopsis multilineata form *algonquinensis*, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 1, pt. 2:849, fig. 493 d.

Triodopsis multilineata algonquinensis, Franzen, 1944, Trans. Kansas Acad. Sci., 47:264, 271, pl. 1, fig. 7.

Range: Illinois, Wisconsin, Nebraska (fossil?) and Kansas.

In Kansas this snail is known only from Atchison County.

Description: Shell about ¾ inch in diameter; depressed (h d index between .67 and .72); pale straw to red, usually with color bands; whorls 5-6; sutures impressed; surface with fine, oblique striae; imperforate, some specimens showing an incompletely covered umbilicus; aperture lunate, lip white, reflected.

Measurements of Figured Specimen (Pl. 5)

Height, 12.5 mm.; greater diameter, 18.0 mm.; number of whorls, 4½

Recognition Characters: This snail differs from *T. m. multilineata* in smaller size and more depressed shape. The mahogany-red color bands distinguish this species from other polygyrids of similar size.

Habitat and Habits: In general, similar to those of the typical subspecies. In Kansas *T. m. algonquinensis* has been found only in marshes in northwestern Atchison County, where local populations are abundant. Shells in these populations vary from light

straw color, with only faintly perceptible color bands, to those in which the reddish color bands have widened to produce an almost solid mahogany-red color over the entire shell. The animals are gregarious, and often occur in groups of 20 or more within a radius of a few inches.

Triodopsis divesta (Gould)

Pl. 5, figs. 10, 11, 12; text fig. 37

Helix abjecta Gould, 1848, Proc. Boston Soc. Nat. Hist., 3:40. Not *Helix abjecta* Lowe, 1831.

Helix divesta Gould, 1851, Terr. Moll. 2:358. Substitute name for *Helix abjecta* Gould.

Triodopsis divesta (Gould), Pilsbry, 1940, Land Mollusca of North America, vol. 1, pt. 2, p. 851, fig. 494.

Range: Missouri, Arkansas, northern Louisiana, northeastern Oklahoma, and extreme southeastern Kansas. Records in Kansas are limited to those in three counties within and at the northwestern limits of the Ozarkian faunal province in the State.

Description: Shell about ¾ inches in diameter, pale straw color; imperforate; surface with fine, strong, transverse striae; aperture lunate, peristome whitish, reflected; whorls 4½ to 5; parietal callus thin, without denticle.

Measurements of Figured Specimen (Pl. 5)

Height, 9.5 mm.; greater diameter, 18.0 mm.; number of whorls, 5

Shells of *Triodopsis divesta* resemble in size and general characters those of *T. multilineata algonquinensis*, except that color bands are never present.

Habitat and Habits: This species inhabits deciduous forests, where it lives under stones, trunks of fallen trees, under the started bark of dead trees, and in forest litter. In Kansas, it seems almost solitary in habit; generally, no more than two individuals will be found closely associated.

Genus *Allogona* Pilsbry

Allogona profunda (Say)

Pl. 5, figs. 19, 20, 21; text fig. 39.

Helix profunda Say, 1821, Jour. Acad. Nat. Sci., Philadelphia, 2:160, specimens obtained from near Cincinnati and at Engineer Cantonment on the Missouri River, type locality not designated. Neotype A. N. S. P. 11165, probably from Council Bluffs, Iowa.

Mesodon profunda, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:201.

Polygyra profunda, Hanna, 1909, Nautilus, 23:82.

Allogona profunda, Pilsbry, 1940, Land Mollusca of North America (north of Mexico), pt. 1, 2:877, figs. 507 a, b.

Range: Eastern United States from New York and North Carolina westward to Minnesota and eastern Kansas, and a disjunct area in Louisiana and Mississippi.

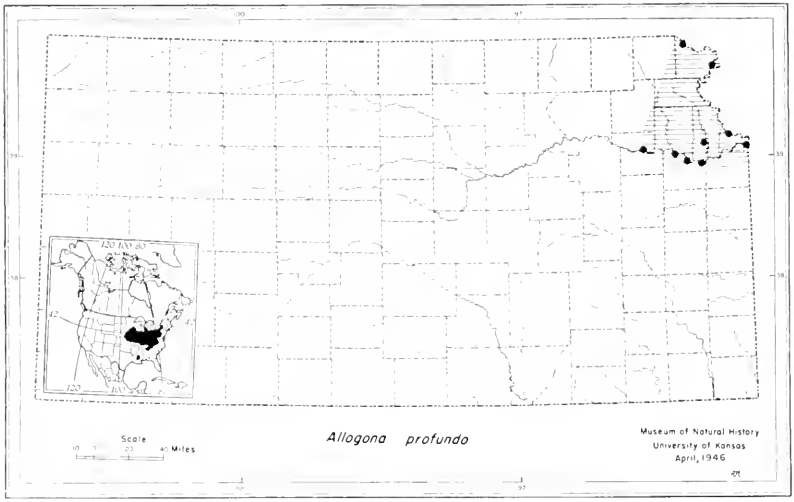


FIG. 39. Distribution of *Allogona profunda* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: The shell of this snail is approximately one inch in diameter, solid, depressed (height diameter index about .50), helicoid, and honey-yellow. One or more brownish color bands are present on only a few shells in Kansas. The surface is ornamented with numerous oblique riblike growth lines. The sutures are deeply impressed. The greater diameter of 30 adult shells from several localities in Kansas ranges from 21.6 mm. to 28.1 mm. Adults have a white, broadly reflected peristome.

In addition to size and shape, the relatively wide umbilicus (its diameter equal to about $\frac{1}{5}$ the greater diameter of the shell) and the thickening usually present on the basal portion of the peristome near the umbilicus (Pl. 5, fig. 21) serve to distinguish this from all other large helicoid shells of the region.

The animal is long and narrow, light brown, the head and eye-peduncles being darker.

Habitat and Habits: Allogona profunda is a woodland snail. It reaches its western limits in Kansas along the wooded valley sides adjacent to the Kansas (Kaw) River. Baker (1902:151) reported that in Illinois it was especially abundant "about old camp fires where there is some charred wood." According to Call (1900:395) this species ". . . has the habit of climbing far up on the sides of trees in the low lands, fastening itself by the epiphragm. I have taken specimens as high as 10 feet above the ground."

Baker (*loc. cit.*) noted it to be "bold in captivity, allowing its captor to pick it up without retracting into its shell." This trait

would make it of particular value as classroom demonstration material.

Some authors recognize the unbanded individuals as representing a different subspecies. Since both the banded and unbanded individuals occur in the same populations, this practice does not seem warranted.

Family BULIMULIDAE Pilsbry

The family Bulimulidae is a South American family. A few of its numerous genera have spread northward into Mexico and the southern United States. The genus *Bulimulus* is the only truly southern influence in the gastropod fauna of Kansas.

The shells in the various members of the family are conic to globose-conic, generally white, but in most genera there is some coloration superimposed upon this background. Color markings may take the form of vaguely outlined splotches, spiral bands or transverse stripes of various widths. In some genera, notably in *Liguus*, the color patterns are conspicuous, and range through brilliant hues of blue, yellow, red and black. The aperture of the shell is lunate to subcircular; the peristome is simple and unreflected. There is often a columellar callus, not well enough defined to be called a denticle, and many shells have a thickening within the aperture, parallel to the edge of the lip. Shells of the genus *Bulimulus* are relatively heavy, and vary in length from ¾ to 1½ inches.

Genus *Bulimulus* Leach

Bulimulus dealbatus dealbatus (Say)

Pl. 6, fig. 7; text fig. 40

Helix dealbata Say, 1821, Jour. Acad. Nat. Sci., Philadelphia, 2:159, type locality not designated (Say mentioned Missouri and Alabama). Neotype, from Alabama (?), in the A. N. S. P.

Bulimus dealbatus, Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:56.

Bulimulus dealbatus, Hanna, 1909, Nautilus 23:94; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31(6):119; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34(16):1040, plate C, fig. 10.

Bulimulus dealbatus, Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:7, figs. 4 a-d.

Range: South-central United States, from Texas and Alabama northward to Kansas and Illinois.

In Kansas this snail is for the most part limited to the eastern third of the state, but isolated colonies are known in Osborne and in Russell counties.

Description: No other terrestrial snail of comparable size in Kansas has a shell shaped like that of *Bulimulus dealbatus*. The term bulimuliform is applied, however, to similar globose-conic shells regardless of size. Shells of

B. d. dealbatus in Kansas average about 20 mm. (¾ inches) in height. They are smooth, usually white or occasionally light brown, mottled with ashy streaks, and somewhat translucent. The whorls number about 6 with the sutures deeply indented. The ovate aperture occupies about one-half or more of the height of the shell. No denticulations are present. The inner lip of the parietal wall is flattened and expanded, projecting over the small but distinct umbilicus. The white columellar wall is somewhat dilated, but not reflected.

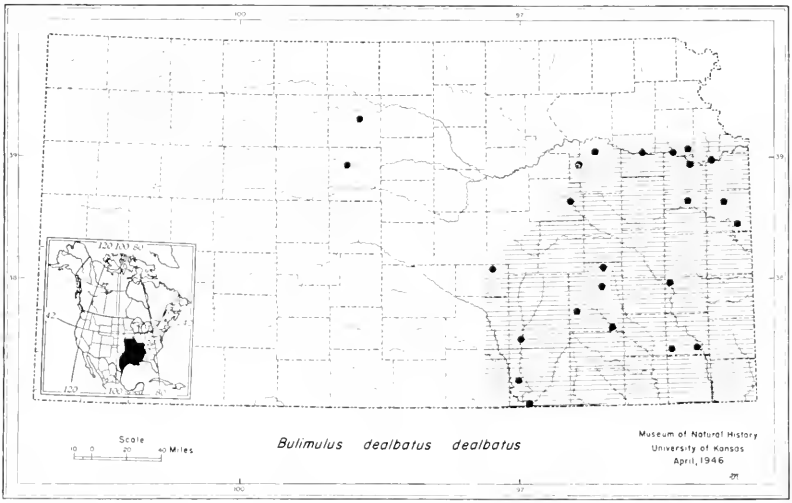


FIG. 40. Distribution of *Bulimulus dealbatus dealbatus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Measurements of Figured Specimen (Pl. 6)

Length, 22.5 mm.; diameter, 13.7 mm.; number of whorls, 7

Habitat and Habits: B. d. dealbatus is more characteristic of arid, open country than most other snails of the state, but is not entirely limited to such situations. We have collected the species from forested areas, but have found it to be more common on the summit areas of bluffs along rivers and streams. *B. d. dealbatus* is colonial, but in our experience not so numerous at any given place as is *Anguispira a. alternata*. *Bulimulus d. dealbatus* has a greater proclivity for climbing shrubs and trees than any of the other local snails. Leonard and Goble (1952:1041) report finding both adults and juveniles aestivating on the previous year's crop of weeds. Only two individuals were found on green vegetation; the subspecies seems to prefer dead material as aestivation sites. This snail is also known to hibernate by burrowing in the soil.

Family HAPLOTREMATIDAE Baker

Snails of this family are notable for their abberrant internal morphology, and because of their rapacious habits, unusual among pulmonates. Shells are heliciform, usually light-colored, and have convex whorls and a round, simple peristome. The family is widely distributed over the United States, but speciation is most pronounced along the west coast, where numerous kinds are distributed from California to Alaska. The family is represented in Kansas by a single species, which is notably unlike any other snail of comparable size in the state.

Genus *Haplotrema* Ancey

Haplotrema concavum (Say)

Pl. 6, figs. 4, 5, 6; text fig. 41

Helix concava Say, 1821, Jour. Acad. Nat. Sci., Philadelphia, 2:159, type locality unknown.

Macrocyclis concava, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:205 (cites specimens from Kansas City, Missouri).

Haplotrema concavum, Franzen, 1944, Trans. Kansas Acad. Sci., 47:266, pl. 1, figs. 2, 5; Pilsbry, 1946, Land Mollusca North America (north of Mexico), 2, pt. 1:208, fig. 100.

Range: Eastern North America, from northern Florida to slightly beyond the 45th parallel, west to Iowa and Kansas, south to Alabama.

This snail reaches its western limits in the eastern tier of counties in Kansas.

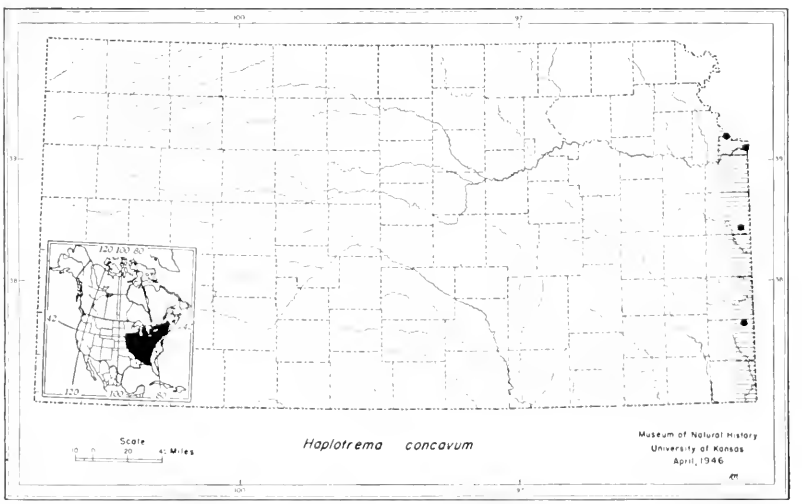


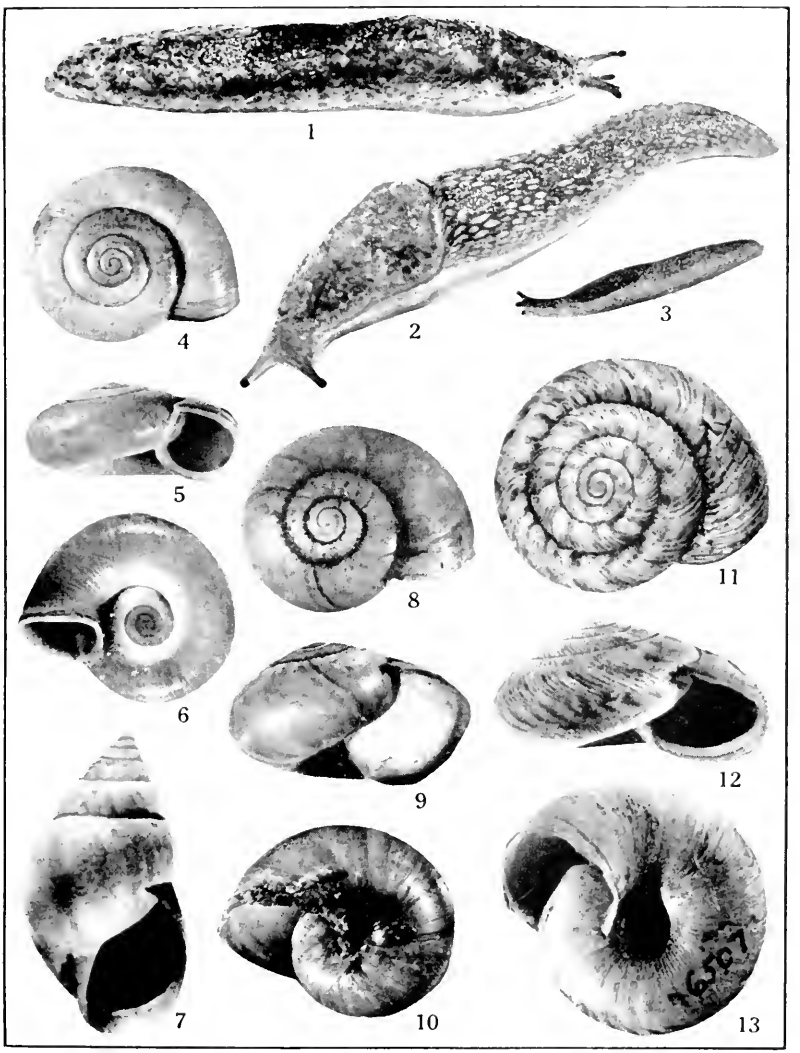
FIG. 41. Distribution of *Haplotrema concavum* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

PLATE 6

Slugs and other Gastropods in Kansas

1. *Philomycus coralinianus* (Bosc), Whiteford Ranch, 3 mi. E Fontana, Miami County, Kansas. Collected by A. B. Leonard, 6 May 1956. Catalogue number 10613. Figure approximately natural size.
2. *Limax maximus* Linneaus, from basement of home near intersection of 6th and Ohio Streets, in Lawrence, Douglas County, Kansas. Collected by A. B. Leonard, 7 July 1950. Catalogue number 10614. Figure approximately natural size.
3. *Deroceras laeve* (Muller), University of Kansas campus, at base of dam of Potter's Pond, Lawrence, Douglas County, Kansas. Collected by A. B. Leonard, 6 May 1958. Catalogue number 10600. Figure enlarged approximately 1½ times.
4, 5, 6. *Haplotrema concavum* (Say), Miami County Park, 2½ mi. E Fontana, Miami County, Kansas. Collected by A. B. Leonard, 8 April 1943. Catalogue number 1327. Figures enlarged approximately 3 times.
7. *Bulimulus dealbatus dealbatus* (Say), 2 mi. S Lecompton, Douglas County, Kansas. Collected by A. B. Leonard, 6 May 1945. Catalogue number 3621. Figure enlarged approximately 2 times.
8, 9, 10. *Mesomphix cupreus ozarkensis* (Pilsbry and Ferriss), 5 mi. E Baxter Springs, Cherokee County, Kansas. Collected by A. B. Leonard, 9 April 1943. Catalogue number 1328. Figures enlarged approximately 2 times.
11, 12, 13. *Anguispira alternata alternata* (Say), 2½ mi. SE Ottawa, Franklin County, Kansas. Collected by E. J. Roscoe, September 1950. Catalogue number 6507. Figures enlarged approximately 2 times.

PLATE 6



Description: Shell 12 to 14 mm. (about one-half inch) in greater diameter, depressed (height diameter index about .50); spire slightly convex; yellowish to greenish-white; texture glossy; striate irregularly; whorls about 5, convex, rounded, sutures deeply impressed; last whorl may or may not descend in front; umbilicus broadly open, revealing all whorls to apex (Pl. 6, figs. 4, 5, 6); aperture rotund-lunate; outer and basal margins of peristome narrowly expanded.

Measurements of Figured Specimen (Pl. 6)

Height, 6.5 mm.; greater diameter, 13.5 mm.; number of whorls, 4½

The size, shape and broad umbilicus serve to distinguish this species from all other Kansas snails. In the Key to Families juvenal individuals may be mistaken for members of the family Zonitidae.

The body is narrow, blackish, and mottled with light yellow. The eyepeduncles are long and bluish. The foot is obtusely rounded behind, and blunt in front. The shell is carried well back on the dorsal surface of the body in locomotion.

Habitat and Habits: In Kansas, *Haplotrema concavum* is a forest snail, being found in leaf litter, logs, brush and under "started" bark. In other areas it has been noted on open hillsides (Call, 1900:371), around marshes, and in grass heaps in town gardens (Goodrich and van der Schalie, 1944:269). Baker (1902:174), states that it has been collected at Bowmanville, Illinois, under "started" bark four feet above the surface of the ground.

This snail is unique among Kansas gastropods in being carnivorous, although it has not been established that it is exclusively so. It is known to prey upon its own kind. It is not colonial, only a few specimens being found at any given locality.

Baker (1902:174) says of its locomotion that "the animal is very nervous in progression, constantly extending and retracting its eyepeduncles, the shell swaying from side to side with a wobbly motion."

A detailed account of the mating behavior of this snail is given by Webb (1943).

Family ZONITIDAE Pilsbry

The family Zonitidae comprises a large and rather heterogeneous group of terrestrial gastropods varying widely in size and form. The smallest species possess a shell less than one-twelfth of an inch in diameter, and the largest kinds have a shell as much as an inch in diameter. In form the shells vary among the several genera from discike to heliciform, and in others the shells are distinctly conic. In some genera the peristome bears denticles, but this is true of none of those represented in the Kansas fauna. Color of

the shells varies from light amber to a deep coppery brown; the surface is usually finely striate, giving the shells, at least when fresh, a silky texture.

KEY TO THE SPECIES OF ZONITIDAE IN KANSAS

1. Spire of shell elevated, distinctly conical 2
   Spire of shell not conical, depressed, flattened, dome-shaped, . 3
2. Diameter of shell greater than 10 mm.; whorls about 7; shell yellowish . . . . . *Ventridens ligera*, p. 120
   Diameter of shell less than 4 mm.; whorls about 7; shell amber . . . . . *Euconulus chersinus polygyratus*, p. 110
3. Diameter of shell greater than 12 mm.; shell glossy; olive chestnut to dark mahogany . . . . *Mesomphix cupreus ozarkensis*, p. 114
   Diameter of shell less than 8 mm. 4
4. Surface of shell having radial grooves 5
   Surface of shell lacking radial grooves 9
5. Diameter of shell 6 mm. or more; whorls 6 or more 7
   Diameter of shell less than 6 mm.; whorls less than 6 6
6. Umbilical perforation distinctly open; radial grooves obsolete on base of shell . . . . . *Retinella electrina*, p. 111
   Umbilical perforation minutely open, or closed by reflection of lip of aperture; radial grooves distinct on base of shell. *Retinella indentata indentata*, p. 113
7. Spire of shell slightly elevated; whorls convex; striae obsolete on base of shell; greatest diameter of shell below middle of last whorl . . . . . *Paravitrea significans*, p. 115
   Spire of shell plane to slightly dome-shaped; whorls plano-convex; striae not obsolete on base of shell; greatest diameter of shell not below middle of last whorl 8
8. Aperture semilunate, the diameter less than one-half the height . . . . . *Paravitrea capsella capsella*, p. 115
   Aperture not semilunate, the diameter more than one-half the height . . . . . *Paravitrea simpsoni*, p. 117
9. Diameter of shell 2.0 mm. or more 10
   Diameter of shell less than 2.0 mm. 11
10. Diameter of shell 2.0 to 2.5 mm.; shell whitish; whorls no more than 4 . . . . . *Hawaii minuscula*, p. 117
    Diameter of shell 5.0 mm. or slightly more; shell amber to mahogany; whorls 4 to 4½ . . . . . *Zonitoides arboreus*, p. 122
11. Diameter of shell more than 1.5 mm, but never greater than 2.0 mm.; whorls 3 to 3½; surface finely striate, having both radial and spiral striae . . . . . *Striatura meridionalis*, p. 123
    Diameter of shell never greater than 1.5 mm.; whorls 3; surface of shell radially costulate decussated by spiral striae. *Striatura milium*, p. 124

Genus *Euconulus* Reinhardt

Euconulus chersinus polygyratus (Pilsbry)

Pl. 8, figs. 15, 16, 17; text figs. 42, 43

Conulus chersinus polygyratus Pilsbry, 1889, Nautilus, 12:116.

Euconulus chersinus cf. *polygyratus*, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:412, Pl. xxxi, fig. 16; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:240, fig. 119e; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 134, pt. 2:1045, Pl. CI, fig. 17.

Range: Eastern North America from southern Canada (Ontario) and Maine westward to Wisconsin, south to Illinois, Missouri, and eastern Kansas.

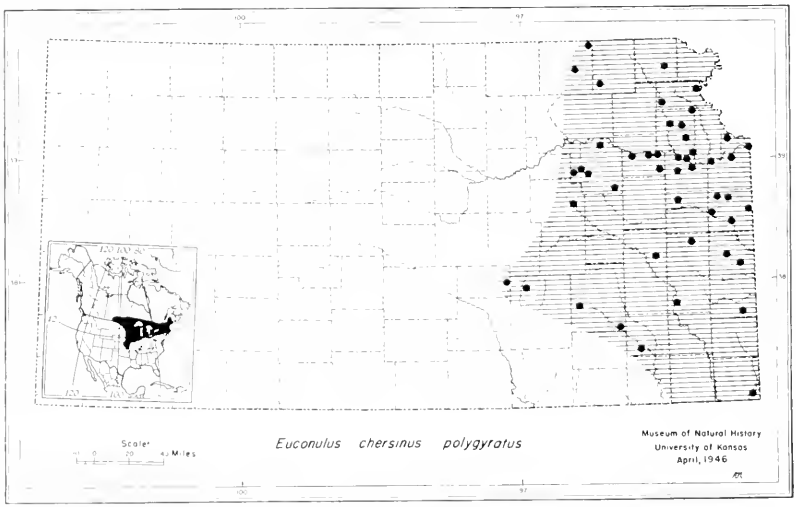


FIG. 42. Distribution of *Euconulus chersinus polygyratus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell about ⅛ inch in diameter (3 mm.); globose-conic, spire dome-shaped, strongly convex in outline; yellowish; whorls 6½-7½, rounded periphery high on body whorl; sutures impressed; umbilicus small or covered; aperture elliptical; lip thin, not reflected except near umbilicus.

Measurements of Figured Specimen (Pl. 8)

Height, 2.8 mm.; greater diameter, 3.2 mm.; number of whorls, 7

Recognition Characters: The minute, conic shell, the surface of which has a polished texture, serves to identify this species. In shape and size, the shell resembles that of *Strobilops labyrinthica*, but the latter has distinct and prominent riblets on the surface.

Habitat and Habits: This species is to be found in and about decaying wood, under sticks, logs, the loosened bark of fallen trees, beneath stones and in leaf litter on the forest floor. I have never found examples in open grasslands in Kansas. The species is said to require a rather moist habitat, which is confirmed by its distribution in the more humid eastern part of the state, but it survives long periods of drought.

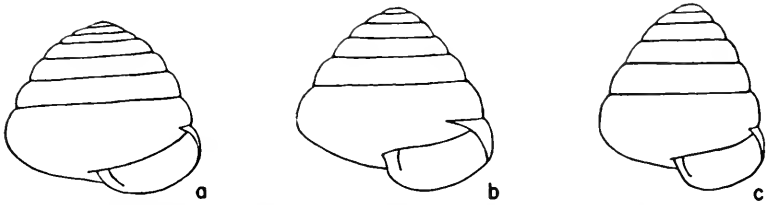


FIG. 43. *Euconulus chersinus polygyratus.* Three forms of shells found in populations in Kansas: a, representative of most individuals; b, representative of occasional individuals that in Oklahoma and Texas would be termed *E. c. trochulus*; c, representative of occasional examples that in southeastern United States would be termed *E. c. chersinus.* Occasional shells are intermediate between these figured examples.

Subspecies: Several subspecies of *Euconulus chersinus* have been described largely on the basis of differences in the shape of the shell. Records of specimens that resemble the subspecies *Euconulus chersinus chersinus* and *E. c. trochulus* are shown in figure 43. It seems doubtful that these variations in the shells are more than local in nature in Kansas; at least for the present these are not being recognized as valid members of the gastropod fauna of Kansas. Further study may throw a different light upon the problem.

Genus *Retinella* Fisher

Retinella electrina (Gould)

Pl. 8, figs. 12, 13, 14; text fig. 44

Helix electrina Gould, 1841, Invert. Mass., p. 183, fig. 111, type locality Fresh Pond, Cambridge, Massachusetts.

Retinella electrina, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:411, pl. xxxi, fig. 12; Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:256, fig. 126; Franzen and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1042, pl. CII, figs. 28, 29.

Range: North America, Europe, Asia. In North America from southeastern Canada south to Mexico in the Rocky Mountain states; Kansas, Missouri, Maryland in the east. There is a single record from Kodiak Island, Alaska.

In Kansas *Retinella electrina* is distributed generally over the eastern fourth of the State, but is more populous in the northeastern section.

Description: Shell about ¼ inch in diameter (4-5 mm.); heliciform, depressed, more than twice as broad as high; yellowish or greenish, transparent,

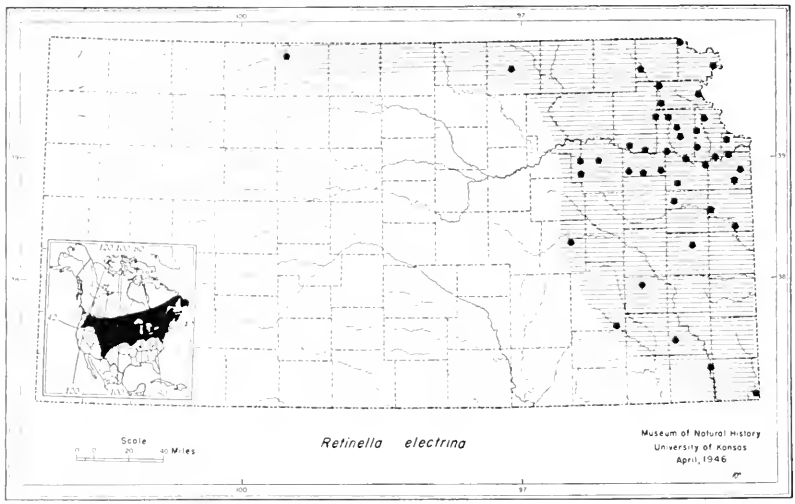


FIG. 44. Distribution of *Retinella electrina* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

glossy, sculpture of crowded, radial impressed lines; base smooth except for faint growth lines; whorls about 4, rounded, abruptly enlarging, last convex below; umbilicus wide, deep, about $\frac{1}{6}$ diameter of shell; sutures distinct but shallow; aperture rotund, lip not expanded.

Measurements of Figured Specimen (Pl. 8)

Height, 2.6 mm.; greater diameter, 5.1 mm.; number of whorls, 4½

Foot long, narrow transparent; collar, back and tentacles almost black, paler toward edges; sole dark gray; animal otherwise closely resembling *Zonitoides arboreus.*

Recognition Characters: Easily distinguished from *R. indentata* by open instead of closed umbilicus. Differs from *Z. arboreus* in having radial sculpture, more abrupt enlargement of last whorl, different shape in apertural view, glossy instead of dull texture, and smooth instead of pitted shell.

Habitat and Habits: This snail has been found in both upland wooded areas and along the margins of streams. It seems to require a fairly moist environment, not occurring out in open grasslands as does *Zonitoides arboreus* with which *electrina* is frequently elsewhere associated. It is to be looked for under sticks, logs, rocks and in crevices of started bark as well as in leaf litter. In southern Ontario, according to Oughton (1948:127), *R. electrina* is restricted to the margins of river and lakes, and to marshy or oozy ground, while farther north it inhabits a greater variety of terrain.

Pilsbry (1946:259) credits Clapp with observing, "In November

. . . *R. electrina* under sticks and bark frozen in a little globule of ice. The animal was lively when thawed out. At the same time, *Vitrina limpida* was most active."

Retinella electrina is often associated with *R. indentata,* but appears to be less common at any given locality than that species (Franzen and Leonard, 1943:41; Leonard and Goble, 1952:1043).

Retinella indentata indentata (Say)

Pl. 8, figs. 9, 10, 11; text fig. 45

Helix indentata Say, 1823, Jour. Acad. Nat. Sci. Philadelphia, 2:372, type locality "Harrigate and New Jersey."

Zonites indentatus, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:202.

Retinella indentata, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci. 45:338, pl. 1, fig. 15; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 9:411, pl. 31, fig. 14; Pilsbry, 1946, Land Mollusca of North America, vol. 2, pt. 1:288, fig. 146a; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:19; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1034, pl. CII, figs. 30, 31.

Range: North America from Canada (46° N Lat.) south to northern Alabama; from Maine west to Kansas.

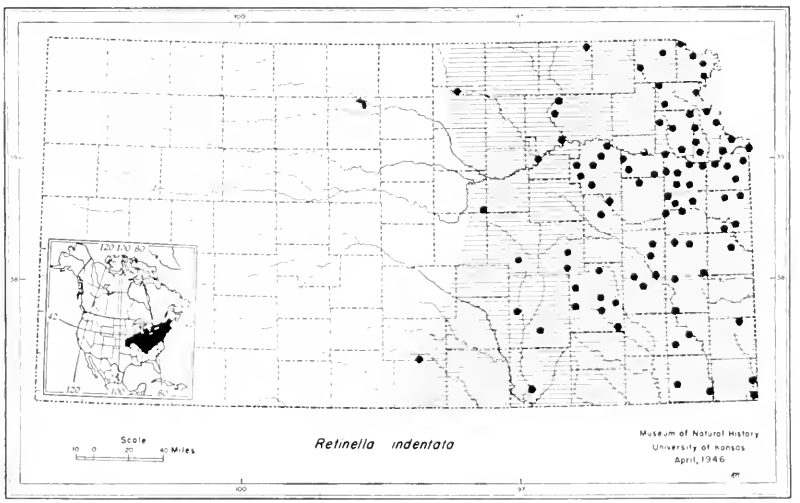


FIG. 45. Distribution of *Retinella indentata* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell about 1/5 inch in diameter (4.5-5.5 mm.); heliciform, depressed; yellowish, highly polished, translucent; sculpture of impressed radiating lines; whorls 4, rounded; sutures impressed; umbilicus minute, umbilical region indented; aperture lunate; lip thin, not reflected.

Measurements of Figured Specimen (Pl. 8)

Height, 2.9 mm.; greater diameter, 5.0 mm.; number of whorls, 4⅓

Recognition Characters: This species can be distinguished from *Retinella electrina* by the minuteness of the umbilicus.

Habitat and Habits: This species is found under and in rotting logs, leaves and other forest debris in both upland and floodplain situations. It is frequently found in association with *Retinella electrina* and *Zonitoides arboreus.* According to Baker (1902:183) the species moves rapidly, is bolder than *R. electrina* and is less common in the sense that fewer individuals are found together.

Genus *Mesomphix* Rafinesque

Mesomphix cupreus ozarkensis (Pilsbry and Ferriss)

Pl. 6, figs. 8, 9, 10; text fig. 46

Omphalina fuliginosa ozarkensis Pilsbry and Ferriss, 1907, Proc. Acad. Nat. Sci. Philadelphia, for 1906, p. 562, type locality Petit Jean Mountains, south of Magazine Mountains, Logan County, Arkansas. Type A. N. S. P. # 91348.

Mesomphix cupreus ozarkensis, Franzen, 1944, Trans. Kansas Acad. Sci., 47:264, 271, pl. 1, fig. 7; Pilsbry, 1946, Land Mollusca of North America, vol. 2, pt. 1:337, figs. 173 g, 175.

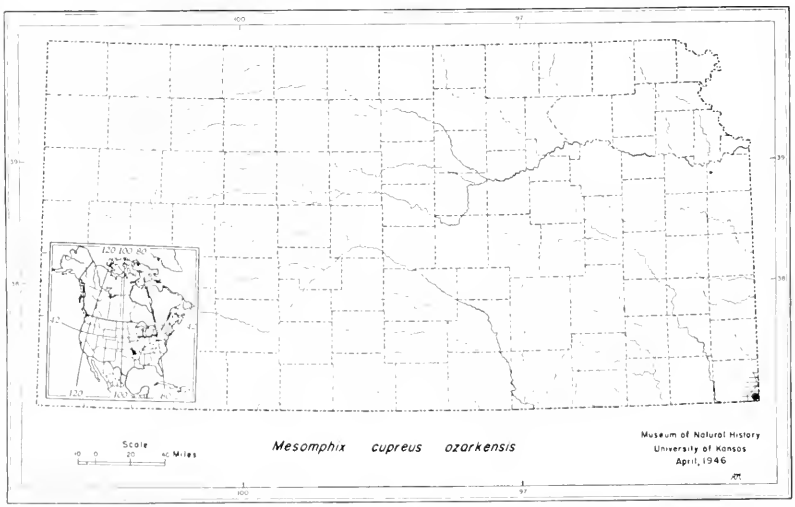


FIG. 46. Distribution of *Mesomphix cupreus ozarkensis* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Range: The Ozarkian faunal province in Arkansas and Kansas.

Description: Shell ¾ to 1 inch in diameter (16-25 mm.); discoidal, depressed, light, thin; whorls 4½, increasing rapidly in size; color olive green to olive

chestnut; body whorl marked with fine spiral striae; other whorls smooth; umbilicus narrow and deep, contained about 9 times in lesser diameter; aperture obliquely oval, lip not reflected, thin callus present; in living specimens darkly pigmented branches of vena cava distinctly visible through shell.

Measurements of Figured Specimen (Pl. 6)

Height, 9.1 mm.; greater diameter, 15.9 mm.; number of whorls, 4

Recognition Characters: No snail in Kansas with a shell of similar shape and equal size has the whorls increasing in size so rapidly.

Habitat and Habits: This snail lives on moist, well-shaded hillsides, usually buried in leaf-litter and humus up to the apex. On rainy days the snail may be observed actively crawling over the surface of the ground (Franzen, 1944:269).

Genus *Paravitrea* Pilsbry

Paravitrea capsella capsella (Gould)

Pl. 7, figs. 4, 5, 6; text fig. 47

Helix rotula Gould, 1848, Proc. Boston Soc. Nat. Hist., 3:38, non Lowe, 1853.
Helix capsella, Gould, 1851, In Binney, Terr. Moll., 2:239, pl. 29a, fig. 1.
Paravitrea capsella, Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:374, fig. 195a, b; Roscoe, 1952, Nautilus 65:144.

Range: Eastern United States, from Virginia and North Carolina west to Kansas, south to Alabama.

In Kansas, known only from Cherokee County.

Description: Shell slightly less than ¼ inch in diameter (5-6 mm.); discoidal, height about ½ of diameter; amber colored, translucent, shiny, whorls 6-7, closely spaced, somewhat flattened; surface with distinct, impressed radiating striae; suture margined; aperture narrow, semilunar; umbilicus small, deep, contained about 7 times in diameter of shell; lip thin, not reflected.

Measurements of Figured Specimen (Pl. 7)

Height, 2.3 mm.; greater diameter, 4.6 mm.; number of whorls, 6⅛

Recognition Characters: The shell of this species differs from that of *P. significans* in being lower spired and in having the periphery higher on the body whorl. *P. c. capsella* is about the same size as *P. sampsoni* but is higher spired, and the last whorl is not decidedly larger than the preceding whorls.

Habitat and Habits: This is a woodland snail found under dead leaves, loose bark and underneath fallen branches.

Paravitrea significans (Bland)

Pl. 7, figs. 1, 2, 3; text fig. 47

Helix significans Bland, 1866, Amer. Jour. Conch., 2:372, pl. 21, fig. 9, type locality Fort Gibson, Muskogee County, Oklahoma. Type A. N. S. P. # 11984.

Paravitrea significans, Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:380, fig. 190, No. 7, 8a; Roscoe, 1952, Nautilus 65:144.

Range: Oklahoma, Missouri, Kansas, Arkansas, Illinois and Tennessee. In Kansas known only from Allen and Cherokee counties.

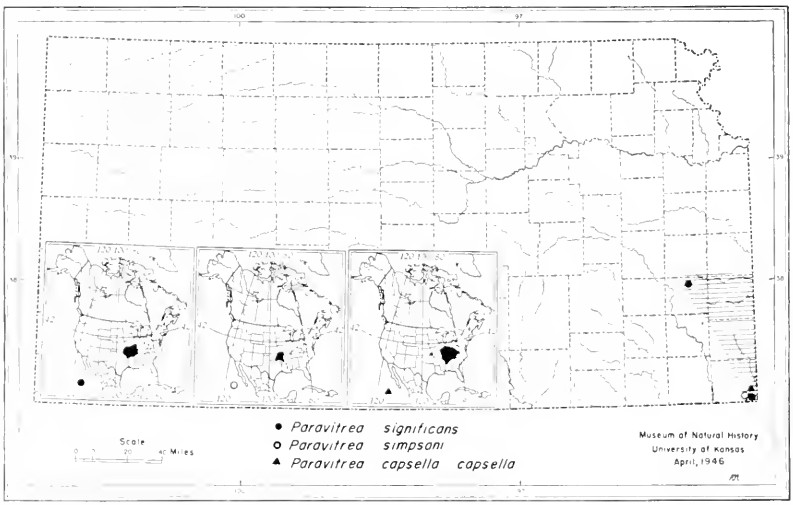


FIG. 47. Distribution of *Paravitrea significans*, *Paravitrea simpsoni* and *Paravitrea capsella capsella* in Kansas. Locality reports are shown by symbols. Inset maps show approximate distribution of these species in North America.

Description: Shell slightly less than ¼ inch in diameter (5 mm.); discoidal, depressed, thin; pale yellow to white, shining surface having fine, regular striae that are obsolete on base; whorls 6, periphery of body whorl placed well below middle of whorl; sutures impressed; umbilicus contained about 5 times in shell diameter, base of shell excavated around it; aperture oblique, depressed, lunate; lip thin, not reflected.

Measurements of Figured Specimen (Pl. 7)

Height, 3.2 mm.; greater diameter, 6.1 mm.; number of whorls, 6½

Recognition Characters: The peculiar shape of the shell, whereby the periphery is situated well below the middle of the body whorl, serves readily to distinguish *P. significans* from its relatives. The spire is more elevated than in either of the other two Paravitreas occuring in the State. Some juveniles are difficult to separate from *P. c. capsella*. But *P. significans* can be recognized by denticles that show through the base of the shell as white spots. Denticles are lacking in *P. c. capsella*.

Habitat and Habits: This is a woodland snail, the habitat of which resembles that of *P. c. capsella*.

Paravitrea simpsoni (Pilsbry)

Pl. 7, figs. 7, 8, 9; text fig. 47

Zonites simpsoni Pilsbry, 1889, Proc. Acad. Nat. Sci., Philadelphia, 41:412, pl. 12, figs. 8-10, type locality Limestone Gap, Atoka County, Oklahoma. Type A. N. S. P. # 61676.

Paravitrea simpsoni, Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:383, fig. 196; 6, 6b; Roscoe, 1952, Nautilus 65:144.

Range: Missouri, Arkansas, Oklahoma, Kansas.

In Kansas known only from Cherokee County.

Description: Shell slightly less than ¼ inch in diameter (4.5-5.5 mm.); depressed, spire low; thin; yellowish to whitish; surface shining; whorls 5-5½, rounded, tightly coiled, last increasing abruptly in size; sculpture of impressed lines, weak on base of shell; umbilicus contained about 4.5 times in shell diameter; aperture oblique, lunate.

Measurements of Figured Specimen (Pl. 7)

Height, 2.0 mm.; greater diameter, 4.4 mm.; number of whorls, 4¾

Recognition Characters: The shell of *Paravitrea simpsoni* is more depressed than that of either *P. significans* or *P. c. capsella*. The rapidly enlarging body whorl serves readily to distinguish *P. simpsoni* from *P. significans*, and the less depressed position of the aperture will distinguish *P. simpsoni* from *P. c. capsella*.

Habitat and Habits: Like the other species of *Paravitrea* in Kansas, *P. simpsoni* is a snail of forested terrain, living like most gastropods of the forest floor, under bark, sticks, leaves and even stones.

Genus *Hawaiia* Gude

Hawaiia minuscula minuscula (Binney)

Pl. 11, figs. 17, 18, 19; text fig. 48

Helix minuscula Binney, 1840, Boston Jour. Nat. Hist., 3:435, pl. 22, fig. 4, type locality Ohio.

Zonites minusculus, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:202.

Zonitoides minuscula, Hanna, 1909, Nautilus, 23:95.

Zonitoides minuscula alachuana, Hanna, 1909, Nautilus, 23:95.

Hawaiia minuscula, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:338, figs. 10, 11; Leonard, 1943, Trans. Kansas Acad. Sci., 46:238, pl. 1, figs. 5, 6; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:412, pl. 31, figs. 20, 21; Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:420, fig. 228, a, b; 229:1-3; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1042, pl. CI, figs. 20, 21.

Range: Hawaiia minuscula is widely distributed in North America from Alaska to the West Indies; it is also found in Japan, Hawaii, Pitcairn Island and Tahiti. In Kansas, it is found almost throughout the State, but is more numerous in the eastern portion.

PLATE 7

Shells of Zonitidae in Kansas

All figures enlarged approximately 7 times natural size.

1, 2, 3. *Paravitrea significans* (Bland), 7 mi. E of Baxter Springs, Cherokee County, Kansas. Collected by D. S. Franzen, 15 September 1943. Catalogue number 6535.

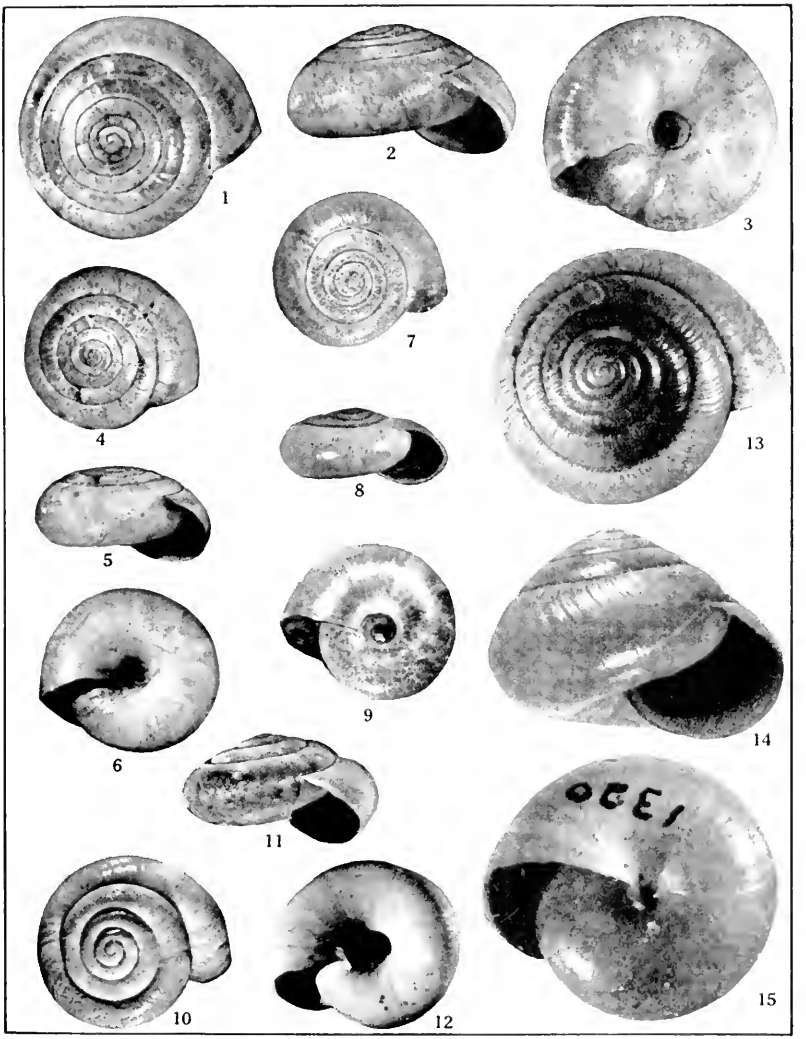
4, 5, 6. *Paravitrea capsella capsella* (Gould), 7 mi. E Baxter Springs, Cherokee County, Kansas. Collected by D. S. Franzen, 15 September 1943. Catalogue number 6771.

7, 8, 9. *Paravitrea simpsoni* (Pilsbry), 7 mi. E Baxter Springs, Cherokee County, Kansas. Collected by D. S. Franzen, 15 September 1943. Catalogue number 6763.

10, 11, 12. *Zonitoides arboreus* (Say), 2½ mi. W, ½ mi. N Perry, Jefferson Co., Kansas. Catalogue number 6770. Collected by Dee Saunders, 2 July 1950.

13, 14, 15. *Ventridens ligera* (Say), Pigeon Lake, 2½ mi. E Fontana, Miami County, Kansas. Collected by A. B. Leonard, 3 April 1943. Catalogue number 1320.

PLATE 7



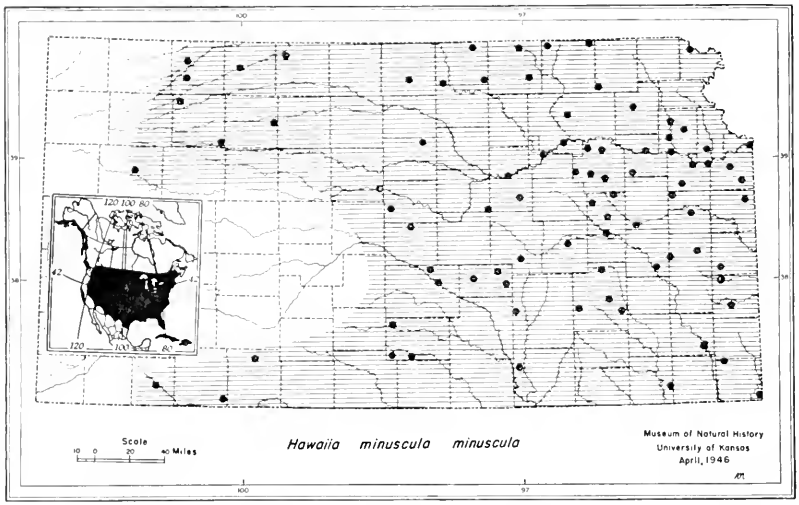


FIG. 48. Distribution of *Hawaiia minuscula minuscula* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell less than ¼ inch in diameter (2-2.5 mm.); heliciform, depressed, spire low; white or pale gray; thin, shining; sculpture of fine, irregular striae; whorls 4, convex, gradually increasing in size; sutures impressed; umbilicus about ⅓ of shell diameter, deep; aperture nearly circular, lip thin, not reflected.

Measurements of Figured Specimen (Pl. 11)

Height, 1.3 mm.; greater diameter, 3.1 mm.; number of whorls, 4½

Foot narrow; eye-peduncles relatively short, cylindrical, and bluish-white.

Recognition Characters: The only snail likely to be confused with this species is *Helicodiscus singleyanus*, which has a broader, shallower umbilicus and is smaller than *Hawaiia minuscula*.

Habitat and Habits: Hawaiia minuscula is found under logs, sticks, stones and in clumps of grass in both floodplain and upland situations. Baker (1902:190) states that "The animal is very timid in captivity, hesitating a long time before starting to crawl over the surface upon which it has been placed."

Genus *Ventridens* Binney

Ventridens ligera (Say)

Pl. 7, figs. 13, 14, 15; text fig. 49

Helix ligera Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:157, type locality Missouri.

Ventridens ligerus, Franzen, 1944, Trans. Kansas Acad. Sci., 47:277, Pl. 1, fig. 3.

Range: Eastern North America, from southern Canada to Michigan, south to Oklahoma (in the west), Florida (in the east).

Known only from Miami County in Kansas, in deep forest near the Marais des Cygnes River.

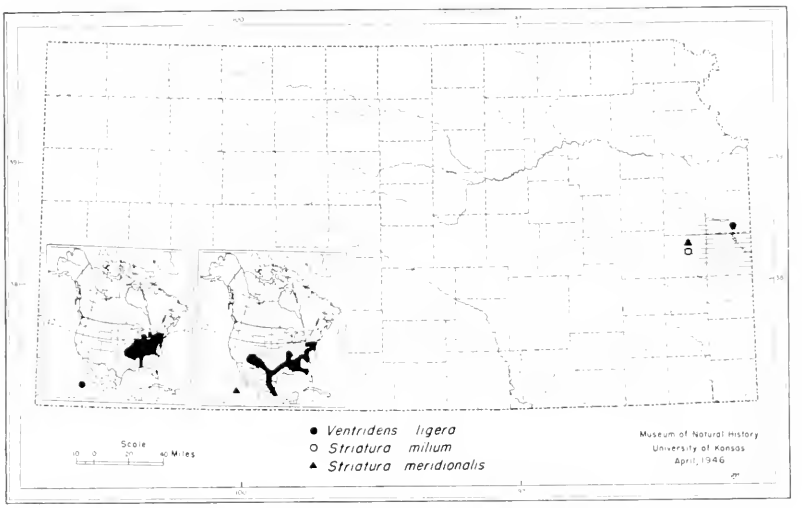


FIG. 49. Distribution of *Ventridens ligera, Striatura milium* and *Striatura meridionalis* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Description: Shell between ½ and ¾ inches in diameter (11-16 mm.); subglobose, spire elevated; pale yellow, deep yellow on base of last whorl, polished texture, surface irregularly but strongly striate, base smooth; whorls 6-7, rounded; umbilicus small, deep; sutures impressed; lip thin, not reflected; aperture rounded, semilunate, edentate.

Measurements of Figured Specimen (Pl. 7)

Height, 11.1 mm.; greater diameter, 13.0 mm.; number of whorls, 7⅓

The animal has a long and narrow foot, acutely pointed behind; back and tentacles slate black, paler posteriorly, collar pale gray peppered with white; eye-peduncles long, slender, tapering.

Recognition Characters: The only other snails in Kansas having a similarly shaped shell are the much smaller *Euconulus* and *Strobilops.*

Habitat and Habits: This snail is to be found in moist situations on uplands as well as on floodplains. Franzen (1944:272-273) describes the Pigeon Lake area, from which the Kansas specimens were taken, as ". . . one of the few virgin timber growths in Kansas. Here, in a grove, hickory trees reach a height of about 50 feet. The fallen timber, debris, and leaf mold in this moist and almost marshy area, afford good habitats for this species. Leonard

first found a colony of this species under a log with *Pitymys*. A number of the shells had been chewed by these mice. The collection made in the fall of the year also indicates a fair series of unworn shells." Mating behavior has been described by Webb (1948).

Genus *Zonitoides* Lehmann

Zonitoides arboreus (Say)

Pl. 7, figs. 10, 11, 12; text fig. 50

Helix arboreus Say, 1816, Nicholson's American Edit. Brit. Encyclopedia, vol. 2, article Conchology, species no. 2, pl. 4, fig. 4 (no pagination).

Zonites arboreus, Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:55; Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Zonitoides arboreus, Hanna 1909, Nautilus, 23:95; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:338, fig. 16; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:413, pl. 31, fig. 15; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Pilsbry, 1940, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:480, figs. 261, 262; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1004, pl. CII, figs. 26, 27.

Zonitoides nitida, Hanna, 1909, Nautilus, 23:95.

Range: Widely distributed over the North American continent from northern Canada to Mexico, and Central America. Introduced in Hawaii, Japan, South Africa, Australia and various localities on the Eurasian continent.

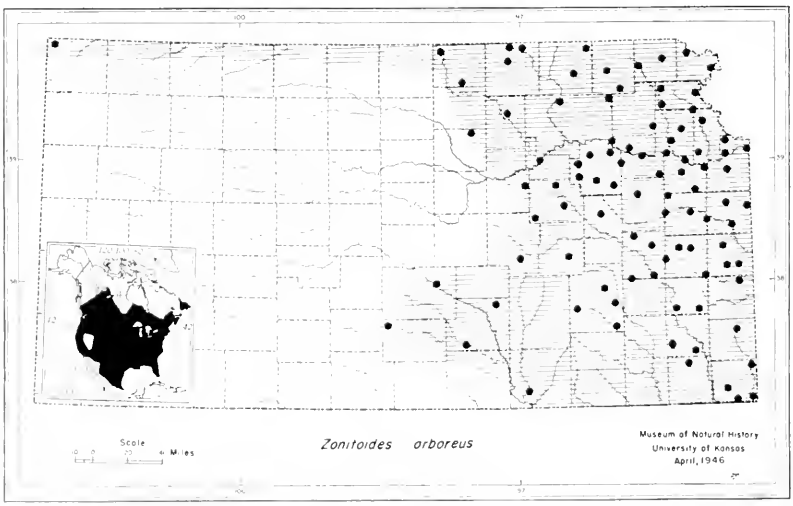


FIG. 50. Distribution of *Zonitoides arboreus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

This species is widely distributed in the eastern half of Kansas, but in western Kansas is known from a single locality in Cheyenne County.

Description: Shell between ⅛ and ¼ inches in diameter (4-6 mm.); helicoform, depressed, yellowish, translucent, glossy; weakly sculptured with irregular

growth lines, minute spiral striae visible under lens; whorls 4-5, rounded, regularly increasing in size; sutures impressed; umbilicus deep, contained about 4½ to 5 times in shell diameter; aperture lunate; wider than high; lip thin, not reflected.

Measurements of Figured Specimen (Pl. 7)

Height, 2.4 mm.; greater diameter, 5.0 mm.; number of whorls, 4¾

The foot of the animal is long and narrow; head and upper body black or bluish, posterior portion whitish, sometimes transparent; eye-peduncles long and slender, eyes black, bulbous; tentacles short.

Recognition Characters: Readily distinguished from the Retinellas which it superficially resembles and with which it is frequently found associated by the lack of radially impressed lines.

Habitat and Habits: The habitat is notably varied. The snail is found in wooded areas, on bluffs along streams, in grassland and under stones and boards. It is found most abundantly in and around loose bark of fallen trees. Leonard and Goble (1952:1044) have attributed its scarcity in certain localities to absence of decaying logs. The animal is gregarious, several individuals usually being found in one spot. It is one of the most common snails in North America.

The shell appears quite dark in the living animal due to its translucency. Baker (1902:189) states that "When in progression the shell is carried on the back at an angle of 45 degrees, tipping to the left side of the body, and the head and neck are stretched far in advance of the aperture of the shell. The eye-peduncles are always nervously thrust about as though searching for danger, and the least noise or jar will cause them to be drawn into the body." Pilsbry (1946:482) remarks that "Its movements are rather quick. The eye tentacles are usually carried widely diverging."

This snail is of some economic importance in Louisiana, where it attacks the roots of cane, permitting attack by deleterious microorganisms. (Naut. 39:70.)

A concise account of the anatomy may be found in the paper by Bartsch and Quick (1926).

Genus *Striatura* Morse

Striatura meridionalis (Pilsbry and Ferriss)

Pl. 11, figs. 7, 8, 9; text fig. 49

Vitrea milium meridionalis Pilsbry and Ferriss, 1906, Proc. Acad. Nat. Sci. Philadelphia, p. 152, type locality along Guadalupe River above New Braunfels, Texas. Type A. N. S. P. 90724.

?*Vitrea milium*, Hanna, 1909, Nautilus, 23:95.

Striatura meridionalis, Pilsbry, 1946, Land Mollusca of North America (north of Mexico), vol. 2, pt. 1:493, fig. 270.

Range. Eastern North America from Pennsylvania to Kansas, southward to Florida and Mexico; Bermuda.

Known definitely from Kansas only from one locality in Anderson County. The Hanna record, if a *Striatura*, would probably be this species.

Description: Shell slightly less than $^1/_{16}$ inch in diameter (about 1.75 mm.); helicoform, depressed; yellowish to grayish; sculpture of small, vertical riblets crossed by minute impressed lines giving a reticulated appearance; first embryonic whorl distinctly striate spirally; whorls 3½, rounded; sutures impressed; umbilicus contained about 3 times in shell diameter; aperture sub-circular, lip thin, not reflected.

Measurements of Figured Specimen (Pl. 11)

Height, 0.9 mm.; greater diameter, 1.7 mm.; number of whorls, 3½

Recognition Characters: The shell of this snail may be distinguished from those of similar shape and equal size by the characteristic reticulate pattern of the surface sculpture.

Habitats and Habits: This species lives in the leaf-litter and other debris of the forest floor. Its small size and pallor cause it to be easily overlooked in the field. It is most readily collected by sifting leaf litter and searching the siftings with the aid of a low-power microscope.

Striatura milium (Morse)

Pl. 11, figs. 4, 5, 6; text figures 49

Helix milium Morse, 1859, Proc. Boston Acad. Soc. Nat. Hist., 7:28.

Striatura milium Morse, 1864, Jour. Portland Soc. Nat. Hist., 1:18, pl. 7, fig. 43, text figs. 41, 42.

Zonites milium Binney, 1878, Terrestrial Mollusca, 5:119, figs. 34, 35.

Striatura milium (Morse), Pilsbry, Land Mollusca of North America, vol. 2, pt. 1:495, fig. 272.

Range: From well north in Canada, through Maine to New York on east coast, west to Michigan and Kansas, with records in West Virginia, Ohio, Indiana, Illinois and Kentucky.

In Kansas, *Striatura milium* has been found living at a single locality in Anderson County, together with *S. meridionalis*. *S. milium* is, however, known as a fossil in middle Pleistocene deposits in the State.

Description: Shell minute, scarcely $^1/_{10}$ inch in diameter (1.5-1.7 mm.), helicoid, spire depressed, translucent, gray; whorls three, suture distinct to deeply channeled near apex; umbilicus small, abrupt, exhibiting all volutions; aperture ovate, peristome simple; surface sculpture of exquisitely fine riblets, crossed by finer spiral lines.

Measurements of Figured Specimen (Pl. 11)

Height, 0.8 mm.; greater diameter, 1.6 mm.; number of whorls, 3¾

The animal is white, with dark splotches on the head and tentacles.

Habitat and Habits: Little is known of the general habitat in Kansas, except that at the single locality at which the living species

has been collected, the animals were found by sifting leaf litter taken from the ground in a woodland.

KEY TO THE SPECIES OF SLUGS IN KANSAS

1. Mantle covering entire dorsal portion of body; animal, when extended, three or more inches in length; color grayish to yellowish, mantle bearing irregular black splotches. *Philomycus carolinianus*, p. 138
   Mantle, covering no more than one-third of body, situated anteriorly 2
2. Animal, when extended, four or more inches in length; color amber to yellowish, dorsal portion of mantle and body bearing elongate black splotches *Limax maximus*, p. 125
   Animal, when extended, no more than one inch in length; color uniformly gray to black . . . . . *Deroceras laeve*, p. 126

Family LIMACIDAE Gray

The family Limacidae comprises gastropods in which the shell has been reduced to a flat plate, which in most genera is completely covered and therefore not visible externally. They are commonly called "slugs," a term derived from Middle English *slugge*, denoting sluggishness, a name which these animals have earned because of their slowness of locomotion. The foot is elongate, giving the animal a somewhat wormlike appearance. Members of the family Limacidae differ from those of the family Philomycidae (also represented in Kansas) in that the mantle covers only a part of the anterior portion of the body, whereas in the latter family, the mantle covers the entire length of the body. There are many other differences between the two families, which are not closely related.

Limacids, like many other slugs, have been so widely distributed by commerce that it is difficult to discover the original ranges of some species. It is clear, however, that *Limax maximus*, often found in Kansas especially near human habitations, in basements of houses, in greenhouses, and in gardens, is a European species that has been introduced artificially by commerce, while *Deroceras laeve* is a natural component of the North American gastropod fauna.

Most genera of the Limacidae are native to Europe and the adjacent parts of Asia and Africa.

Genus *Limax* Linnaeus

Limax maximus Linnaeus

Pl. 6, fig. 2

Limax maximus Linnaeus, 1758, Systema Naturae (10th Ed.) 1:652.

Limax maximus Linnaeus, Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:524, figures 282, 283.

Range: Limax maximus is distributed in Europe, Asia Minor, and northern Africa. It has been introduced in North and South America, South Africa, Australia, Hawaii, and many other places.

Description: A large slug, often extended to four inches when crawling; yellowish-gray, usually spotted with black; black spots on shield (mantle) often fused into irregular splotches; black markings behind shield usually in form of elongate spots, more or less arranged in series of three bands, but color markings highly variable; sole of foot pale yellowish; internal shell oblong, thin, almost flat, having faint concentric growth lines; shell, 9-12 millimeters long.

Recognition Characters: Limax maximus is recognizable by its large size, which differentiates it from *Deroceras;* the latter never is longer than about one inch. The skin of *Deroceras* is also much darker, varying from dull gray to glossy black, and unlike the yellowish, splotched skin of *L. maximus.*

Habitat and Habits: Limax maximus is a slug of gardens, basements, greenhouses, and other buildings and their environs in cities and surburban areas. It seeks dark, moist places in which to hide during the day, and from which it forages at night. When in motion, the foot lays down a track of mucous, which may often be seen the following day as meandering, glistening trails on sidewalks or other smooth surfaces over which the slug has traveled. Locally, *L. maximus* becomes a pest in greenhouses and in vegetable gardens, but serious damage of this kind in Kansas in unknown to me.

Genus *Deroceras* Rafinesque

Deroceras laeve (Müller)

Pl. 6, fig. 3; text fig. 51

Limax laevis Müller, 1774, Verm. Terr. et Fluv. Hist., 2:2 (Denmark).

Limax gracilis Rafinesque, 1820, Ann. of Nat., 1:10.

Deroceras laeve (Müller), Baker, 1930, Occasional Paper Mus. Zool. Univ. Michigan, no. 220:41, pl. 11, figs. 1, 6, 7.

Deroceras gracile Rafinesque ?, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., vol. 29, p. 425, pl. 32, fig. 25.

Deroceras laeve (Müller), Pilsbry, 1948, Land Mollusca North America, vol. 2, pt. 2:539, figs. 289, 290a, 291, 292e, 292d.

Deroceras laeve (Müller), Leonard and Goble, 1952, Univ. Kansas Sci. Bull., vol. 34; 1041, pl. C, fig. 7.

Range: Widely distributed in North America from the Arctic to Florida and Central America. According to Pilsbry (1948:540) the southern limit of distribution has not been determined. *Deroceras laeve* is also generally distributed in Europe.

In Kansas, the species probably occurs all over the State where local habitat situations are suitable.

Description: A small slug, about one inch (25 mm.) in length when fully extended; pale yellowish gray to dark gray or even bluish black; mantle occupying about one-third length of animal, situated near anterior end of body, usually darker than remainder of animal; foot paler than dorsal surface;

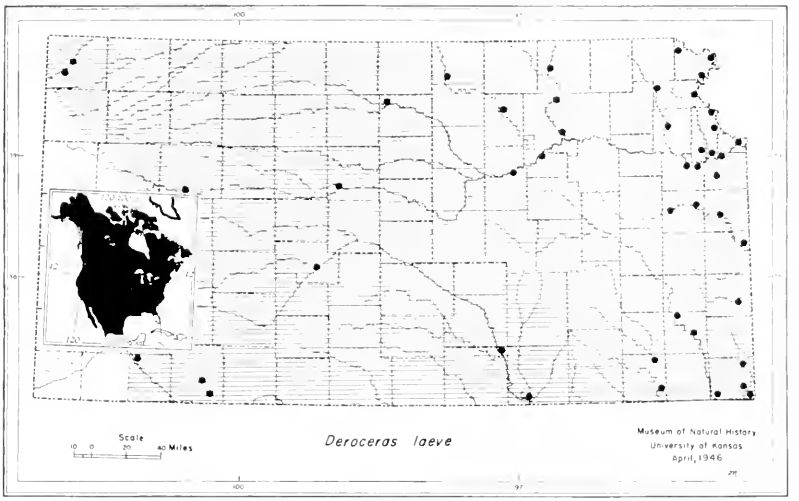


FIG. 51. Distribution of *Deroceras laeve* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

shell internal, ovoid, thin, flat, having concentric growth lines from nucleus situated anteriorly.

Recognition Characters: Deroceras laeve is readily distinguished among slugs known to occur in Kansas by its small size, and almost uniform gray coloration. In size and general form it resembles *Deroceras reticulatum*, which may occur in the State, although no authentic records are known. The latter species is generally lighter in color, varying from a ground color of white, cream or flesh, on which is superimposed elongate, dark, splotches of pigment.

Habitat and Habits: Deroceras laeve lives beneath sticks, stones, bark and leaves in woodlands, and beneath boards, logs, and even sidewalks in urban communities. It seems not to invade basements of houses, as does *Limax maximus*, although *D. laeve* sometimes becomes numerous in greenhouses. It requires a rather moist habitat, and has been observed crawling about submerged for periods of an hour or more. *Deroceras laeve* is highly vagile at night; the glistening trails of dried mucous often can be observed on sidewalks and other relatively smooth surfaces.

Family ENDODONTIDAE Pilsbry

The shells of the numerous members of the family Endodontidae are typically depressed helicoid to discoid, in many species carinate at the periphery, and nearly always openly umbilicate. An opaque periostracum is present in the majority of kinds; this is in many

examples banded or marked with flammulate splotches of color. Unlike the shells of snails in the family Zonitidae, the surface is not glossy, but may be sculptured by parallel or radial striae. Size of shells varies greatly; among the endodontids in Kansas, the diameter of the shell varies from nearly an inch (23 mm.) in *Anguispira* to scarcely more than a millimeter in *Punctum*. The aperture varies from subcircular to compressed lunate. Although the peristome is invariably thin and simple, the aperture of some individuals bears denticles within.

Members of family are distributed widely over the earth, especially among the islands of the great oceans; a large proportion of the genera and species are found on islands.

KEY TO SPECIES OF ENDODONTIDAE IN KANSAS

1. Shell large, adult individuals more than 15 millimeters in diameter; color pattern of reddish-brown transverse stripes and splotches ..... *Anguispira alternata alternata*, p. 128
   Shell small, less than 6 millimeters in diameter; no color pattern 2
2. Shell minute, diameter less than 2.5 millimeters; spiral sculpture weak 3
   Shell large, more than 2.5 millimeters in diameter; surface sculpture of strong spiral threads 4
3. Surface sculpture of strong radial striae; diameter not greater than 1.5 millimeters ..... *Punctum minutissimum*, p. 136
   Surface sculpture weak to absent; diameter 2.0-2.5 millimeters. ..... *Helicodiscus singleyanus singleyanus*, p. 133
4. Spiral threads weak or absent on first whorl; denticles never visible in aperture ..... *Helicodiscus parallelus*, p. 131
   Spiral threads strong on first whorl; denticles often visible in aperture ..... *Helicodiscus eigenmanni*, p. 132

Genus *Anguispira* Morse

Anguispira alternata alternata (Say)

Pl. 6, figs. 11, 12, 13; text fig. 52

Helix alternata Say, 1816, Nicholson's Encyclopedia, article Conchology, species no. 4, pl. 1, fig. 2; type locality "Middle States." Neotype A. N. S. P. No. 12234, from Philadelphia, Pa.

Patula alternata, Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:55; Call, 1886, *op. cit.*, 1:206.

Pyramidula alternata, Hanna, 1909, Nautilus 23:95.

Anguispira alternata, MacMillan, 1940, Annal Carnegie Mus., 27:380, pl. 38, figs. 1, 2; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29 (9): 414, pl. 32, fig. 27; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 30 (6):119.

Anguispira alternata, Pilsbry, 1948, Land Mollusca of North Amer., 2, pt. 2:568, fig. 305.

Range: Eastern Canada and the United States, from Nova Scotia to Lake

of the Woods; westward in the United States to about the 97th meridian, south to middle Louisiana and Mississippi; generally absent in the Atlantic and Gulf Coastal Plains.

This, the most common of the larger snails in Kansas, is distributed generally over the eastern third of the state.

Description: Anguispira a. alternata may readily be distinguished from all other snails in Kansas by the color of the shell. This distinctive coloration consists of reddish-brown blotches or "flames" on a pale yellow or light brown ground. The colors of the shell may be somewhat darker in living individuals in comparison with empty shells owing to the thinness of the shell, which allows the body of the animal to show through.

Populations vary considerably in such shell characters as size, shape and angulation of whorls, coloration, and degree of development of ribbing. Baker (1904) published the results of a study of the variation in the height diameter index, but a detailed study of the nature and extent of variation in many other features of the shell and internal anatomy is needed. Until such a study is completed the species may be described only in more or less general terms.

The shell is large (averaging about ¾ inches in diameter), thin, and somewhat depressed (height diameter index ranging from .50 to .65). The whorls number about 5½, and the sutures are well impressed. The surface of the shell is usually prominently sculptured by irregular growth lines. The lip of the aperture in some individuals is not reflected except slightly near the umbilicus. It is contained about 4½ times in the greater diameter.

Measurements of Figured Specimen (Pl. 6)

Height, 11.5 mm.; greater diameter, 20.0 mm.; number of whorls, 5

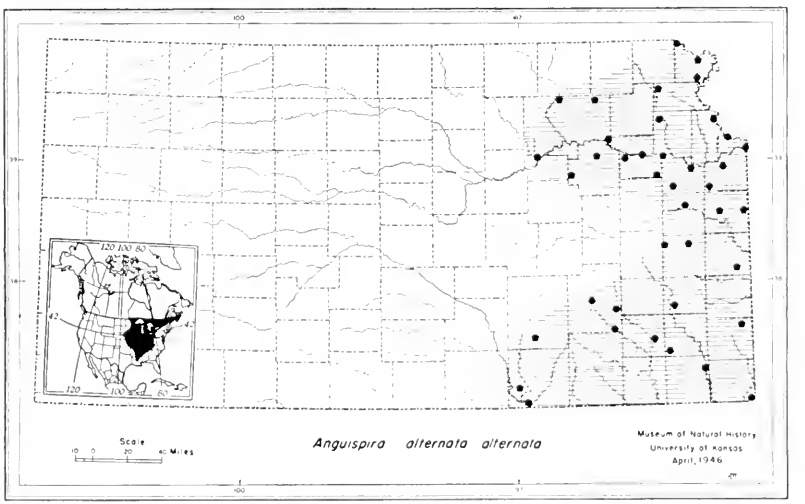


FIG. 52. Distribution of *Anguispira alternata* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Upper surface of foot dull scarlet, becoming dusky toward posterior end; tentacles pale slate; mantle margin bright red; sole of foot light blue; mucus of living animal saffron colored.

A "form" *angulata* is recognized by some authors; the name applies to those individuals in which the carination of the body whorl is pronounced. We have found individuals that would be referable to this "form" in Kansas populations, but in view of the highly variable nature of the species and the admitted fact (Pilsbry 1948:547) that "form" *angulata* grades imperceptibly into *A. a. alternata* in certain parts of its range we do not recognize the former as distinct from the typical subspecies of the state.

For similar reasons we do not recognize the nominal subspecies *A. a. ericusis* (Clapp), distinguished from the typical subspecies by higher spire and darker coloration. Leonard and Leonard (1946:119) found the two kinds in the same population on a sandy substrate in Greenwood County. Available evidence indicates that *A. a. ericusis* is merely an ecologic form, without genetic significance.

Habitat and Habits: One of the most common and widespread snails in the United States, *Anguispira a. alternata* is found in a wide variety of habitats in Kansas. It may be observed not only on wooded floodplains but also on uplands in appropriate situations, such as under logs, brush piles, boards, rock piles and about rocky ledges. In Illinois Baker (1939:84) reports that the species has been obtained from trees at considerable heights above ground. In favorable localities, particularly during or after a light summer rainstorm, this snail can be observed in considerable numbers crawling over the surface of logs, rocks and leaf litter. Leonard and Leonard (*loc. cit.*) reported that at one station in Greenwood County ". . . these snails were so numerous on the flood plain of Fall River that it was literally impossible to walk without crushing their shells at every step" *Anguispira a. alternata* is, in fact, one of the few gregarious kinds of snails in the state, and may therefore be obtained in considerable numbers quite easily, a point of special significance to those desiring to study variation in natural populations.

The locomotion of this snail is described by Baker (*loc. cit.*) as "slow and careful . . . the animal is sluggish in its movements. . . . The results of four tests on rate of locomotion by Oughton (1948:127) showed a speed of 2.1 to 2.3 centimeters per minute, or a theoretical 6.9 to 7.5 *miles per year*, much slower than in either of the two species of slugs tested (*Deroceras gracile* and *Pallifera dorsalis*).

The behavior of *A. a. alternata* preparatory to hibernation has been recorded by Jones (1935a), who has also furnished details regarding the physiology of shell secretion (Jones 1945b).

Genus *Helicodiscus* Morse

Helicodiscus parallelus (Say)

Pl. 8, figs. 3, 4, 5; text fig. 53

Helix lineata Say, 1817, Jour. Acad. Nat. Sci. Philadelphia, 1:18; 2:373. non Olivi, 1792; Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:55; Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Planorbis arallellus Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:164 (corrected to *parallelus* in the index, p. 407), type locality "Upper Missouri" (Council Bluffs, Iowa, selected by Pilsbry, 1948:627).

Helicodiscus parallelus, Hanna, 1909, Nautilus, 23:95; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, fig. 13; Leonard, 1943, Trans. Kansas Acad. Sci., 46:238, pl. 1, fig. 3; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:414, pl. xxi, fig. 19; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:119; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:625, fig. 339; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1039, pl. CI, figs. 24, 25.

Range: Eastern North America, from Newfoundland southwest to South Dakota, southeast to Arkansas; absent from Gulf Coastal plain generally.

Description: Shell under ¼ inches in diameter (3-4 mm.); planorboid, spire only slightly elevated; pale yellow or greenish, dull, sculpture of numerous, narrow spiral ridges; whorls 4-4½, convex, closely spaced, slowly increasing in size, last whorl broadly rounded at periphery and base; sutures deeply impressed; broadly umbilicate, showing all whorls in basal view; aperture semilunate, lip thin, not reflected; 1-3 teeth in cavity of last whorl; callus thin.

Measurements of Figured Specimen (Pl. 8)

Height, 1.3 mm.; greater diameter, 4.4 mm.; number of whorls, 4

Pale, having irregular dark spots.

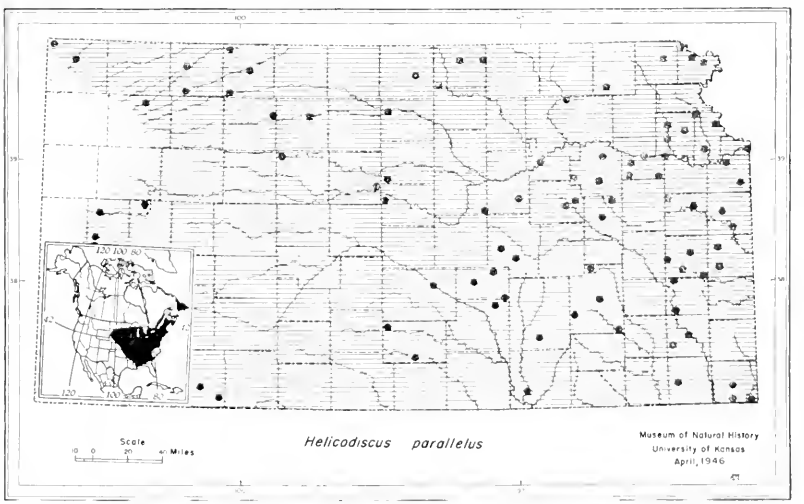


FIG. 53. Distribution of *Helicodiscus parallelus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Recognition Characters: The small, flattened, coin-shaped shell, spiral striation and wide umbilicus will distinguish this snail from all others in the state.

Habitat and Habits: Pilsbry (1948:627) has described this forest snail as ". . . a timid creature, hard to observe, as it takes alarm when approached with a lens, though apparently blind. It lives on decaying wood in shady or humid places, also on damp leaves." Goodrich and van der Schalie (1944:275) report that the commonest habitat of this snail in Indiana is on flood plains.

The position of the shell when the animal is in motion is rather peculiar, the shell being carried almost flat, and most of the animal being ahead of it (see figure in Baker, 1939:88). The eye-peduncles are held almost straight up, the tentacles pointing ahead.

"Professor E. S. Morse, who first called attention to the peculiar features of this little snail, was also the first to notice that it is blind, or at least lacks pigment in the eyes. The eye-peduncles are transparent whitish throughout, without a trace of the usual black eye-spots. The peculiar pose of the eye-peduncles described above . . . is assumed especially when the animal is coming out and also just at the beginning of retraction. Perhaps the ocular retractor muscles are contracted before the buccal retractor, thus pulling the eye-peduncles back first. When fully extended the eye-peduncles and head are usually posed as in other helicoid snails" (Pilsbry, *loc. cit.*).

Helicodiscus eigenmanni eigenmanni Pilsbry

Pl. 8, figs. 6, 7, 8; text fig. 54

Helicodiscus eigenmanni Pilsbry, 1900 Nautilus, 14:41.

Helicodiscus eigenmanni Pilsbry, Hanna, 1909, Nautilus, 23:95; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:630, fig. 342, a, b, c.

Range: Helicodicus eigenmanni eigenmanni has been reported from Texas, Colorado, Kansas, and the Mexican states of Chihuahua and Puebla.

In Kansas, known only from Douglas and Wyandotte counties, where it was collected by G. D. Hanna in 1909. We have not been successful in attempts to rediscover the species.

Description: Shell discoidal, spire flat to slightly elevated, whorls 4 to nearly 5, increasing slowly in size, last descending near aperture; umbilicus widely, cup-shaped; peristome simple, or in some individuals provided with two palatal denticles; surface of shell provided with spaced spiral threads, as in *Helicodicus parallelus*, but more robust above and weaker below than in that species.

In the specimens collected by Hanna, the spiral threads are badly worn.

Measurements of Figured Specimen (Pl. 8)

Height, 1.7 mm.; greater diameter, 4.6 mm.; number of whorls, 4½

Recognition Characters: Helicodiscus eigenmanni most closely resembles

H. parallelus in the gastropod fauna of Kansas, but differs in larger size, generally more robust shell, and shallower, cup-shaped umbilicus. Denticles, when present in *H. eigenmanni*, are situated in the peristome, whereas those of *H. parallelus* are deeply placed, and can rarely be seen from the aperture.

Habitat and Habits: Nothing is known of the habitat conditions under which Hanna found this species in Kansas, except that specimens were collected in each instance "near the Kaw River" (G. D. Hanna's notes, May 2 and July 4, 1909).

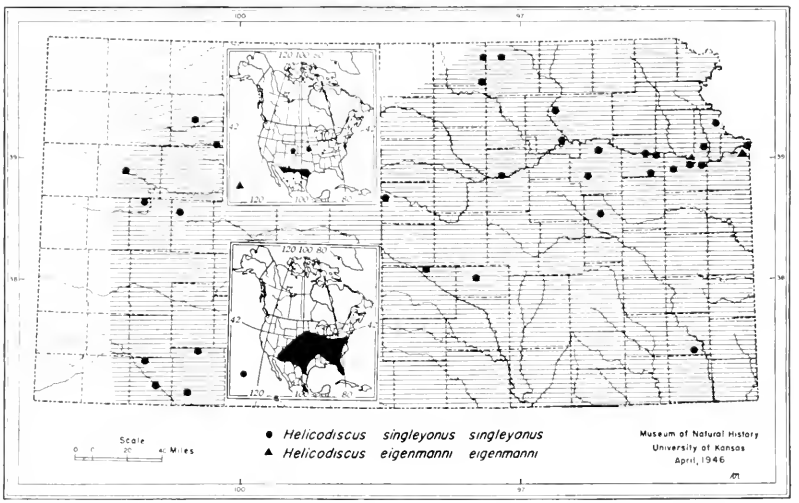


FIG. 54. Distribution of *Helicodiscus singleyanus singleyanus* and *H. eigenmanni eigenmanni* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of this species in North America.

Helicodiscus singleyanus singleyanus (Pilsbry)

Pl. 11, figs. 10, 11, 12; text fig. 54

Zonites singleyanus Pilsbry, 1890, Proc. Acad. Nat. Sci. Philadelphia, for 1889, p. 84; *ibid.*, 1888, pl. 17, fig. M, type locality New Braunfels, Comal Co., Texas. Type A. N. S. P. No. 160058.

Zonitoides singleyana, Hanna, 1909, Nautilus, 23:95.

Helicodiscus singleyanus inermis, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 9.

Helicodiscus singleyanus, Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:636, fig. 346.

Range: United States from New Jersey and Florida west to South Dakota, southwest to Arizona.

Description: Shell about 1/10 inch in diameter (2.5 mm.); helicoform, depressed; spire low, convex; color whitish, translucent, glossy; whorls 4, convex; sutures impressed; umbilicus about one-third diameter of shell; aperture lunate, lip thin, not reflected.

PLATE 8

Shells of Strobilopsidae, Zonitidae, and Endodontide in Kansas

All figures enlarged approximately 5 times natural size.

1, 2. *Stribilops labyrinthica* (Say), NE ¼, sec. 16, T. 12 S, R. 23 E, 4 mi. S and 2 mi. E of Bonner Springs, Johnson County, Kansas. Collected by E. J. Roscoe, 14 April 1951. Catalogue number 7593.

3, 4, 5. *Helicodiscus parallelus* (Say), NW ¼, sec 28, T. 22 S, R. 1 E, Harvey County, Kansas. Collected by E. J. Roscoe, 20 May 1951. Catalogue number 7310.

6, 7, 8. *Helicodiscus eigenmanni* (Pilsbry), SW ¼, sec 30, T. 22 S, R. 12 E, Greenwood County, Kansas. Collected by E. J. Roscoe, 3 July 1951. Catalogue number 8196.

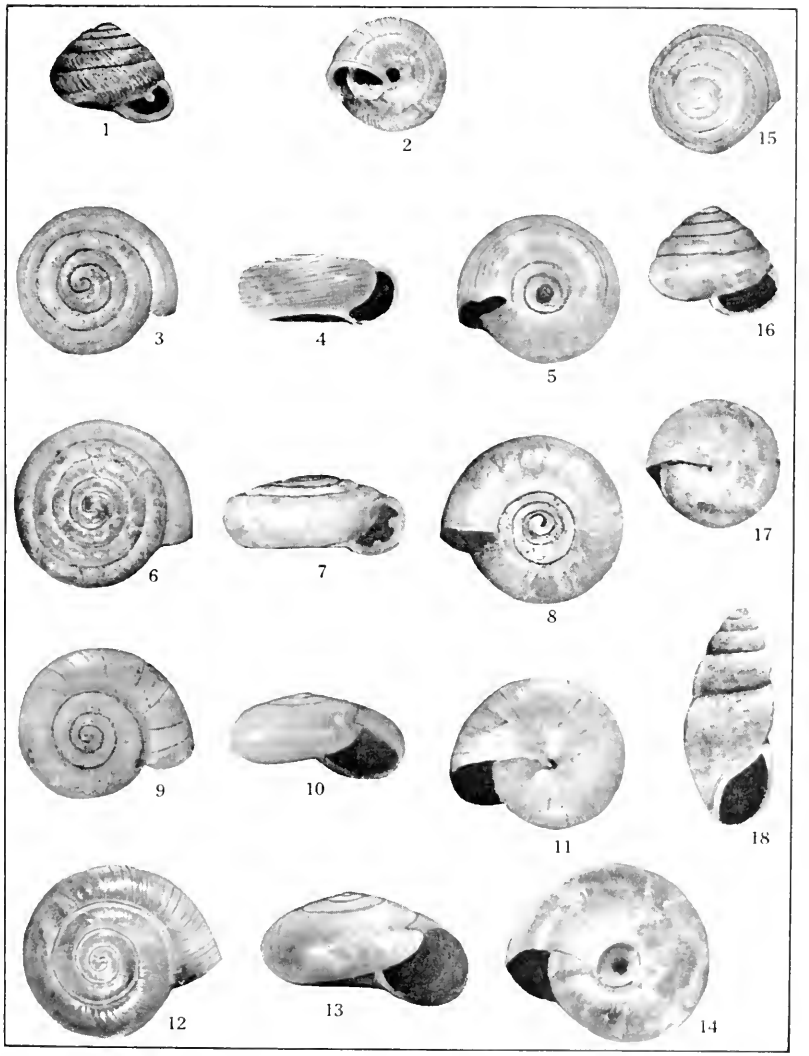
9, 10, 11. *Retinella indentata* (Say), 1 mi. W, ½ mi. N Clinton, Douglas County, Kansas. Collected by E. J. Roscoe, 7 April 1951. Catalogue number 7217.

12, 13, 14. *Retinella electrina* (Gould), 1 mi. W, ½ mi. N Clinton, Douglas County, Kansas. Collected by E. J. Roscoe, 7 April 1951. Catalogue number 7216.

15, 16, 17. *Euconulus chersinus* (Say), 2½ mi. S, 3 mi. E Lawrence, Douglas County, Kansas. Collected by A. B. Leonard, 25 May 1946. Catalogue number 4775.

18. *Cionella lubrica* (Muller), Lawrence, Douglas County, Kansas. Collected by G. D. Hanna, 8 August 1909. Catalogue number 1944.

PLATE 8



Measurements of Figured Specimen (Pl. 11)

Height, 0.9 mm.; greater diameter, 2.1 mm.; number of whorls, 4.

Recognition Characters: The shell of this species is most likely to be confused with that of *Hawaiia minuscula*, but differs in shallower umbilicus and usually smaller size. Juveniles are difficult to separate from those of *Hawaiia* and *Striatura*.

We have not been able to recognize the subspecies *H. s. inermis* Baker in Kansas.

Habitat and Habits: In Kansas *Helicodiscus singleyanus singleyanus* has been found in siftings from leaf litter, but many of our records are from drift, and may be unreliable, since the species is abundant in certain Pleistocene deposits; western records are particularly suspect as to recent age.

Pilsbry states (1948:636) that, "It seems to be a burrowing species," but we have no observations that bear on his observation.

Genus *Punctum* Morse

Punctum minutissimum (Lea)

Pl. 11, fig. 1, 2, 3; text fig. 55

Helix minutissima Lea, 1841, Trans. Amer. Philos. Soc., 9:17, type locality vicinity of Cincinnati, Ohio.

Punctum pygmaeum, Hanna, 1909, Nautilus, 23:95.

Punctum minutissimum (Lea), Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:644, fig. 350.

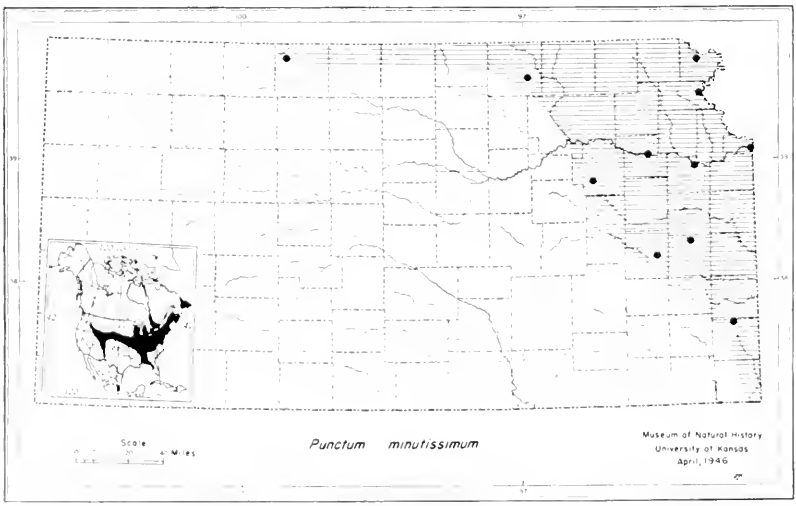


FIG. 55. Distribution of *Punctum minutissimum* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Range: Distributed over much of North America, from southern Canada to Mexico.

Irregularly distributed in the eastern half of Kansas.

Description: Shell minute, less than $^1/_{16}$ inch in diameter (1-1.5 mm.); heliciform, subglobose, spire elevated; brownish or reddish, somewhat translucent, dull or shiny; sculpture of close, fine striae; whorls about 4, last one well rounded, its sutures descending about to periphery of preceding whorl; sutures deeply impressed; broadly umbilicate, umbilicus contained about 4 times in shell diameter; aperture rotund, lip not reflected, thin.

Measurements of Figured Specimen (Pl. 11)

Height, 0.8 mm.; greater diameter, 1.4 mm.; number of whorls, 3½

Recognition Characters: The minute, globose shell distinguishes this tiny snail from all others in the State.

Habitat and Habits: Punctum minutissimum is a forest snail, to be looked for on damp leaves, around decaying logs, sticks, and bits of bark. Morse (quoted by Pilsbry, 1948:645), speaking of specimens from Maine, states that "dense, hard-wood growth appears to be their favorite position. They prefer rotten bark of beech trees, and frequently are found in the large forms of fungi, such as *Polyporus* and *Boletus*."

Their small size has, perhaps, caused them to be overlooked in favorable habitats, but with a little experience they can be observed in the field even with the unaided eye. Sifting leaf-litter and pieces of bark onto a piece of white paper is a good method of obtaining them.

Family PHILOMYCIDAE Keferstein

The family Philomycidae comprises large slugs, superficially resembling the Limacidae, but actually not closely related to the limacid slugs. There is a large shell sac, but no internal shell, although occasionally minute, isolated calcareous granules can be found within the sac. The mantle covers the entire dorsal surface, instead of being limited to the anterior part of the body as it is in the limacids. The internal anatomy is quite dissimilar to that of slugs in the family Limacidae.

The distribution of the family Philomycidae is somewhat unusual; it occurs in Japan and China to Java and the Celebes, and has been introduced into Hawaii. The family is distributed in humid temperate and tropical America as far south as Colombia, but it is absent in the mountain and Pacific coast states of the United States, and in the West Indies. Pilsbry (1948:749) thought that the family Philomycidae evolved into the slug condition far

earlier than did the Arionidae, and that, "The family was apparently an early branch from the endodontid stock which also gave rise to the Arionidae [another family of sluglike gastropods]."

Genus *Philomycus* Rafinesque

Philomycus carolinianus (Bosc)

Pl. 6, fig. 1; text fig. 56

Limax carolinianus Bosc, 1802, Hist. Nat. Vers., 1:80, pl. 3, fig. 1.
Philomycus carolinianus (Bosc), Clapp, Nautilus, 1920, 33:83, figs. 1-3.
Philomycus carolinianus (Bosc), Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:753, fig. 404.

Range: Distributed from New Jersey south to Florida, and west to Louisiana and Kansas. In Kansas, the species is confined to the eastern fourth of the State, except for a single record in Meade County, where individuals have been found in humid situations in or near marshes produced by artesian springs.

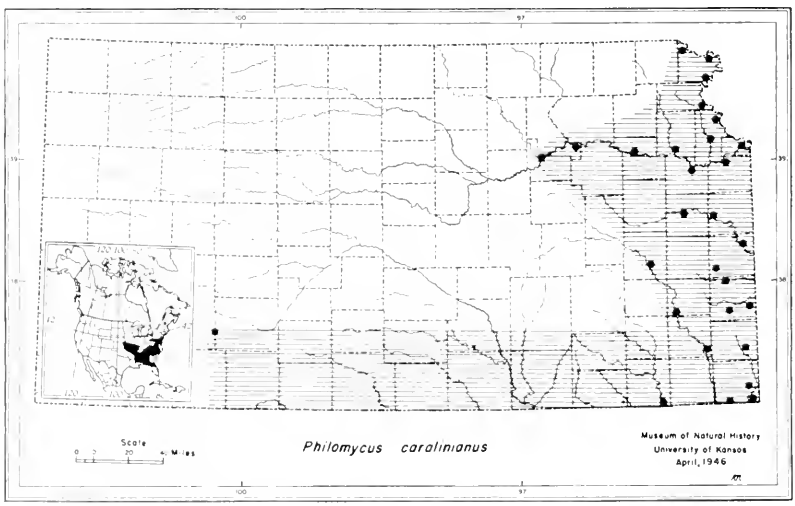


Fig. 56. Distribution of *Philomycus carolinianus* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Body robust, cylindrical, up to four inches in length when fully extended in locomotion; sole broad, ochraceous buff, dorsal surface ashy to buff; mantle splotched with black, and having two longitudinal rows of black, rounded to irregular spots near midline. Alcoholic specimens generally no longer than 40 to 50 mm.; slugs tend to contract greatly when killed and preserved.

Recognition Characters: The elongate, cylindrical form, the mantle that completely covers the dorsal surface of the body, and the tendency to possess two longitudinal rows of black spots on the mantle, will serve to identify this

species. The mantle covering the entire dorsal surface distinguishes *Philomycus carolinianus* from *Limax* in which the mantle is limited to the anterior part of the body; although the color patterns are typically different in the two species, they are so irregular in both as to be unreliable criteria for differentiating the two in Kansas.

Habitat and Habits: Philomycus carolinianus is a species of forests, where it lives beneath the trunks of fallen trees, under started bark, or in deep leaf litter. Individuals frequently live in burrows produced by beetles and other insects in decaying logs, and many hiberate in this kind of place. Unlike *Limax maximus*, *Philomycus carolinianus* does not frequent urban situations; I have never found it in basements of houses, nor in greenhouses.

Family SUCCINEIDAE Mörch

Because the shells of many of the species in the Family Succineidae are notoriously unreliable as aids to their identification, the species of this family occurring in Kansas have been treated differently than most kinds of gastropods considered in this handbook. A knowledge of the internal anatomy of succineids is paramount to an understanding of their identification, as well as their evolution. For further details, the reader is referred to the study of the Succineidae in Kansas made by Miles (1958).

The family Succineidae includes a large group of terrestrial pulmonate snails that are world-wide in distribution. Species are most numerous in North America, southern Asia, and Hawaii (Pilsbry, 1948:772). Because of several distinctive characters, discussed in detail by Pilsbry (*loc. cit.*), the family is not considered to be closely related to any other family of pulmonate gastropods.

Jaw (Fig. 10a, b): Perhaps the most distinctive character, found only in the Family Succineidae, is the large, squarish accessory plate dorsal to the cutting edge of the jaw, which ordinarily possesses a single median projection on the cutting edge. In several species of *Succinea*, ribs are present on the anterior surface of the jaw, but in Kansas, only *Succinea ovalis* possesses such ribs.

Shell (Plate 9): The close resemblance in general form of the shell in all species in Kansas, has been primarily responsible for the present confused state of the taxonomy of our members of this family. The shell is simple and lacks distinctive color patterns or ornamentation that might be useful taxonomically. The shell is thin, transparent, and imperforate. Its spire is short, and there are up to four whorls in specimens from Kansas. A characteristic feature is the relatively large aperture, ranging from 50 per cent to more than 80 per cent of the length of shell.

Color of shell varies among members of a single population, but in general,

is some shade of yellow or brown. The family has long been referred to as "the amber snails" (Lee, 1951b). The color of the shells of any species of the Family Succineidae should not be primarily relied upon in identifying species. Although the shells of *Succinea concordialis* have a ruddy or reddish apex, the same condition has been observed in the shells of other species. Furthermore, the color of the shell often changes after death of the animal.

Genitalia (Figs. 2-9): The reproductive system furnishes the most accurate means of distinguishing species of Succineidae. The genitalia of all species of this family may be termed simple, in that they lack accessory organs, such as dart sacs, muciparous glands, and flagellae, present in some other families of snails.

The succineids are monoecious, as are most pulmonate gastropods. The male and female reproductive systems open to the outside of the animal through a common genital atrium, which is situated immediately behind the right eyestalk. Since male and female systems join at a common atrium, the intact reproductive system can be removed from the animal with comparative ease. In all species of Succineidae the darkly pigmented retractor muscle of the right eyestalk passes between the junction of penis and vagina.

Since detailed anatomical and functional studies of the reproductive organs of Succineidae are not available for most species, it is necessary to resort to interpretations based on studies of snails belonging to other families. The unreliability of such extrapolations is obvious.

The *hermaphrodite gland* (ovotestis) is at the extreme posterior end of the animal and occupies the apex of the shell in the living state. Both ova and sperm are formed in this gland. Hickman (1931:243) studied spermiogenesis in *Succinea ovalis* and discussed this organ in some detail. He characterized the hermaphrodite gland as being composed of many acini "pressed closely together, each opening into an atrium which communicates with the hermaphrodite duct." Hickman (*op. cit.*) referred to *Succinea ovalis* as a "simultaneous hermaphrodite" because male and female germ cells develop at the same time from an indifferent germinal epithelium. The color of the hermaphrodite gland is usually whitish-gray, with the periphery deeply pigmented dark gray. The gland is invested by the digestive gland on all but the surface to which the hermaphrodite duct attaches. The surrounding digestive gland may be teased away rather easily from the hermaphrodite gland.

The *hermaphrodite duct* originates on the free surface of the hermaphrodite gland. Size and shape of this duct vary according to age of the animal. In small, immature specimens, the duct is thin and often unconvoluted to a greater degree. The degree of pigmentation on the duct has been used in the diagnoses of some species of Succineidae by Pilsbry (1948). Degree of pigmentation is of no taxonomic value, because most series of all species considered in the present paper have shown extreme variation in this character. The hermaphrodite ducts of different individuals vary from deeply pigmented to light-colored and immaculate. It is worth noting that pigmentation of any internal organ is too variable to be of taxonomic importance. Furthermore, there is seemingly no correlation between age of the animal and degree of pigmentation of any structure.

The hermaphrodite duct terminates at the *fertilization sac*, situated at the base of the seminal vesicles. This sac sometimes is and sometimes is not the same color as the seminal vesicles.

The *seminal vesicles* of all individuals examined are paired; Pilsbry (*op. cit.*) reported this to be the prevalent condition among species of Succineidae. The two structures are occasionally equal in size, but generally unequal; in a series of any species in Kansas, the relative sizes of the seminal vesicles vary considerably.

The albumin gland is often the largest organ of the genitalia, especially in *Quickella*. The ventral proximal portion of the gland contains the fertilization sac and seminal vesicles. Albumin for the ova is supposedly supplied by this gland, which in *Helisoma trivolvis* opens through a duct into the fertilization sac (Abdel-Malek 1954:114). The albumin gland is usually pale, although it may be pigmented to varying degrees.

The term *oviduct* is here used in preference to uterus, because all members of the Family Succineidae are oviparous; the term "uterus" should be reserved for use in animals that are viviparous or ovoviviparous.

The size of the oviduct varies with the stage of sexual development of the animal. In immature animals the oviduct is smaller in diameter and more compact; its bulk may be exceeded by that of the prostrate gland. In sexually mature animals the distended oviduct may obscure the penis, vagina, and seminal receptacle. This distension is especially obvious in large individuals of *Succinea concordialis*.

The term *seminal receptacle* is synonymous with "spermatheca"; both words seem equally applicable. Sperm introduced during mating are stored in this organ (Abdel-Malek, *op. cit.*). It is usually globular, although elongate-oval in some individuals of *Quickella vagans*. The size of the structure varies widely in some series of animals. The duct of the seminal receptacle originates on the oviduct at varying position, according to the species. The portion of the female tract below the origin of the duct of the seminal receptacle is termed the vagina.

A nearly infallible rule seems to be that the seminal receptacle is associated with the left salivary gland, for in most individuals, the seminal receptacle or its duct is connected with this salivary gland by connective tissue. The seminal receptacle and intestine may be in actual contact, or they may be separated and joined by connective tissue.

The relative length of the *vagina* is constant within a species, but varies among species of the Family *Succineidae*. In *Succinea ovalis* and *Oxyloma retusa* the vagina is nearly as long as the penis, but is much shorter than the penis in *Quickella vagans*, *G. wandae*, *Succinea concordialis*, *S. vaginacontorta*, and *S. pseudavara*. A peculiar torsion in the vagina is the primary distinguishing character of *S. vaginacontorta* (Lee 1951b).

The *prostate gland* is relatively large and conspicuous in *Quickella*, *Oxyloma* and *Succinea ovalis*. In the remaining species of succineids occurring in Kansas, this gland is smaller. Contrary to the description by Pilsbry (1948:835), in which the prostate gland of *Succinea concordialis* is termed large, this gland is relatively small in this species in Kansas. In young *Quickella* and young *Oxyloma*, the size of the prostate gland frequently exceeds that of the oviduct.

The term *vas deferens* is applied to the sperm duct from the point at which it leaves the prostate gland until it inserts on the distal end of the penis; length and diameter of the duct varies. It is long and relatively thin in *Oxyloma retusa* and *Succinea ovalis*, but shorter and thicker, in *S. concordialis*. Intermediate conditions prevail in other species. Usually, the distal portion of the vas deferens is differentiated into an *epiphallus*, which in turn inserts on the penis. The epiphallus reaches its greatest differentiation in *Oxyloma* and is completely contained within the penial sheath in that genus. In *Succinea*, the epiphallus may or may not be completely contained within the sheath. An epiphallus is not distinctly differentiated in *Quickella*, although the vas deferens thickens as it enters the penis. In the present account, a short epiphallus is considered to be present in *Quickella* beginning at, or near, the insertion of the penial retractor muscle on the sperm duct. Differences in the *penis* have been used extensively to separate species. In *Oxyloma* and *Succinea* the penis is surrounded by a sheath, which varies in thickness and other characters among the various species. In *Quickella*, a penial sheath is not present.

The penis of *Oxyloma* possesses a structure termed an *appendix*, a small protuberance situated approximately at the point where the epiphallus inserts. The size, shape, and position of this appendix has been given considerable taxomic weight in diagnosing species of *Oxyloma* (Pilsbry, 1948); several species have been diagnosed almost exclusively upon the appearance of the appendix. It has become evident to me, however, that the appendix varies within a population, from a small, blunt structure, scarcely evident, to one that is longer and tapering. It seems obvious that variations in the appendix are not specifically diagnostic. All populations of *Oxyloma* discovered in Kansas are considered to be *Oxyloma retusa*.

Quickella is unique among genera of Succineidae in Kansas in lacking a penial sheath. The penis possesses an appendix that is usually larger than the penis. Lee (1951a) thought that the terms penis and appendix are not applicable in *Quickella*, because he considered these structures to be elaborations of the vas deferens. However, in the present discussion, the standard interpretation of penis, and appendix is retained.

KEY TO THE SPECIES OF THE FAMILY SUCCINEIDAE IN KANSAS

1. A. Penial sheath not present; large appendix present which equals, or exceeds, length of penis 2
   B. Penial sheath present. Appendix, if present, smaller than penis 3
2. A. Appendix approximately equal to, or slightly longer, than penis ..... *Quickella vagans*, p. 161
   B. Appendix much longer than penis due to presence of outgrowth from distal end; this outgrowth may be thrust "papillalike" into appendix ..... *Quickella wandae*, p. 164
3. A. Appendix present on distal end of penis ..... *Oxyloma retusa*, p. 159
   B. Appendix not present on penis 4
4. A. Vagina having prominent torsion just above entrance to genital atrium ..... *Succinea vaginacontorta*, p. 155
   B. Vagina lacking torsion 5

5. A. Vagina nearly as long as penis; duct of seminal receptacle surrounded by loop of oviduct *Succinea ovalis*, p. 143
   B. Vagina much shorter than penis; duct of seminal receptacle not surrounded by loop of oviduct 6
6. A. Vas deferens flattened, wide, becoming incorporated into sheath of penis soon after crossing junction of penis and vagina; foot of animal possesses prominent dark gray flecks over entire surface *Succinea concordialis*, p. 146
   B. Vas deferens not flattened, thin; becomes attached to sheath of penis distally; foot of animal with pigmentation concentrated primarily anteriorly and on posterior tip *Succinea pseudavara*, p. 158

Genus *Succinea* Draparnaud

Succinea ovalis Say

Pl. 9, figs. 2, 11, 12; text figs. 57, 58, 69

Succinea ovalis Say, 1817, Jour. Acad. Nat. Sci. Philadelphia, vol. 1, p. 15; DeKay, in part, 1844, Nat. Hist. New York, Mollusca, p. 53, pl. 4, fig. 52; Pilsbry, 1908, Proc. Acad. Nat. Sci. Philadelphia, p. 45, with var. *optima*, p. 46, and var. *chittenangoensis*, p. 49; Walker, 1928, Terrestrial Mollusca of Alabama, p. 167; Walker, 1904, Sixth Rep. Michigan Acad. Sci., p. 187; Ingram, 1943, Nautilus, vol. 56, p. 92; Pilsbry, 1948, Land Mollusca of North America, vol. 2, p. 801, figs. 429-432.

Helix (Cochlohydra) ovalis Say, Ferrussac, 1822, Tabl. syst. Limacons, p. 26; Hist. Nat. Moll., pl. 11a, fig. 1.

Succinea ovatis Leidy, 1851, in Terr. Moll., vol. 1, pp. 213, 231, pl. 13, figs. I-III.

Succinea obliqua Say, 1824, *In* Appendix to Keating's Narrative Exped. source St. Peter's River, etc., Major Long's Second Expedition, vol. 2, p. 260, pl. 15, fig. 7; W. G. Binney, 1878, Terr. Moll., vol. 5, p. 423, and most authors of the last century.

Succinea campestria Say, Gould, 1841, Invertebrates of Massachusetts, p. 195, fig. 126; DeKay, Invertebrates of Massachusetts, p. 53, pl. 4, fig. 54. Not *Succinea campestris* Say.

Succinea totteniana Lea, 1841, Trans. Amer. Philos. Soc., vol. 2, p. 32; W. G. Binney, 1878, Terr. Moll., vol. 5, p. 425, pl. 67b, fig. 2.

Helix (Cochlohydra) putris Ferussac, Tableau Syst. fam. Limacons, p. 26, no. 9; Hist. Nat. Moll., pl. 11A, fig. 9.

Succinea putris L., Cockerell, Nautilus, vol. 6, p. 30.

Type Locality: Philadelphia, Pennsylvania.

Description of Shell: Oval, inflated, thin, translucent, greenish-yellow, summit paler or reddish; glossy; lightly marked with wrinkles of growth; whorls two and a half, strongly convex, last one inflated, convex throughout; aperture ovate, about three-fourths length of shell (after Pilsbry, 1948:802).

The shells of Kansas specimens agree closely with this description, excepting the ratio of length of aperture to the length of shell, which averages somewhat less than three fourths (see below). The shell is usually the same color over its entire surface; the "reddish summit," present in the living states, is due to coloration of the brown digestive gland in the apex. Because of its distinct appearance at all stages of growth and its limited distribution in Kansas, the shell is seldom, if ever, mistaken for that of any other species of succineid in the State.

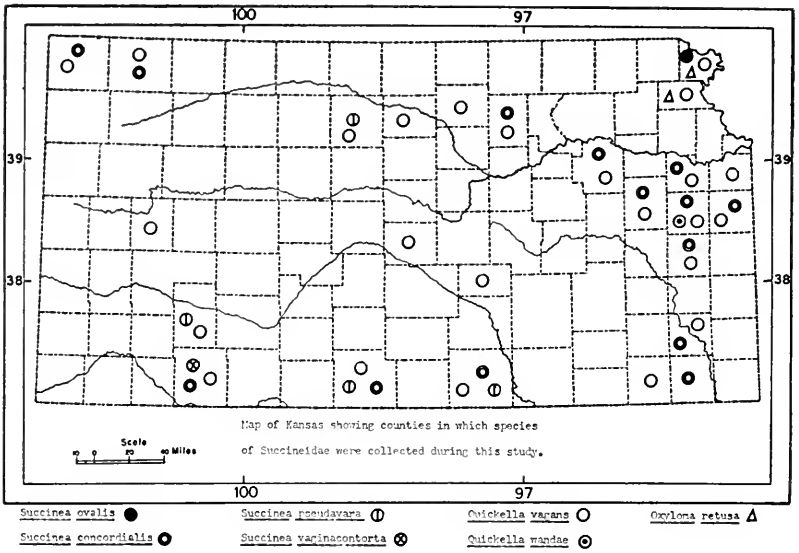


FIG. 57. Distribution of the seven species of Succineidae known in Kansas. Except for the symbols representing records of *Succinea pseudavara*, *S. vaginacontorta* and *Quickella wandae*, each symbol represents a series of collections in the county in which the symbol occurs.

Measurements of Shells of *Succinea ovalis* Say

Length	Diameter	Length of aperture	Diameter of aperture
18.8 mm.	10.8 mm.	12.0 mm.	8.6 mm.
11.6	6.9	8.8	6.0
17.4	9.4	11.7	7.4
15.2	8.6	10.4	6.8
9.8	5.7	7.1	4.5

Soft Anatomy: The external appearance of the living animal varies considerably, as is true with most species of Succineidae in Kansas. The ground color of the foot, is usually pale yellow; the sole is always yellow-orange, the periphery possessing darker orange color than the center. The sole is seemingly never pigmented.

Although some specimens are nearly immaculate, some pigmentation usually is present. Pigmentation varies from a faint gray stippling anteriorly on the sides of the head and foot, to dark gray stippling anteriorly on the sides of the head and foot, to dark gray vertical bars extending the entire length of the foot. In some examples, there is whitish stippling on the sides of the foot and under the collar, giving a glistening appearance to the animal when viewed under a dissecting microscope. The top of the head is invariably pigmented. The majority of specimens possess dark gray pigmentation evenly distributed over the dorsal surface of the head, in the area bordered laterally by the tentacular retractor muscles, which are visible through the epidermis of the snail.

The pattern of markings of the mantle over the lung varies markedly; the color of this species is ordinarily some shade of brown.

The jaw of *Succinea ovalis* is unique among Kansas succineids in possessing accessory ribs, in addition to the usual median projection (Fig. 69).

Genitalia (Fig. 58): The genitalia of *Succinea ovalis* are distinctive among the species under consideration in several respects. The base of the duct of the seminal receptacle is as large in diameter, frequently larger, than the oviduct at its point of origin, but narrows before reaching the globular seminal receptacle. The oviduct describes a loop around the duct of the seminal receptacle. This feature is diagnostic of *Succinea ovalis* in Kansas. The penis is large, completely filling the sheath. The vagina is nearly as long as the penis.

Genitalia are white except that the hermaphrodite duct, prostate gland, and seminal vesicles are invariably pigmented to some degree. The prostate gland is large and usually brown. The vas deferens is long and sinuous and differentiated into a distinctly thicker epiphallus beyond the point of insertion of the penial retractor muscle. The epiphallus is invariably free from the penial sheath, the epiphallus usually producing a sigmoid flexure. The penial retractor muscle is relatively thick and of equal diameter throughout its length.

The appearance of the free, looped epiphallus varies from specimen to specimen, but the loop is always present.

Distribution: Succinea ovalis barely enters northeastern Kansas in Doniphan County, inhabiting bluffs along the Missouri River. Numerous specimens have been collected from these bluffs along Kansas Highway 7, from Iowa Point to White Cloud (Doniphan County). Baker (1902:219) gives its distribution as eastern and central parts of northern United States, and west to Manitoba, Canada, and south to Arkansas and Georgia. This would place the western limit of its range in Kansas.

In Kansas, *Succinea ovalis* was generally found in shaded, damp situations along the base of bluffs, sometimes at considerable distances from the river. Invariably, the snails were on the ground under a protective cover of grass, leaves and twigs. A series of approximately fifty living specimens was collected on 9 April, 1955, from a low, wooded hill overlooking the Missouri River at White Cloud. On most other occasions, fewer specimens were found at any given time, generally six to twelve, but in April 1956, seventeen specimens, ranging from immature to adult, were found in a small ravine filled to a depth of two feet with dead leaves. The snails, some of which were hibernating, were clinging to leaves.

General Remarks: Strandine (1941:86) studied the ecology of a population of *Succinea ovalis* on a flood plain in Illinois. He found that the available leaf-mold seemingly influences population density, which "increases in the spring and early summer when

the available leaf-mold is greatest." Strandine further found that "fluctuations in the density of the *Succinea ovalis* population coincides with the fluctuations in the soil moisture, the organic matter, and the pH; the snail population increasing when the pH is increasing and the soil moisture and organic matter are decreasing."

Shimek (1935:6) found *Succinea ovalis* generally distributed throughout Iowa in wooded areas, especially in low alluvial bottomlands. He noted a population twenty-five to seventy-five feet above the river, entirely above the highest flood level.

Parasites: Ingram and Hewitt (1943:92) reported the occurrence of the sporocyst of a trematode *(Leucochloridium)* in *Succinea ovalis* in New York State. The sporocyst is banded with shades of brown, white, and green. Sporocysts, presumably of *Leucochloridium,* have been observed in Kansas in three individuals of *S. ovalis,* intertwined among the organs of the reproductive system.

Ellis (1926:140) reported that the sporocyst *(Leucochloridium)* is a stage in the life cycle of the fluke *Distomum;* the brightly colored branches in the tentacles of the snail (*Succinea putris*) attract the attention of birds, which peck off the tentacles and infect themselves. According to Ellis, the snail then grows a new tentacle!

Succinea concordialis Gould

Pl. 9, figs. 6, 9; text figs. 57, 59-60, 70

Succinea concordialis Gould, 1848, Proc. Boston Soc. Nat. Hist., vol. 3, p. 38 (Lake Concordia); 1851, in Binney, Terr. Moll., vol. 2, p. 82, pl. 67a, fig. 2; W. G. Binney, 1878, Terr. Moll., vol. 5, p. 418; 1885, Manual American Land Shells, p. 441; Pilsbry and Ferriss, 1906, Proc. Acad. Nat. Sci. Phila., p. 159, figs. 11, 12; F. C. Baker, 1939, Fieldbook Illinois Land Snails, p. 123, 2 figs. (unnumbered); Pilsbry, 1948, Land Mollusca North America, vol. 2, p. 833, figs. 452-454.

Succinea munita Binney, 1851, Terr. Moll., vol. 1, p. 128 (*nomen nudum*), *teste* W. G. Binney.

Succinea forsheyi Lea, 1864, Proc. Acad. Nat. Sci. Philadelphia, p. 109; Jour. Acad. Nat. Sci. Philadelphia, ser. (2), vol. 6, p. 178, pl. 24, fig. 107.

Succinea haleana Lea, 1864, Proc. Acad. Nat. Sci. Philadelphia, p. 109.

Succinea halei Lea, Jour. Acad. Nat. Sci. Philadelphia, ser. (2), vol. 6, p. 180, pl. 24, fig. 110.

Succinea witteri Shimek, 1913, Nat. Hist. Bull. State Univ. Iowa, vol. 6, p. 31, pl. 1, figs. 1-4.

Description of Shell: Obliquely ovate, elongate, reflexed, apex acute, thin but firm, transparent, shining, feebly striated lengthwise and spirally, color pale honey yellow, with tip ruddy; whorls three and somewhat more, very oblique; aperture ample, not less than a broad, thin callus covers left margin; margin slightly detached anteriorly, forming rudiment of an umbilicus (after Pilsbry, 1948:833).

Measurements of Shells of *Succinea concordialis* Gould

Length	Diameter	Length of aperture	Diameter of aperture
11.8 mm.	6.5 mm.	8.0 mm.	4.8 mm.
13.4	7.8	9.7	6.0
13.7	7.3	9.6	5.5
12.7	7.2	9.0	5.3
11.0	6.0	8.0	4.6
9.1	4.9	6.1	3.6

Shells of adult *Succinea concordialis* are not easily confused with those of other species in Kansas. The shining surface and ruddy apex is characteristic. However, shells of immature specimens often lack the ruddy apex and may be confused with those of *Quickella vagans*.

Type Locality: Lake Concordia, Louisiana.

Soft Anatomy: In the living state, the animal is easily identified by the characteristic black or dark gray, white-spotted, mantle, which is seen through the transparent shell. Pilsbry (1948:834) states that the spots are yellow in this species, but all specimens seen by me from Kansas possessed white spots, which appeared yellow when viewed through the shell. The foot is light gray, flecked with dark gray. This pigmentation is more or less evenly distributed over the exposed portion of the body when the animal is active. The dark maculations are larger than those on any other species of the Succineidae in Kansas. Pigmentation on the posterior tip of the foot and dorsally on the head is arranged in a pattern of vertical bars; this pattern is not exhibited on the sides of the foot. The sole is gray, sometimes tinged with yellow. A few specimens possess faint stippling on the sole of the foot.

Jaw (Fig. 70).

Genitalia (Fig. 3): The genitalia of *Succinea concordialis* vary little in populations in the state. The species in Kansas differs from the description given by Pilsbry (1948:835) primarily in one respect; the prostate gland is always relatively small in comparison to the oviduct and other organs of the genitalia. Pilsbry (*loc. cit.*) states that the prostate gland of this species is comparatively large; his accompanying illustration confirms his statement. It should be noted, however, that Pilsbry's description is based on rather small specimens from one locality (Del Rio, Texas). More than one hundred specimens have been examined from widely scattered localities in Kansas; the shells of these specimens ranged from less than 6 mm. in length (immature) to more than 14 mm. (adults).

The duct of the seminal receptacle is unusually slender in *Succinea concordialis* and originates low on the oviduct at approximately the level where the vas deferens crosses the junction of penis and vagina. The seminal receptacle is globular. The vas deferens is diagnostically short, wide, and somewhat flattened, becoming attached to the sheath of the penis immediately after crossing the junction of penis and vagina. The penial sheath is small in relation to the size of the complete genitalia; this size relationship is especially noticeable in large snails. The sheath is thin, semi-transparent, enclosing a relatively thin penis. A distal opening in the sheath, allowing the epiphallus partially to emerge, has been seen in a few small specimens, but in the great majority of specimens the sheath is entire. The penial retractor muscle inserts on the distal end of the sheath. Penis and sheath may be dark gray, although they are usually immaculate.

Explanation of Text Figures 58-61

Genitalia of *Succinea ovalis*, *S. concordialis* and *S. vaginacontorta*.

All figures enlarged approximately 10 times.

58. Genitalia of *Succinea ovalis* Say, ½ mi. N White Cloud, Doniphan County, Kansas. Collected by C. D. Miles, 9 April 1955. Catalogue number 10264. The epiphallus (EP) is shown in median section, to illustrate the heavy muscular wall.

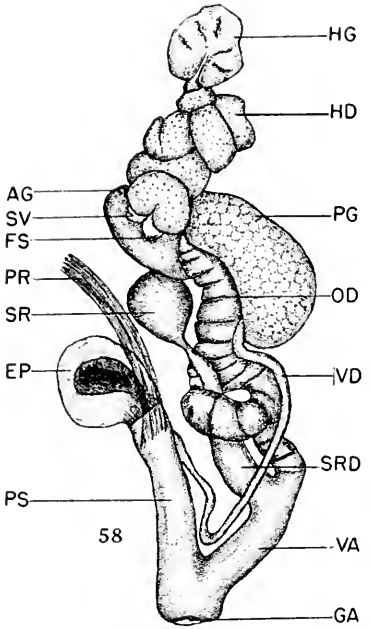
59. Genitalia of *Succinea concordialis* Gould, roadside ditch at St. Francis, Cheyenne County, Kansas. Collected by C. D. Miles, 2 June 1956. Catalogue number 10266.

60. Detail of genitalia of *Succinea concordialis* to show the relation of the penis to the sheath.

61. Genitalia of *Succinea vaginacontorta* Lee, Meade County Park, 8 mi. S, 5 mi. W Meade, Meade County, Kansas. Collected by C. D. Miles, 3 June 1956. Catalogue number 10266.

Guide to Symbols Used in Figures

AG, albumen gland
EP, epiphallus
FS, fertilization sac
GA, Genital atrium
HD, Hermaphroditic duct
OD, oviduct
P, penis
PG, prostate gland
PR, penial retractor muscle
PS, penial sheath
SR, seminal receptacle
SRD, duct of seminal receptacle
SV, seminal vesicle
TVA, torsion of vagina
VA, vagina
VD, vas deferens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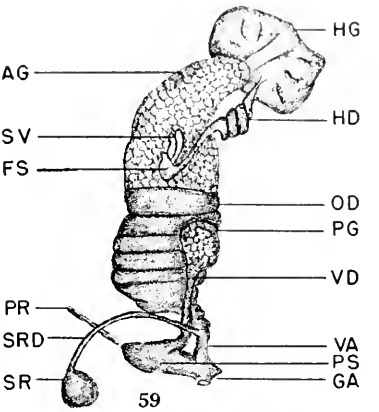
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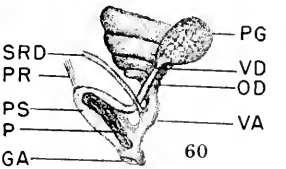
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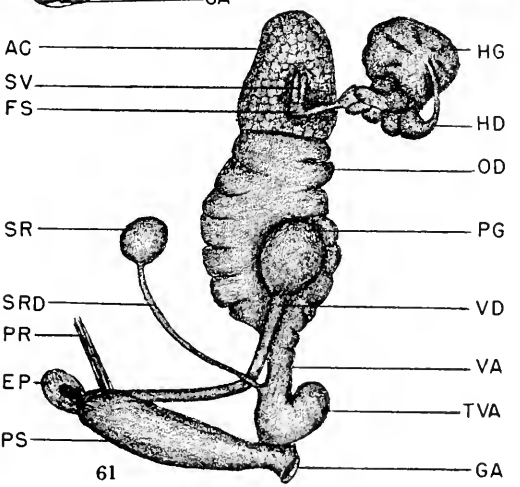
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61

Explanation of Text Figures 62-66

Genitalia of *Succinea pseudavara* and *Oxyloma retusa*.
All figures enlarged approximately 10 times.

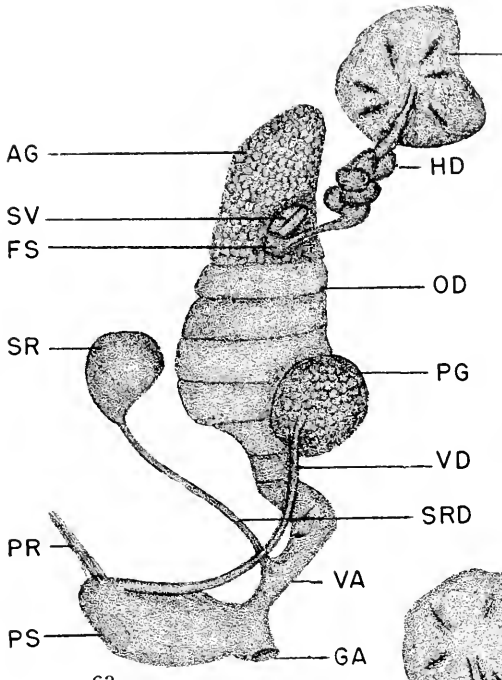
62. Genitalia of *Succinea pseudavara* Webb, 4 mi. W Medicine Lodge, Barber County, Kansas. Collected by C. D. Miles, 4 June 1956. Catalogue number 10334.

63. Genitalia of *Oxyloma retusa* (Lea), Muscotah Marsh, 1½ mi. S Muscotah, Atchison County, Kansas. Collected by C. D. Miles, 14 July 1955. Catalogue number 10285.

64, 65, 66. Drawings of the penis and appendices of three examples of *Oxyloma retusa* from a large population (see fig. 63 for locality) to show variability in the appendix. Sheath of penis not shown.

Guide to the Symbols Used in Figures

AG, albumen gland
AP, appendix
EP, epiphallus
FS, fertilization sac
GA, genital atrium
HD, hermaphroditic duct
HG, hermaphroditic gland
OD, oviduct
P, penis
PG, prostate gland
PR, penial retractor muscle
PS, penial sheath
SR, seminal receptacle
SRD, duct of seminal receptacle
SV, seminal vesicle
VA, vagina
VD, vas deferens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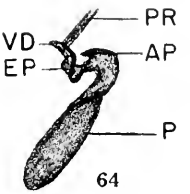
62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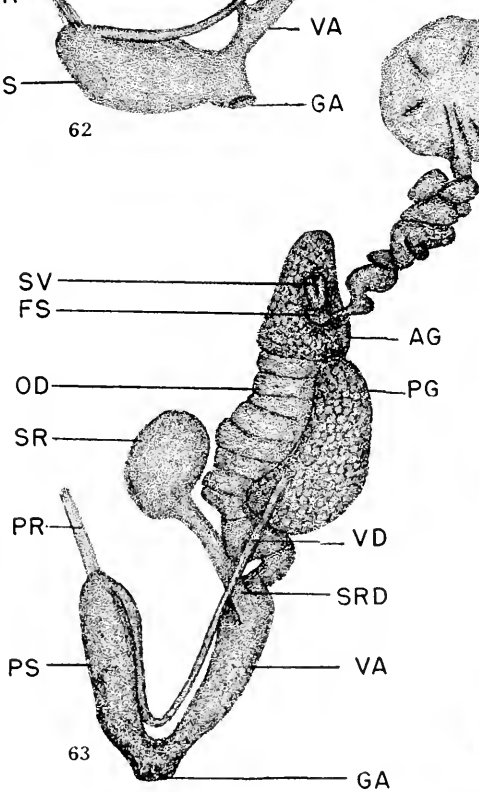
64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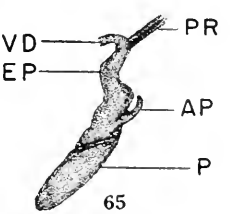
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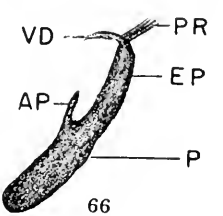
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Explanation of Text Figures 67-70

Genitalia of *Quickella vagans* and *Q. wandae*,
and the Jaws of *Succinea ovalis* and *S. concordialis*

67. Genitalia of *Quickella vagans* (Pilsbry), 2⅗ mi. W Burlingame, Osage County, Kansas. Collected by C. D. Miles, 12 June 1956. Catalogue number 10272. Enlarged approximately × 10.

68. Genitalia of *Quickella wandae* Webb, 7 mi. N Ottawa, Franklin County, Kansas. Collected by C. D. Miles, 8 April 1956. Catalogue number 10274. Enlarged approximately × 10.

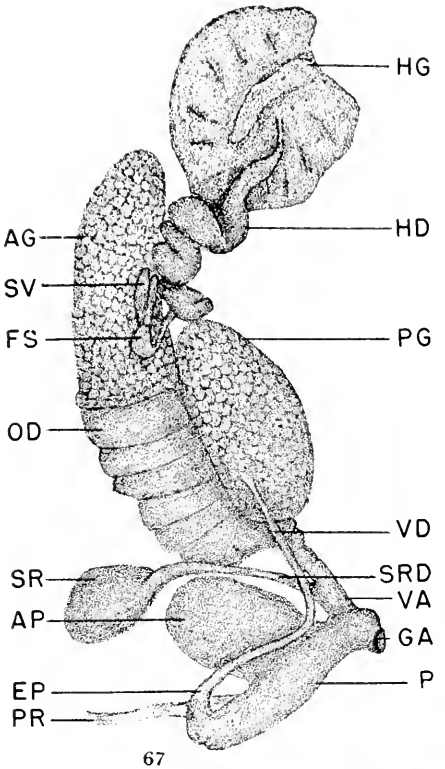
Note in this drawing, that the penis and its appendix have been rotated about 180° around the genital atrium, in order to show structures more advantageously. The normal position of these organs is seen in figure 67.

69. Jaw of *Succinea ovalis* Say (Cat. No. 10264; see fig. 58 for other data), showing the ribs on the anterior face of the cutting edge. *S. ovalis* is the only species of Succineidae in Kansas, in which the jaw bears such ribs. Enlarged approximately × 30.

70. Jaw of *Succinea concordialis* Gould (Cat. No. 10266; see fig. 59 for other data). The accessory plate (APL), present on the jaws of all succineids, is a diagnostic feature of the family. Enlarged approximately × 30.

Guide to Symbols Used in Figures

APL, accessory plate
AG, albumen gland
AP, appendix
CE, cutting edge
EP, epiphallus
EX, extension of appendix
FS, fertilization sac
GA, genital atrium
HD, hermaphroditic duct
HG, hermaphroditic gland
OD, oviduct
P, penis
PG, prostate gland
PR, penial retractor muscle
R, ribs
SR, seminal receptacle
SRD, duct of seminal receptacle
SV, seminal vesicle
VA, vagina
VD, vas deferens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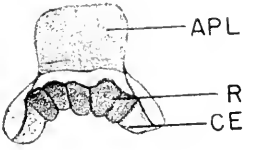
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APL
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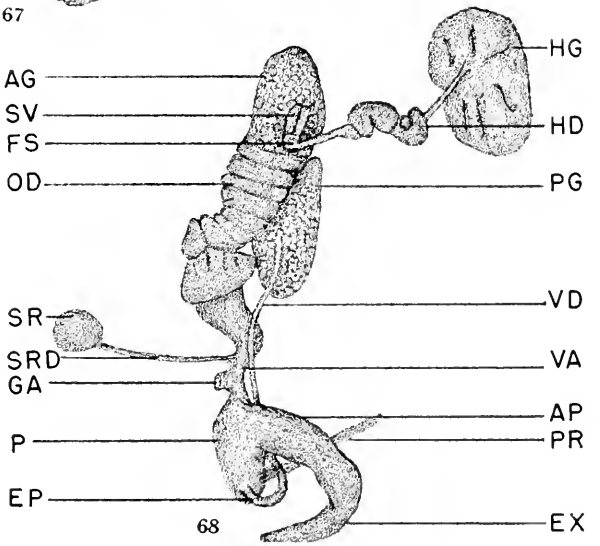
70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68

The hermaphrodite duct is usually some shade of gray, and is never brown as in some other species of Succineidae in Kansas. The duct becomes tightly convoluted soon after leaving the hermaphrodite gland, and then straightens before inserting at the fertilization sac. Approximately two-thirds of the duct is convoluted.

Distribution: Succinea concordialis seemingly occurs throughout Kansas (Fig. 57); in numbers it is exceeded only by *Quickella vagans*. Pilsbry (1948:834) cites the following states in which this species has been reported: Texas, Louisiana, Arkansas, Missouri, Illinois, Iowa, Tennessee, Alabama, and Florida. Webb (1954:10) reported this species from Marshall County, Oklahoma. Franzen and Leonard (1943:339) noted its occurrence in Kingman County, Kansas.

Succinea concordialis has been found in Kansas in two distinct habitats. Generally, it occurs near the edges of streams in wet situations, clinging to vegetation near or in water, or living in the wet leaf mold at the edge of the water.

Elsewhere, the species inhabits comparatively dry environments. In Meade County State Park, a number were found near the lake, in a low area overgrown by thick vegetation, but several isolated places were sandy and barren. The sand was only slightly damp. S. *concordialis* was found there, inhabiting the damper places in the sand. *Quickella vagans* was also present in approximately equal numbers. The only shade was provided by a dead bush.

On a few other occasions, *Succinea concordialis* was found in drier situations, and the species is observed in the open, exposed to the sun, more than other species of Succineidae in Kansas.

General Remarks: Succinea concordialis was reluctantly placed in the section *Calcisuccinea* by Pilsbry (1948:826) because the genitalia resemble superficially those of S. *campestris* Say, S. *lutcola* Gould, and S. *l. floridana* Pilsbry. Webb (1954:10) has recently removed S. *concordialis* from *Calcisuccinea* and placed it in a new section, *Demosuccinea*, characterized by the fusion of the pore in the distal end of penial sheath, which prevents the epiphallus from emerging in a loop as it does in species of *Calcisuccinea*. I have observed several immature specimens of S. *concordialis* possessing a pore that allowed the epiphallus to emerge in a slight loop. Nevertheless, Webb's placing S. *concordialis* in a new section seems justified, because the pore in the penial sheath is seemingly always obliterated in the adult animal.

Parasites: One specimen of S. *concordialis* from Lone Star Lake, Douglas County, was infested by a fly larva, seemingly identical with those in several specimens of *Quickella vagans*.

Succinea vaginacontorta Lee

Pl. 9, fig. 3; text figs. 57, 61

Succinea vaginacontorta Lee, 1951, Occas. Pap. Mus. Zool.; Univ. Michigan, no. 533, p. 1, pl. 2, fig. 7.

Description of Shell: Shell dextral, fully developed; whorls 3, having suture only moderately impressed; whorls increase from apex to body whorl without marked discontinuity in size. In life, shell dull, translucent, light, horn yellow with greenish tones; striae well raised; epidermis of upper whorl eroded revealing dull white deeper layers of shell; parietal wall having well-developed callus, covering base of sightly curved columella; aperture obliquely ovate, flaring slightly at base of outer lip; interior of aperture having thin, shiny, transparent sheen (after Lee, 1951b:2, description of holotype).

Shell of Holotype: Length, 9.8 mm.; width, 5.9 mm.; aperture length, 5.7 mm.; aperture width, 4.2 mm.

Type Locality: Southwest corner of sec. 18, T. 33 S, R. 28 W, approximately 8 miles south and 4 miles west of Meade, Meade County, Kansas.

I found only one specimen of this species; it was at Meade County State Park, 3 June, 1956, on a bank of an artificial pond near the lake. The specimen was associated with numerous individuals of *Quickella vagans*. The animal remained unrecognized until dissected. Measurements of its shell are: length, 8.4 mm.; diameter, 4.9 mm.; length of aperture, 5.2 mm.; diameter of aperture, 3.6 mm.

This shell generally fits the original description; the callus is not well developed, but the striae are quite pronounced.

Externally, "the animal is a dull, grayish white with the anterior part finely peppered with black pigment . . . the surface of this hermaphroditic animal is sufficiently transparent in the region of the genital furrow to expose the outlines of both the vagina and penis . . . the edge of the mantle may have a few too many concentrations of black pigment. Some appear gray. The rest of the mantle is finely reticulated" (Lee, 1951b:3).

Genitalia (fig. 61): *Succinea vaginacontorta* is distinguished from all other known species of the Succineidae by the presence of a prominent torsion in the vagina, occurring slightly posterior to the junction of the vagina with the common genital atrium.

In the single specimen examined, the hermaphrodite duct is light gray. The unequal seminal vesicles are somewhat darker. The albumen gland, oviduct, prostate gland, and vagina are white. The penial sheath is relatively larger than in any other succineid examined and the epiphallus emerges from the penial sheath in a flattened loop. Distally, the penial sheath and vas deferens are peppered with gray. The prostate gland is small, and the vas deferens thick. The latter structure approaches the junction of penis and vagina and then rises to run parallel to the penial sheath until the vas deferens enters the sheath distally. The penial retractor muscle is thin and inserts on the penial sheath at the base of the free loop of the epiphallus. The seminal receptacle is small and globular, the duct originating immediately above the twisted portion of the vagina. The duct is long and slender.

The penial sheath is thick and resistant to cutting, more so than in any other species of the family known to occur in Kansas. As Lee (1951b:5)

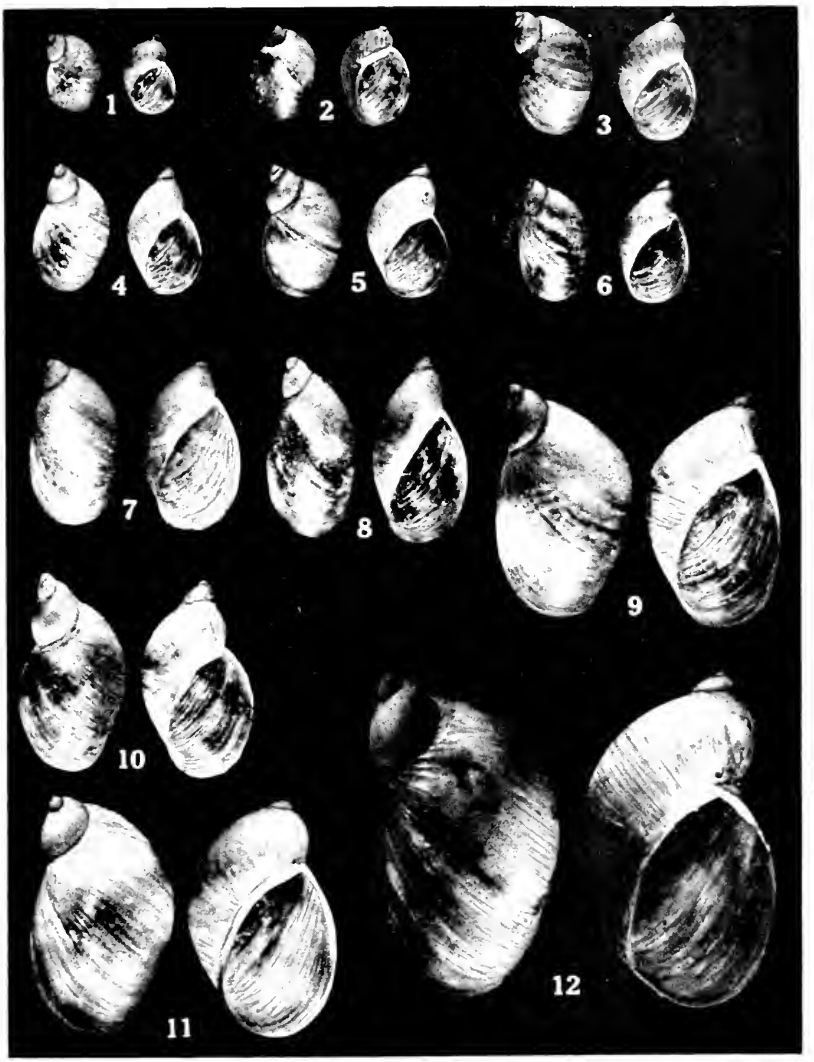
PLATE 9

Shells of Succineidae in Kansas

All figures enlarged approximately 2 times natural size.

1. *Quickella wandae* Webb, 7 mi. N Ottawa, Franklin County, Kansas. Collected by C. D. Miles, 8 April 1956. Catalogue number 10274.
2. *Succinea ovalis* Say. Shells of juvenal individuals, $^{2}/_{10}$ mi. N White Cloud, Doniphan County, Kansas. Collected by C. D. Miles, 22 April 1956. Catalogue number 10265.
3. *Succinea vaginacontorta* Lee, Meade County Park, 2 mi. S, 5 mi. W Meade, Meade County, Kansas. Collected by C. D. Miles, 3 June 1956. Catalogue number 10266.
4. *Succinea pseudavara* Webb, roadside embankment at Cimarron, Gray County, Kansas. Collected by C. D. Miles, 3 June 1956. Catalogue number 10268.
5. *Quickella vagans* (Pilsbry), shore of Lone Star Lake, 12 mi. SW Lawrence, Douglas County, Kansas. Collected by C. D. Miles, 28 July 1955. Catalogue number 10273.
6. *Succinea concordialis* Gould, University of Kansas Natural History Reservation, 4 mi. N, 1½ mi E Lawrence, Douglas County, Kansas. Collected by C. D. Miles, 16 May 1956. Catalogue number 10270.
7. *Oxyloma retusa* (Lea), 1½ mi. S Muscotah, Atchison County, Kansas. Collected by C. D. Miles, 11 May 1956. Catalogue number 10277.
8. *Oxyloma retusa* (Lea), $^{9}/_{10}$ mi. N Iowa Point, Doniphan County, Kansas. Collected by C. D. Miles, 4 September 1955. Catalogue number 10276.
9. *Succinea concordialis* Gould, 6 mi. W Altamont, Labette County, Kansas. Collected by C. D. Miles, 5 June 1955. Catalogue number 10271.
10. *Quickella vagans* (Pilsbry), $2^{3}/_{5}$ mi. W Burlingame, Osage County, Kansas. Collected by C. D. Miles, 12 June 1956. Catalogue number 10272.
11. *Succinea ovalis* Say. Shells of young individuals, $^{1}/_{5}$ mi. N White Cloud, Doniphan County, Kansas. Collected by C. D. Miles, 9 April 1955. Catalogue number 10264.
12. *Succinea ovalis* Say. Mature individuals, $^{1}/_{5}$ mi. N White Cloud, Doniphan County, Kansas. Collected by C. D. Miles, 9 April 1955. Catalogue number 10264.

PLATE 9



indicated in his original description, the penis is enclosed in a sheath "of tough, fibrous, fuzzy, connective tissue." In other species of *Succinea* examined, the sheath is thin and usually semi-transparent. The penis is relatively thin in *S. vaginacontorta*.

Distribution: *Succinea vaginacontorta* has been reported to occur only in Kansas. Webb (*op. cit.*) found the species at the following localities: Lawrence, Douglas County; south of Kingman, Kingman County; 6 miles north of Meade, Meade County; 3-4 miles north of Herington, Dickinson County.

Succinea pseudavara Webb

Pl. 9, fig. 3; text figs. 57, 61

Succinea pseudavara Webb, 1954, Gastropodia, vol. 1, no. 2, p. 10, fig. 8.

Shell: Amber-colored, rather polished, frequently coated with mud as in *Quickella vagans;* these two species easily confused; transverse striae less regular and riblike than in *Q. vagans;* spire approximately as long as aperture; apex pink-brown, darker than the remaining whorls; shell lacks filelike papillae of *Q. vagans* and revolving striae of *S. concordialis*.

Identification of *S. pseudavara* probably cannot be made from the shell alone, as Webb pointed out in his original description. He did not include measurements of shells. Several shells of this species from the bank of the Arkansas River in the City Park at Cimarron, Gray County, Kansas, measured as follows:

Measurements of Shells of *Succinea pseudavara* Webb

Length	Diameter	Length of aperture	Diameter of aperture
7.2 mm.	4.3 mm.	5.0 mm.	2.9 mm.
8.1	4.7	5.4	3.3
8.2	4.9	5.5	3.2
7.0	4.0	4.5	2.6

Because specimens of *S. pseudavara* were found at only four localities, two of which yielded four snails, no generalities can be made from ratios derived from measurements.

Type Locality: "About 1½ miles east of the University of Oklahoma Biological Station, at Lake Texoma, near Willis, Marshall County, Oklahoma" (Webb, 1954:18).

External Appearance of Animal: The color of the foot is grayish-white and lacks the brownish tint usually present in *Quickella vagans*, with which *pseudavara* may be confused. A small amount of gray stippling is present anteriorly on sides of foot and on top of head. The posterior tip of the animal also is obviously pigmented, in a vague pattern of vertical bars. The sole of the foot was pigmented in only two individuals. The pigmentation on the head and foot is much finer than the flecks present on *Succinea concordialis*, and is concentrated on the anterior and posterior parts of the animal. In *S. concordialis*, the pigmentation tends to be evenly distributed.

The pattern of the mantle resembles that of *Quickella vagans*. The ground color is usually translucent gray with darker gray present in the form of a reticulum. This darker gray is sometimes arranged in peripheral blotches, simulating the usual condition found in *Quickella*. A brownish tint on the

mantle has been observed in a few specimens. The rim of the mantle is white. The kidney usually is not obvious when viewed through the shell.

The eye-stalks are lightly pigmented and there is a narrow stripe of dark gray extending medially between their bases. The dorsal portion of the head and foot, when extended, is evenly pigmented gray on the surface bordered by the dark colored tentacular retractor muscles.

Genitalia (Fig. 61): *Succinea pseudavara* is obviously related to *Succinea concordialis* in details of its genitalia. The penial sheath of the former is large and ovate, enclosing a penis similar in appearance to that of *S. concordialis*. The penis is relatively thick distally, tapers as it approaches the genital atrium and increases abruptly in diameter before reaching the atrium. Most specimens of *S. pseudavara* examined by me agreed with Webb's description (1954:18) in lacking a pore on the distal end of the penial sheath, a loop of the epiphallus, therefore, not appearing. In two specimens, nevertheless, a pore was present and the epiphallus emerged in a loop. Approximately thirty specimens were dissected.

The seminal receptacle is globular; its duct is long and slender. The duct originates low on the oviduct; the vagina is therefore short. The prostate gland resembles that of *S. concordialis*, but is relatively larger. The vas deferens is somewhat thinner than in *S. concordialis* and is not flattened, which is one of the best methods of distinguishing the genitalia of the two species. The vas deferens reaches the junction of the penis and vagina, then rises to extend along the penial sheath before becoming incorporated distally in the sheath and penial retractor muscle. The penial retractor muscle is thin. The seminal vesicles are usually darker than the hermaphrodite duct and were relatively small in the specimens examined.

The entire reproductive system is colored varying shades of gray; the brownish color frequently seen in species of *Quickella* has not been observed in *S. pseudavara*.

Distribution: This species previously has been reported only from Oklahoma (Webb:1954). In the course of my study, specimens were collected from four counties in Kansas: Osborne, Gray, Barber, and Sumner.

Succinea pseudavara was found along the edges of streams in Kansas, associated with *Quickella vagans* and *S. concordialis*. The shade provided by bridges seems to attract this species, although specimens were also collected in more exposed places, under the concealment afforded by grass and other vegetation. The shells of several were coated with mud.

Genus *Oxyloma* Westerlund

Oxyloma retusa (Lea)

Pl. 9, figs. 7, 8; text figs. 57, 63-66

Succinea retusa Lea, 1834, Trans. Amer. Philos. Soc., vol. 5, p. 117, pl. 19, fig. 86; (Ohio, near Cincinnati).

Succinea higginsi "Bland, Nov. spec.." Tryon, July 1866, Amer. Jour. Conch., vol. 2, p. 237, pl. 17, fig. 24; Bland, October, 1866, same volume p. 373, pl. 17, fig. 24; W. G. Binney, 1885, Manual American Land Shells, p. 198, fig. 206.

Succinea retusa magister Pilsbry, 1899, Nautilus, vol. 12, p. 103; 19:109, fig. 2; Walker, 1906, Mollusca of Michigan, p. 502, fig. 110; F. C. Baker, 1939, Fieldbook Illinois Land Snails, p. 125, fig. B.

Succinea calumetensis Calkins, 1878, Valley Naturalist, vol. 1, no. 11, p. 57, text fig.; *cf.* Walker, 1906, Mollusca of Michigan, p. 502, fig. 108.

Oxyloma retusa (Lea), Pilsbry, 1948, Land Mollusca of North America, vol. 2, p. 785, figs. 421, 422C.

Description of Shell: Ovately oblong, thin, pellucid; spire short; whorls 3; aperture below dilate and drawn back; diameter 0.3, length 0.7 of an inch. "It differs so much from any of the described species in the dilation and retraction of the inferior part of the aperture that I have not hesitated to consider it new" (Lea's description, quoted by Pilsbry, 1948:786).

The shell of this species is an intense yellow-horn color. Whorls vary from 2-3, depending on the age of the animal. The suture between the body whorl and the apex is not prominent. The whorls are less convex than in any other known species of the Succineidae in Kansas. The aperture is elongate, occupying 70 per cent of the total length of the shell. In some populations, individual shells vary in greatest diameter to a marked extent. Lee (1951a) has pointed out that the parietal area and outer margin of the peristome tend to be straight, producing in outline an aperture resembling an elongate teardrop.

Type Locality: Ohio, near Cincinnati.

Measurements of Shells of *Oxyloma retusa* (Lea)

Length	Diameter	Length of aperture	Diameter of aperture
12.6 mm.	6.8 mm.	9.2 mm.	5.6 mm.
11.7	6.5	8.5	5.4
10.3	5.9	7.3	4.7
14.1	7.0	10.1	6.2
9.0	5.0	6.8	4.2

External Appearance: Baker (1939:125) reported that *Oxyloma retusa* appears in two color phases: dark in spring, and light in summer and autumn. Both color phases occur in Kansas. In the light phase, the foot of the animal is light gray, or yellow, with clumps of fine stippling present laterally and dorsally on the head and foot. Pigmentation is more profuse anteriorly, in some specimens disappearing toward the posterior half of foot. The sole of the foot is pigmented in some. In the darker color phase, considerably more pigment is present on the head, mantle, and foot. The lateral and anterior pigmentation on the foot of a few specimens may be arranged in vertical rows similar to the pattern exhibited in *Quickella*. The underside of the rim of the mantle is usually pigmented, the pigment being concentrated in the vicinity of the opening to the lung.

The mantle over the lung is stippled with fine dark gray dots, on a gray or tan background. The stippling is uniformly distributed anteriorly on the mantle, but becomes dispersed posteriorly, often appearing in isolated groups of dots on the posterior portion of the animal. Sparse stippling is often present on the rim of the mantle. As in *Quickella*, the pigmentation on the mantle may be concentrated peripherally into blotches, from which faint streaks radiate toward the kidney.

Genitalia (Figs. 63-66): *Oxyloma retusa* is characterized by the presence

of a small appendix on the penis, at about the position where the epiphallus inserts (Figs. 64-66). The appendix is extremely variable in size and shape within the species; this variability also occurs within a population. In large series of animals the appendix may vary from a blunt, scarcely developed protuberance, to a slender, tapering structure. The size of the appendix seemingly is not correlated with the size of the animal. The epiphallus is completely contained within the penial sheath and may be coiled or relatively straight. The penis is large and may be straight within the sheath, but frequently is bent or coiled in a half turn. The position of the appendix depends upon the degree of coiling of penis and epiphallus (Fig. 7).

The seminal receptacle is globular; its duct is short and of approximately the same diameter throughout its length. The duct originates high on the oviduct, resulting in a vagina the length of which is equal to that of the penis. The prostate gland is large and usually speckled with gray. The vas deferens is long, reaching to the junction of the penis and vagina, and then rising to insert on the distal end of the epiphallus after entering the penial sheath. The albumin gland is relatively small in comparison with oviduct and prostate gland. As in all species of Succineidae in Kansas, the degree of pigmentation of the genitalia varies from animal to animal.

Distribution: Oxyloma retusa was collected only in Atchison and Doniphan counties in northeast Kansas. In Atchison County, a large population exists in a marsh maintained by artesian flow, 1½ miles south of Muscotah. Although the snails were abundant there in 1955, the population has since declined.

In Doniphan County, specimens have been taken in considerable numbers. A favorable habitat for *Oxyloma retusa* is roadside ditches along Kansas Highway 7, in the vicinity of Iowa Point. *Succinea ovalis* inhabits the bluffs along these ditches. *O. retusa* may be seen on vegetation several feet from the ground. Specimens were taken also from dead vegetation on the ground and from the wet banks near water.

Elsewhere in North America, *O. retusa* has been reported from Ohio, Illinois, Iowa, Minnesota, North Dakota, and Montana (Pilsbry 1948:786).

Genus *Quickella* Boettger

Quickella vagans (Pilsbry)

Pl. 9, figs. 5, 10; text figs. 57, 67

Succinea campestris vagans Pilsbry, 1900, Nautilus, vol. 14, p. 74.

Quickella vagans (Pilsbry), 1948, Land Mollusca of North America, vol. 2, pt. 2, p. 843, fig. 456.

Shell: Shape globosely oval; whorls convex, surface rather dull or weakly glossy, irregularly and often in places somewhat coarsely wrinkled; shell small, fragile, having only 2½ to 2⅝ whorls in type lot; southern specimens having as many as three whorls; subtranslucent ecru-olive, lacking opaque whitish streaks or whitish inner layer of *campestris* (after Pilsbry, 1948:843).

The shell of this species varies strikingly within Kansas. The number of whorls ranges from 2½, in small individuals, to nearly 4. The color varies from light yellow to reddish brown. In some populations, the whorls tend to become flattened, giving the shell an elongate appearance. Striae are not well developed, although mature shells are never so glossy as those of *Succinea concordialis*. The shells of living snails are frequently coated with mud and debris.

The shells of young individuals may be confused with those of young of *S. concordialis*.

Measurements of Shells of *Quickella vagans* (Pilsbry)

Length	Diameter	Length of aperture	Diameter of aperture
12.6 mm.	6.3 mm.	7.3 mm.	4.6 mm.
11.5	6.2	7.1	4.7
10.0	5.8	6.6	4.4
9.0	5.0	5.4	3.3
6.7	4.2	4.3	3.0

Type Locality: Cape May Point, New Jersey.

External Appearance of Animal: Quickella vagans exists in 2 color phases, light and dark. In the dark phase, there is a characteristic pattern of vertical bars completely around the foot. These bars always are interrupted ventrally, and then continue a short distance to the sole. Anteriorly, four or five bars of pigment are present on the head, extending from the base of the eyestalks ventrally to near the mouth. These anterior bars tend to slant medially as they approach the mouth.

In the light phase, the pigmentation is scanty, or absent. If traces of the vertical bars persist, they invariably are on the anterior part of the animal.

The ground color is variable. It may be cream white or gray, or brownish-orange. There is nearly always a tinge of brown present on the animal, either laterally on the foot and/or dorsally on the head. The color of the sole of the foot is similar to the remainder of the foot, usually with varying degrees of brown. In some specimens the sole is stippled, but ordinarily it is immaculate.

There is seemingly no correlation between size of the animal and the color phase; both phases and intermediates usually are represented within a population.

The mantle of *Quickella vagans* also varies considerably although some modification of a basic pattern is present in most specimens. This pattern consists of streaks of pigmentation radiating inward toward the kidney from the margin of the mantle. Peripherally, the pigmentation is concentrated in blotches, from which the radiating streaks originate. The color varies from gray to brown, and in some specimens may be so intense as to obscure the pattern. The kidney usually is bright yellow or orange, easily visible through the mantle, but this organ may be nearly invisible because of intense pigmentation on the mantle. The ground color of mantle over the lung is usually translucent gray, but may be brown. The color of mantle and foot are independent of one another; a specimen with a lightly pigmented foot may possess a dark mantle.

Genitalia (Fig. 67): The distinguishing characteristic of *Q. vagans* is the

penis-appendix complex. The two structures are variable in their relative sizes, because the appendix is capable of infolding. The size of the appendix may be approximately equal to that of the penis, but is usually somewhat larger. There is no sheath investing the penis. Longitudinal ridges occur within the penis and appendix. From the distal end of the penis the epiphallus rises slightly for insertion of the penial retractor muscle, then descends, as the vas deferens, along the posterior surface of the penis-appendix to the junction of penis and vagina. The penial retractor muscle inserts on the epiphallus and sends a primary branch to the appendix; the penis proper is free of the retractor muscle, except for minor connectives.

The duct of the seminal receptacle originates low on the oviduct, somewhat as in *Succinea concordialis* and *S. pseudavara*. The length of this duct varies and is relatively much thicker than in the two species mentioned above. The seminal receptacle is sometimes globular, but is often elongate-oval. The vagina is short.

Distribution: Quickella vagans is generally distributed over the State and is by far the most abundant representative of the Succineidae in Kansas. Pilsbry (1948:844) records this species from New Jersey and North Carolina. Kagan (1949:38) was the first to discover that the genus *Quickella* occurs as far west as Michigan. Lee (1951a) later identified the species in Michigan. Webb (1953: 213) reported it in Kansas. This species is undoubtedly distributed over much of North America, but has been, and is, confused with species of *Succinea*.

Q. vagans inhabits a variety of habitats. The majority of specimens collected by me were found near margins of streams and lakes. In such places, individuals generally occur on the ground under a protective cover of grass, leaves and twigs, but some were above the ground attached to blades of grass and vegetation. An examination of the undersides of smooth logs and sticks lying on banks of streams often reveal specimens.

This species inhabits also dryer localities, sometimes at considerable distances from standing water. Specimens have been collected on the banks of dry streams in shady, deciduous woods. In June, 1956, large individuals were numerous in low, sandy, areas, barren of vegetation, in Meade County State Park of western Kansas. The sand was damp beneath small dead branches, scattered over the sand. Several large specimens of *Succinea concordialis* were associating with the quickellas.

At Atwood Lake in Rawlins County, of northwestern Kansas, several examples of *Q. vagans* and *S. concordialis* were found in the dry bed of a stream draining into the lake. The snails were under logs and boards on the bed of the stream, shaded by trees. There

was no standing water in sight; Atwood Lake was completely dry at the time.

In Johnson County, of eastern Kansas, a large population lived in a heavily wooded area, along the base of a small hill, under grass and brush, approximately ¼ mile north of DeSoto. This locality is more than one hundred yards from the Kansas River.

Q. vagans invariably lives beneath logs or other vegetation and has not been observed moving in places exposed to the rays of the sun, whereas, *S. concordialis* often is active in hot, dry places exposed to direct rays of the sun.

General Remarks: As mentioned earlier, *S. avara* and *S. grosvenori* previously have been considered to be abundant in Kansas. However, collections studied by Miles (1958) from many localities in Kansas have failed to reveal either species, as well as other species of *Succinea* previously reported in this state. It seems that the variable shell of *Quickella vagans*, and perhaps that of *Q. wandae*, have been confused with the species of *Succinea*. Additional collecting in Kansas may, of course, reveal the presence of additional species of *Succinea*, but I surmise that most shells previously regarded as *S. avara* and *S. grosvenori* were, in fact, *Quickella*. This statement is qualified because the distribution and abundance of *Succinea vaginacontorta* and *S. pseudavara* are imperfectly known; both species resemble *Quickella* and associate with it.

Quickella wandae Webb

Pl. 9, fig. 1; text figs. 57, 68

Quickella wandae Webb, 1953, Jour. Tennessee Acad. Sci., vol. 28, p. 216, pls. 3, 4.

Shell: Closely resembles that of *Quickella vagans* (Pilsbry); greenish yellow; epidermis brownish where thick; apex less obtuse than in *Quickella vagans*, and size less; umbilicus closed on lower half of columella, and rarely partly unsealed (after Webb, 1953:216).

Miles (1958:1529) found only one specimen of *Q. wandae*. It was obtained along with several specimens of *Q. vagans* on 8 April, 1956, from the bank of a small stream, 7 miles north of Ottawa, Franklin County, Kansas.

This one shell possesses 2⅔ whorls. The color is greenish yellow. Striae are well developed on the body whorl, but are scarcely evident on the apex. A parietal callus is present, but is not prominent.

Webb did not include measurements of shells with his original description of this species. The one shell examined by Miles and myself measured: length, 5.4 mm.; diameter, 3.5 mm.; length of aperture, 3.4 mm.; diameter of aperture, 2.4 mm.

Type Locality: 8½ miles south and ½ mile east of Alma, Wabaunsee County, Kansas.

External Appearance of Animal: Rim of mantle at aperture and exertile body flecked with brown; liver light brown; grooves of foot whitish; regions between grooves blackish, fading posteriorly on foot; body anterior to visceral pillar grayish, marked dorsolaterally on each side by unpigmented line; sole whitish, densely flecked with orange; mantle of lung whitish having about nine interrupted streaks of dashlike markings (after Webb, 1953:216—referred to a drowned specimen).

In the single specimen examined, the lateral vertical bars are well developed around the entire foot. They are interrupted ventrally, as in *Quickella vagans*. The mantle pattern differs from the typical pattern of *Q. vagans;* instead, the dashlike markings mentioned in the description by Webb are present. The ground color of the mantle over the lung is light gray.

Genitalia (Fig. 68): The diagnostic feature which serves to distinguish the two known species of *Quickella* in Kansas, is a peculiar white, smooth, extension on the appendix in *Q. wandae*, which lengthens this organ considerably more than the penis. Webb (*loc. cit.*) referred to this extension as a "glandular outgrowth" on the appendix.

The relationship of the penial retractor muscle to the penis-appendix complex may offer an additional diagnostic character. In *Q. vagans*, the muscle inserts on the epiphallus, sending a primary branch to the appendix; the penis is nearly free of any contact with the muscle. In the one specimen of *Q. wandae* examined, the muscle inserts on the epiphallus and the primary branch attaches to the penis near the junction of the penis and the appendix; the appendix is free of the muscle. Whether or not this character is specific for *Q. wandae* is unknown, because of the lack of material.

The remainder of the genitalia of the one animal observed does not differ significantly from the same organs in *Quickella vagans*. The hermaphrodite duct is gold-colored, not pigmented. The seminal vesicles are of unequal size and lightly flecked with brown. The seminal receptacle and duct appear as they do in *Q. vagans*.

Distribution: *Q. wandae* has been reported only from Kansas. Webb collected specimens in four counties: Douglas, Leavenworth, Wabaunsee, and Anderson. The one specimen collected by Miles adds Franklin County to the known range. All specimens collected by Webb were found in rather shady, deciduous woods on well-drained, damp terraces.

General Remarks: In general the shells of *Q. wandae* and *Q. vagans* are indistinguishable.

Family STROBILOPSIDAE Hanna

The family Strobilopsidae contains but the single genus *Strobilops*, widely distributed over the world, although absent from the living fauna of Europe, where it flourished in Tertiary time. The shells of the numerous species are small, scarcely more than 3 millimeters in diameter, generally trochiform, with 4½ to 6 whorls. The surface of the shell is characterized by conspicuous obliquely

radial riblets, and the first whorl bears a series of elongate lamellae, one or two of which may be seen in the aperture. The lamellae enter deeply, some of them in some species entering for the full length of the last volution. There is also a columellar lamella, and a series of basopalatal lamellae in American representatives of the family; the columellar and basopalatal lamellae are situated at some distance from the aperture, and cannot be observed easily in intact shells.

The American species of the family Strobilopsidae occur in the humid eastern half of North America from Canada at about N. Lat. 52°, to Guatemala; in Cuba and Jamaica; in South America from Venezuela to Para in eastern Brazil; in the Galapogos Islands; in Japan, Korea, China and the Philippine Islands.

Genus *Strobilops* Pilsbry

Strobilops labyrinthica (Say)

Pl. 8, figs. 1, 2; text fig. 71

Helix labyrinthica Say, 1817, Jour. Acad. Nat. Sci. Philadelphia, 1:124.

Strobila labyrinthica, Binney and Gray, 1885, Bull. Washburn College, Lab. Nat. Hist., 1:56; Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Strobilops labyrinthica virgo, Pilsbry, 1895, Nautilus, vol. 6, p. 94.

Strobilops labyrinthica, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:422, pl. 31, figs. 22-24; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:854, fig. 463; Leonard and Globe, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1038, pl, CI, fig. 16.

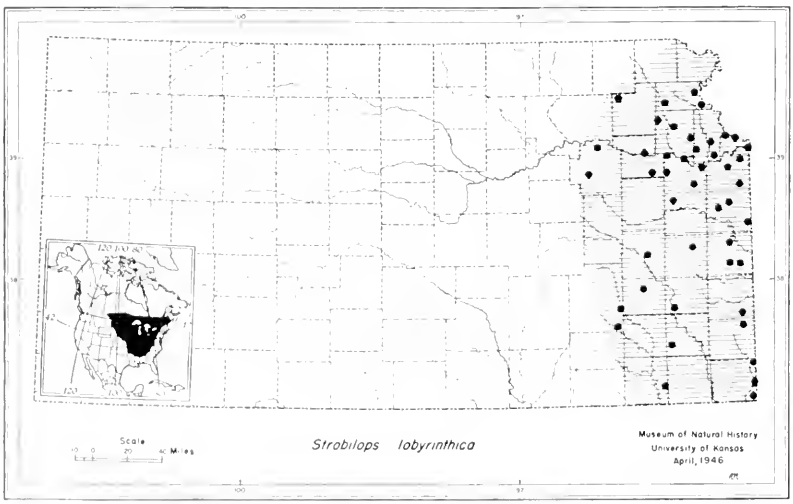


Fig. 71. Distribution of *Strobilops labyrinthica* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Strobilops labyrinthica parietalis, Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120.

Range: Eastern North America from Quebec and Georgia westward to Manitoba, Arkansas, and eastern Kansas.

Distributed generally throughout the eastern fourth of Kansas.

Description: Shell slighdy less than ¼ inch in diameter (2.5 mm.); trochiform, markedly convexly-conic or dome shaped; sculpture of obliquely radial ribs; reddish to brownish, occasionally white; whorls 5½, convex, periphery sub-angular; sutures impressed; umbilicus contained about 10 times in diameter of shell; aperture semilunar; lip reflected, brown; dentition consisting of parietal lamella and infra-parietal lamella.

Measurements of Figured Specimen (Pl. 8)

Height, 1.9 mm.; greater diameter, 3.0 mm.; number of whorls, 5½

Recognition Characters: This snail is unlikely to be confused with any other in the State. The shell most closely resembles that of the various members of *Euconulus* in shape, but can easily be distinguished by prominent ribs, reflected lip, the lamellae, and reddish color.

Habitat and Habits: This snail inhabits forested areas, and is found in and among the leaf litter, decaying logs, beneath started bark and other debris of the forest floor.

The lamellae: In the robust and rather opaque shells of *Strobilops* the lamellae are difficult to observe directly, although they can sometimes be seen in well cleaned shells if viewed by transmitted, rather than by reflected light. Shells can be dissected with difficulty; a better method of exposing the lamellae to view is to imbed the shell in plaster of Paris, and grind the shell down to the desired level. This has the obvious disadvantage, however, of destroying at least part of the shell. The reader is referred to the excellent illustrations of the shells and lamellae of Strobilops in the United States in Pilsbry (1948:849).

Family PUPILLIDAE Turton

The family Pupillidae is a large one, comprising more than forty genera and about 700 species, distributed over all the continents and most islands. The shells are small or minute, in many genera shaped somewhat like a grain of wheat, although the form of the shell varies among the many genera from ovate to elongate cylindric. Almost invariably, the shells are robust, and are readily preserved in geologic sediments.

One of the outstanding characteristics of the pupillid shell is the possession in the aperture of a series of outgrowths of highly variable form among the many kinds, but relatively stable in form in any given species. These outgrowths of the shell, called lamellae,

denticles, or, in common parlance, "teeth," seem to have a basic pattern of five (text figure 17; Pilsbry, 1948, fig. 469), but the number is fewer in some species; and in other species is more owing to the addition of supernumerary denticles. Among the pupillids in Kansas *Pupoides albilabris* has no denticles in the aperture of the shell, while the opposite extreme in the pupillids of our fauna is reached in *Gastrocopta pentodon* having seven or even more denticles or lamellae. The characteristic form of the shells of pupillid gastropods, together with the relatively stable pattern of apertural denticles in the several species, makes the shells of these snails highly reliable features for classification. In this respect the Pupillidae represent the opposite extreme from the Succineidae, in which the shells are almost worthless for classification.

KEY TO THE GENERA AND SPECIES OF PUPILLIDAE IN KANSAS

1. Aperture bearing lamellae or denticles 4
   Aperture lacking lamella or denticles (Genus *Pupoides*) 2
2. Lip of peristome broadly reflected; outer lip having local thickening ..... *Pupoides albilabris*, p. 181
   Lip of peristome not broadly reflected; outer lip lacking local thickening 3
3. Surface of shell bearing widely spaced, radial riblets. ..... *Pupoides hordaceous*, p. 183
   Surface of shell lacking radial riblets ..... *Pupoides inornatus*, p. 183
4. Outer lip of peristome indented (Genus *Vertigo*) 5
   Outer lip of peristome not indented (Genus *Gastrocopta*) 7
5. Apertural denticles more than 4 in number 6
   Apertural denticles not more than 4 in number. ..... *Vertigo tridentata*, p. 187
6. Shell ovate, height less than 2 millimeters ..... *Vertigo milium*, p. 184
   Shell ovate, height more than 2 millimeters ..... *Vertigo ovata ovata*, p. 185
7. Apertural denticles or lamella no more than 3 in number. ..... *Gastrocopta corticaria*, p. 177
   Apertural denticles or lamella more than 3 in number 8
8. Apertural denticles or lamella more than 7 in number 9
   Apertural denticles or lamella less than 7 (but more than 3) in number 10
9. Shell cylindric in shape ..... *Gastrocopta pentodon*, p. 175
   Shell ovate in shape ..... *Gastrocopta tappaniana*, p. 176
10. Angulo-parietal lamella bifid as seen in apertural view 11
    Angulo-parietal lamella not bifid as seen in apertural view 13
11. Outer lip of peristome bearing a distinct thickening or callus. ..... *Gastrocopta procera procera*, p. 178
    Outer lip of peristome lacking a thickening or callus 12
12. Shell ovate, peristome triangular ..... *Gastrocopta contracta contracta*, p. 17
    Shell cylindric, peristome not triangular (squarish). ..... *Gastrocopta pellucida hordeacella*, p. 180

13. Aperture having subcolumellar fold or denticle.
Gastrocopta cristata, p. 180
Aperture lacking subcolumellar fold or denticle 14
14. Shell minute; height not over 2 millimeters *Gastrocopta holzingeri*, p. 174
Shell large; height more than 4 millimeters.
Gastrocopta armifera armifera, p. 169

Genus *Gastrocopta* Wallaston

Gastrocopta armifera (Say)

Pl. 10, fig. 13; text figs. 17, 72

Pupa armifera Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:162, type locality Philadelphia (Germantown, Philadelphia, selected by Pilsbry, 1948:875). Type A. N. S. P. # 11624; Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:56.

Leucochila armifera, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Bifidaria armifera, Hanna, 1909, Nautilus, 23:94.

Gastrocopta armifera abbreviata, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 4; Leonard, 1943, Trans. Kansas Acad. Sci., 46:238, pl. 1, fig. 11; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120.

Gastrocopta armifera, Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:415, pl. 32, figs. 38, 39; Franzen, 1947, Trans. Kansas Acad. Sci., 49:417, pl. 2, figs. 10, 11; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:328, pl. 17, figs. 3-5, text fig. 3; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:874, fig. 472: 1-4; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1029, pl. 101, fig. 23.

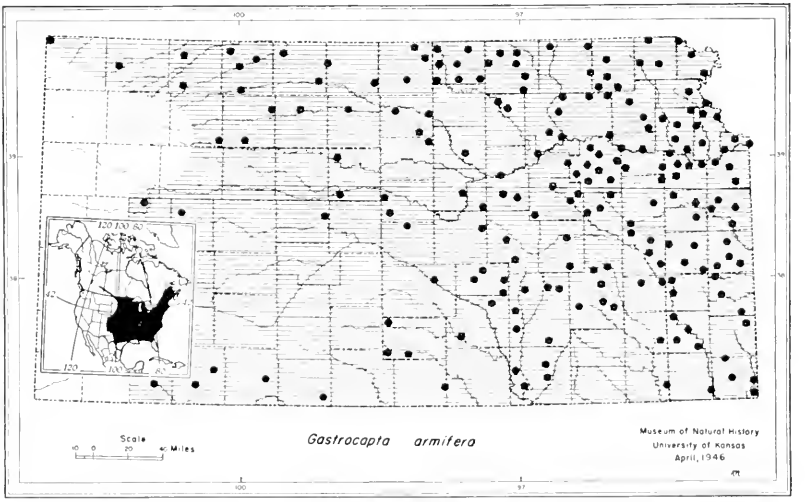


FIG. 72. Distribution of *Gastrocopta armifera* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Range: Eastern North America from southern Canada to northern Florida, west to Alberta, Dakota, New Mexico.

In Kansas, this species is widely distributed over most of the State. Records are lacking in extreme western Kansas.

Description: Shell about ⅛ inch in height (3.6-5.0 mm.); ovate-cylindrical, apex obtuse, grayish-white or waxy in color, glossy; very finely and irregularly striate; whorls 6-7, convex, regularly increasing in size, body whorl more than ½ total height; sutures impressed; umbilicus a chink; aperture oval, more than ½ height of body whorl; lip sharp, white, narrowly reflected; callus wide. Denticles 6-7; a prominent, bifid angulo-parietal situated at center of parietal wall; 4 folds situated on low palatal callus (low, tubercular suprapalatal, prominent elongate, oblique upper and lower palatals, tubercular basal); columellar triangular, projecting outward.

Measurements of Figured Specimen (Pl. 10)

Height, 5.0 mm.; diameter, 2.6 mm.; number of whorls, 6

The body of the animal is comparatively large; foot whitish; head, neck and eye-peduncles black.

Recognition Characters: This is the largest of the Pupillidae in Kansas and can be distinguished on the basis of size alone, but the characteristic pattern of apertural denticles as well as the ovate form of the shell provides further clues to its identity.

Habitat and Habits: This snail occurs in a very wide variety of habitats. It is to be expected wherever land snails are to be looked for in the State, is gregarious, and usually can be collected in considerable numbers.

Goodrich and van der Schalie (1944:275), in writing of the genus as a whole, state that "The species of the middle western area apparently all winter as eggs and in spring develop rapidly toward maturity."

With reference to locomotion, Baker (1902:234) states that "The animal is very slow and deliberate in movement and does not readily crawl about."

Gastrocopta contracta (Say)

Pl. 10, fig. 4; text fig. 73

Pupa contracta Say, 1822, Jour. Acad. Nat. Sci. Philadelphia, 2:374, type locality, Occoquan, Virginia; Binney and Gray, 1885, Bull. Washburn College Lab. Nat. Hist., 1:56.

Pupilla contracta, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:206.

Bifidaria contracta, Hanna, 1909, Nautilus, 23:94.

Gastrocopta contracta, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 2; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 1:417, pl. 32, figs. 34, 35; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120; Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 2, fig. 1; Franzen and Leonard, 1947,

Univ. Kansas Sci. Bull., 31, pt. 2:330, pl. 18, fig. 9; text fig. 4; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:880, fig. 474:9-12; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1031, pl. 101, fig. 11.

Range: Eastern North America from southern Canada to Florida, west to Manitoba and Texas; Mexico.

In Kansas widely distributed in the eastern half of the State.

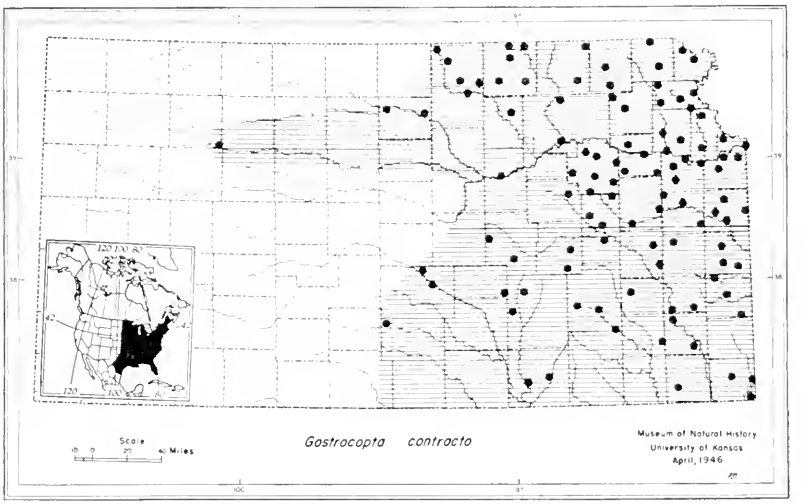


FIG. 73. Distribution of *Gastrocopta contracta* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell less than ⅛ inch in height (2.5 mm.); ovate-conic, bluish-white to waxy, glossy, semitranslucent; finely and irregularly striate; whorls 5-6, convex, increasing gradually in size, body whorl slightly more than ½ total height; sutures impressed; umbilicus a chink; aperture somewhat triangular, lip thin, broadly reflected, continuous; crest of variable distinctness behind peristome and separated from it by wide groove; denticles large, almost filling aperture; angulo-parietal large, fused, upper palatal tubercular, lower palatal, slightly elongate, oblique, deeply immersed; columellar large, lamelliform.

Measurements of Figured Specimen (Pl. 10)

Height, 2.2 mm.; diameter, 1.3 mm.; number of whorls, 5

The foot of the animal is long and narrow, the body white and transparent, and the head, neck and eye-peduncles are black. The eye-peduncles are long and slender, the tentacles conical and short.

Recognition Characters: The shape of the shell and the triangular aperture almost filled by the dentition distinguish *G. contracta* from all other pupillids in Kansas.

PLATE 10

Shells of Pupillidae in Kansas

All figures enlarged approximately 10 times natural size.

1. *Gastrocopta holzingeri* (Sterki), University of Kansas Natural History Reservation, near entrance 5½ mi. NNE Lawrence, in sec. 4, T. 12 S, R. 20 E, Douglas County, Kansas. Collected by G. R. Webb, 9 November 1950. Catalogue number 7012.

2, 3. *Gastrocopta pentodon* (Say), NW ¼ sec. 32, T. 11 S, R. 11 E, Wabaunsee County, Kansas. Collected by E. J. Roscoe, 7 October 1950. Catalogue number 8905.

4. *Gastrocopta contracta* (Say), SW ¼ sec. 3, T. 7 S, R. 14 E, Jackson County, Kansas. Collected by E. J. Roscoe, 17 June 1951. Catalogue number 7851.

5. *Gastrocopta pellucida hordeacella* (Pilsbry), Hutchinson, Reno County, Kansas. Collected by G. D. Hanna, 10 April 1909. Catalogue number 2243.

6. *Gastrocopta tappaniana* (C. B. Adams), NW ¼ sec. 15, T. 28 S, R. 3 W, Sedgwick County, Kansas. Collected by E. J. Roscoe, 28 July 1951. Catalogue number 7898.

7. *Gastrocopta corticaria* (Say), 5 mi. E Baxter Springs, Cherokee County, Kansas. Collected by D. S. Franzen, 8 September 1943. Catalogue number 1317.

8. *Gastrocopta procera procera* (Gould), SE ¼ sec. 22, T. 2 S, R. 40 W, a small spring, 0.1 mi. S of Plum Creek, local drift, Cheyenne County, Kansas. Collected by D. S. Franzen, 14 June 1944. Catalogue number 3463.

9. *Gastrocopta cristata* (Pilsbry and Vanatta), NE ¼ sec. 9, T. 1 S, R. 42 W, or NW ¼ sec. 10, T. 1 S, R. 42 W, flood plain of Arickaree River, Cheyenne County, Kansas. Collected by D. S. Franzen, 13 June 1944. Catalogue number 3458.

10. *Vertigo milium* (Gould), NE ¼, SW ¼ sec. 15, T. 11 S, R. 12 E, Atchison County, Kansas. Collected by G. R. Webb, 28 October 1951. Catalogue number 8839.

11. *Vertigo ovata ovata* Say, Hutchinson, Reno County, Kansas. Collected by G. D. Hanna, 10 April 1909. Catalogue number 2096.

12. *Vertigo tridentata* Wolf, Lawrence, Douglas County, Kansas. Collected by E. C. Johnson and G. D. Hanna, 20 February 1909. Catalogue number 2037.

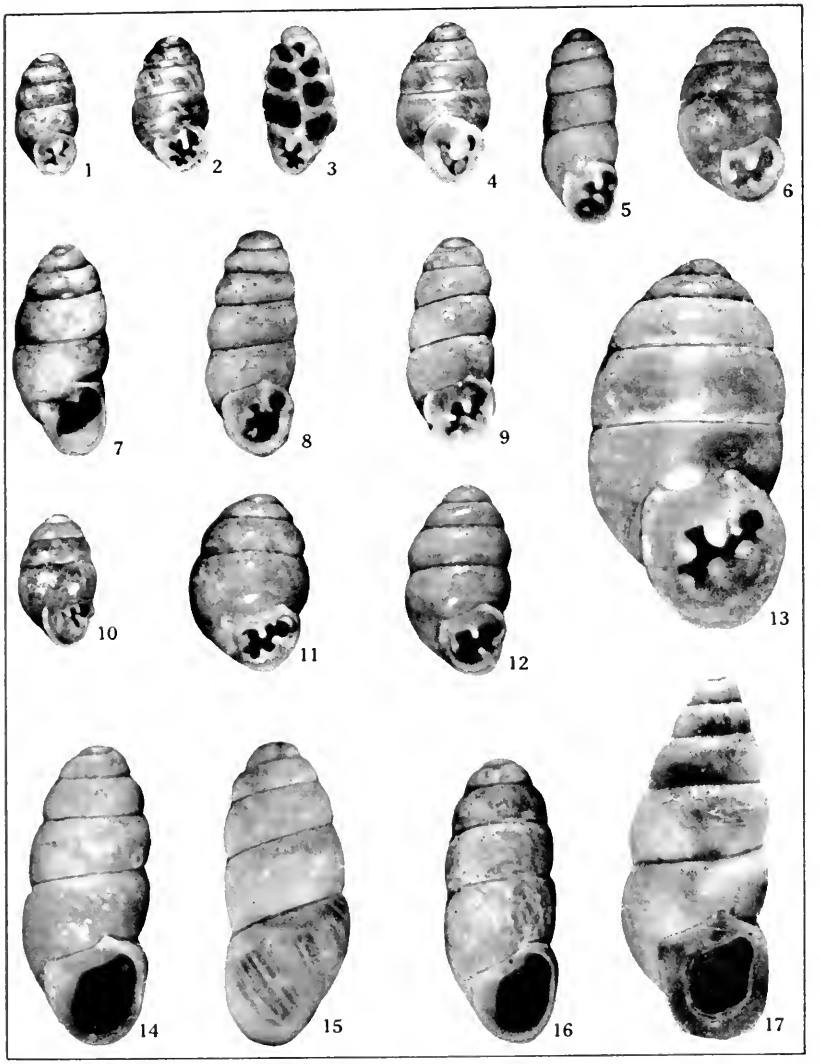
13. *Gastrocopta armifera* (Say), NW ¼ sec. 28, T. 22 S, R. 1 E, Harvey County, Kansas. Collected by E. J. Roscoe, 20 May 1951. Catalogue number 7313.

14, 15. *Pupoides hordaceus* (Gabb), Nickerson, Reno County, Kansas. Collected by G. D. Hanna, 22 December 1908. Catalogue number 2020.

16. *Pupoides inornatus* Vanatta, in drift from flood plain of Arickaree River, NW ¼ sec. 10, T. 1 S, R. 42 W, Cheyenne County, Kansas. Collected by D. S. Franzen, 13 June 1944. Catalogue number 3642.

17. *Pupoides albilabris* (C. B. Adams), Midland, Douglas County, Kansas. Collected by E. C. Johnson, 19 March 1910. Catalogue number 2896.

PLATE 10



Habitat and Habits: This snail occupies almost as wide a variety of habitats as the larger *G. armifera*, the two being commonly found together. *Gastrocopta contracta* does not seem to be so abundant at any one locality nor to occur in so dry a situation as *G. armifera*.

Baker (1902:236) records that "The shell is carried well upright and the motions of the animal are generally slow and methodical. Frequently when crawling over a table it will lift up its head and a portion of its body until only the tail rests on the surface."

Gastrocopta holzingeri (Sterki)

Pl. 10, fig. 1; text fig. 74

Pupa holzingeri Sterki, 1889, Nautilus, 3:37, 96, 199, type locality Will Co., Illinois, type Carnegie Museum No. 62.20385.

Bifidaria holzingeri fordiana, Hanna, 1909, Nautilus, 23:94.

Bifidaria agna, Hanna, 1909, Nautilus, 23:94.

Gastrocopta holzingeri, Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 2, fig. 4; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:333, pl. 18, fig. 2, text fig. 5; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:883, figs. 474:4-6, 475; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1032, pl. 101, fig. 13.

Gastrocopta holzingeri agna (Pilsbry and Vanatta), Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:884, figs. 474:7; 476.

Range: North America from southern Canada and western New York west to Montana, south to New Mexico.

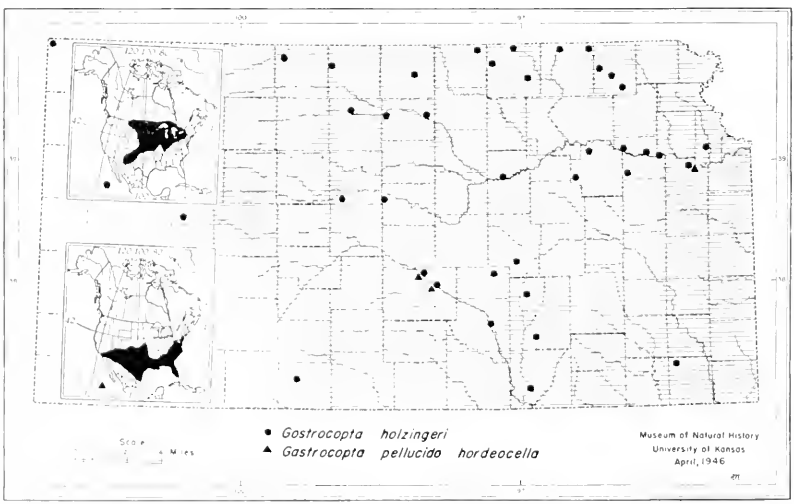


Fig. 74. Distribution of *Gastrocopta holzingeri* and *Gastrocopta pellucida hordeacella* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

In Kansas, *Gastrocopta holzingeri*, occurs over most of the state, but is more abundant in the eastern half.

Description: Shell slightly more than 1/16 inch high (about 2 mm.); cylindrical, apex obtuse, grayish-white, translucent, finely and irregularly rounded, more than ½ height of body whorl; lip thin, reflected, a thin callus present; an oblique crest some distance behind outer lip. Denticles 6 as follows: fused angulo-parietal large; suprapalatal tubercular and low; upper palatal slightly elongate; lower palatal higher and more deeply immersed than upper palatal; basal pyramidal; columellar elongate and high.

Measurements of Figured Specimen (Pl. 10)

Height, 1.7 mm.; diameter, 0.8 mm.; number of whorls, 5

Recognition Characters: The size, shape and color of this shell taken together constitute its readily observable distinctive features.

Habitat and Habits: This snail has been found in both wooded floodplains and in upland forest areas. We have found it abundant also in upland grasslands where permanent moisture is locally available, as, for example, near springs.

Gastrocopta pentodon (Say)

Pl. 10, figs. 2, 3; text fig. 75

Vertigo pentodon Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:376.

Pupilla pentodon, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:205.

Bifidaria pentodon, Hanna, 1909, Nautilus, 23:94.

Gastrocopta pentodon, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 1; Franzen and Leonard, 1943, Univ. Kansas

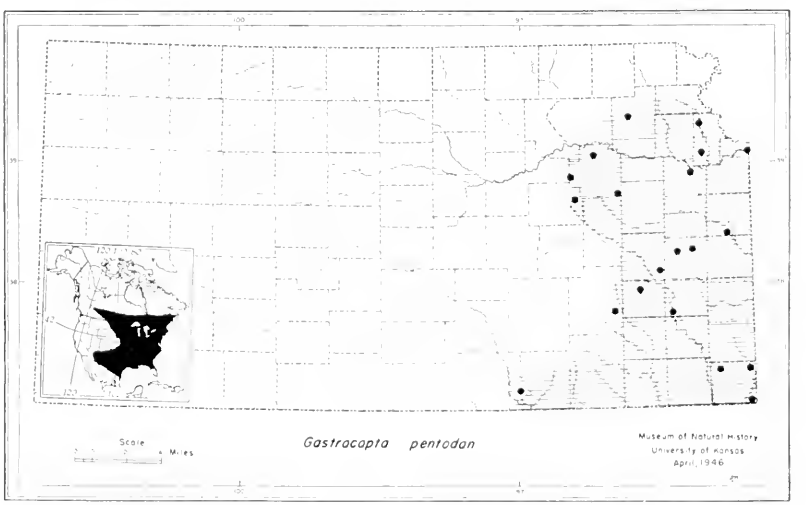


FIG. 75. Distribution of *Gastrocopta pentodon* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Sci. Bull., 29, pt. 2:417, pl. 32, fig. 33; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1032, pl. 101, fig. 12; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:886, fig. 477:2, 3, 5-8.

Gastrocopta tappaniana, Franzen and Leonard, 1947 (partim), Univ. Kansas Sci. Bull., 31, pt. 2:336, pl. 18, fig. 8, text fig. 6.

Range: Eastern North America from southern Canada south to Mexico and central Florida; Guatemala. In Kansas known from eastern third or less but not yet recorded from northernmost tier of counties.

Description: Shell about 1/16 inch in height (1.5-2 mm.); oblong-conic, apex obtuse, whitish, translucent; finely and irregularly striate; whorls 5, convex; sutures impressed; minutely umbilicate; lip thin, reflected, thin callus present; crest behind lip. Denticles 5-8, usually 7, namely angulo-parietal, columellar, upper palatal, lower palatal, subcolumellar, basal, and interpalatal.

Measurements of Figured Specimen (Pl. 10)

Height, 2.0 mm.; diameter 1.1 mm.; number of whorls, 5

Recognition Characters: This snail may be confused with *G. holzingeri* but differs in being more conic, larger and wider, and in the dentition. From *G. tappaniana*, *G. pentodon* differs in being less conic, smaller, and having the body whorl but slightly wider than the preceding whorls.

Habitat and Habits: Gastrocopta pentodon is found in both wooded areas and under suitable cover in grasslands. Baker (1939: 100) states that it is "seldom in wet places."

Gastrocopta tappaniana (C. B. Adams)

Pl. 10, fig. 6; text fig. 76

Pupa tappaniana "Ward" C. B. Adams, 1842, in Thompson's History of Vermont, p. 158.

Bifidaria tappaniana, Hanna, 1909, Nautilus, 23:94.

Gastrocopta tappaniana, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 6; Franzen, 1947, Trans. Kansas Acad. Sci., 49:418, pl. 2, fig. 3; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:336, pl. 18, fig. 8, text fig. 6; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:889, fig. 477, item 9.

Gastrocopta tappaniana curta, Leonard, 1943, Trans. Kansas Acad. Sci., 46:239, pl. 1, fig. 15.

Range: North America from southern Canada (Ontario) and Alabama west to South Dakota and Arizona; absent from southeastern Atlantic states (Virginia to Florida).

In Kansas, *Gastrocopta tappaniana* occurs over most of the State, but populations are much more numerous in the eastern half.

Description: Shell slightly more than 1/16 inch high (1.5-2.5 mm.); conic, apex obtuse, grayish-white, opaque, finely and irregularly striate; whorls 4½-5, convex, increasing rapidly in size; sutures impressed; minutely umbilicate; aperture ovate, oblique; lip thin, reflected; thin callus present; crest behind lip; denticles 6-9, usually 7, namely, fused angulo-parietal, low tubercular infrapalatal, upper palatal, interpalatal, lower palatal, basal, and columellar.

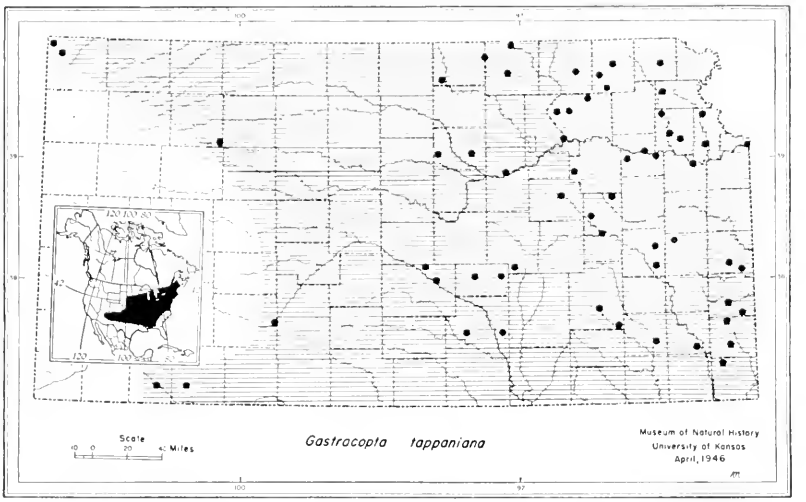


FIG. 76. Distribution of *Gastrocopta tappaniana* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Measurements of Figured Specimen (Pl. 10)

Height, 2.3 mm.; diameter, 1.3 mm.; number of whorls, 5

Recognition Characters: This species may be confused with *G. pentodon* but is markedly more conic, usually larger, and the body whorl is noticeably larger than the rest of the whorls.

Habitat and Habits: This snail is found beneath wood, logs and similar debris in moist places, especially on floodplains and in moist upland forested areas.

Gastrocopta corticaria (Say)

Pl. 10, fig. 7; text fig. 77

Odostomia corticaria Say, 1816, Nicholson's Amer. edition British Encyclopedia, 2, pl. 4, fig. 5, type locality Philadelphia, Pa., Neotype A. N. S. P. # 64524a.

Gastrocopta corticaria, Franzen, 1944, Trans. Kansas Acad. Sci., 47:265, pl. 1, fig. 1; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:339, pl. 18, fig. 8, text fig. 7; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:894, fig. 480:1-4.

Range: Eastern North America from southern Canada (Ontario) west to Minnesota, south to Florida and Louisiana, west to Kansas.

Limited to extreme eastern Kansas.

Description: Shell slightly less than ¼ inch in height (2.5-3 mm.); cylindric-ovate, apex obtuse, grayish-white, translucent, glossy, finely and irregularly striate; sutures impressed; minutely umbilicate; aperture irregularly oval, lip thin, reflected; no callus; no crest behind lip; denticles 2-3; parietal low,

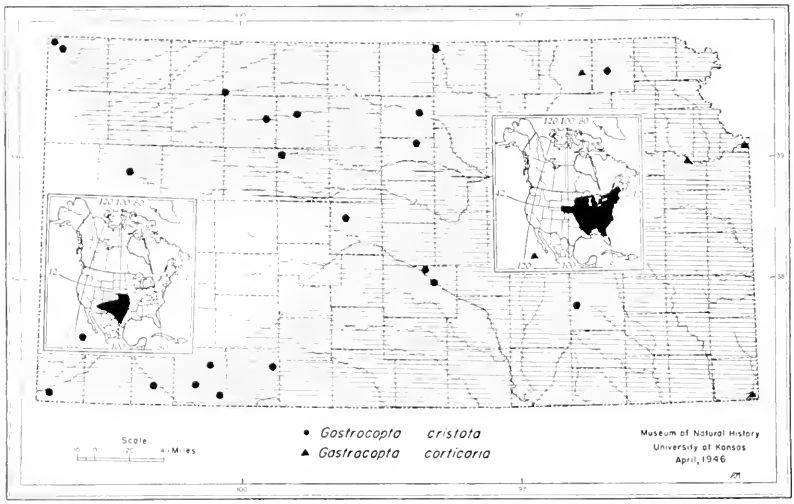


FIG. 77. Distribution of *Gastrocopta cristata* and *Gastrocopta corticaria* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

elongate; low angular sometimes present and sometimes partly fused with parietal; columellar low, tubercular; denticles rarely entirely absent.

Measurements of Figured Specimen (Pl. 10)

Height, 2.8 mm.; diameter, 1.1 mm.; number of whorls, 5½

The body of the animal is whitish; the head and eye-peduncles are darker.

Recognition Characters: This species is readily distinguished from all other gastrocoptids in the State by the small number of denticles and lack of labial teeth.

Habitat and Habits: G. corticaria has been found in the crevices of rotting logs, under sticks and stones, and on the bark of living trees some distance above the ground.

Gastrocopta procera procera (Gould)

Pl. 10, fig. 8; text fig. 78

Pupa procera Gould, 1840, Boston Jour. Nat. Hist., 3:401; 4:359, type locality Baltimore, Maryland. Types: Boston Soc. Nat. Hist. (lost?).

Bifidaria rupicola, Pilsbry and Vanatta, 1900, Proc. Acad. Nat. Sci. Philadelphia, p. 595, pl. 22, fig. 1.

?Leucochila rupicola, Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:205.

Bifidaria procera, Hanna, 1909, Nautilus, 23:94.

Gastrocopta procera duplicata, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 8; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:419, pl. 32, fig. 31.

Gastrocopta procera machungi, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 7; Leonard, 1943, Trans. Kansas Acad. Sci.,

46:239, pl. 1, fig. 14; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:419, pl. 32, fig. 32; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120.

Gastrocopta procera sterkiana, Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120.

Gastrocopta procera, Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 2, figs. 8, 9; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:341, pl. 18, figs. 3, 6, text fig. 8; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:907, fig. 492:1-3; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1033, pl. 101, fig. 15.

Range: Eastern United States from Maryland to South Carolina, west to Kansas and eastern Texas.

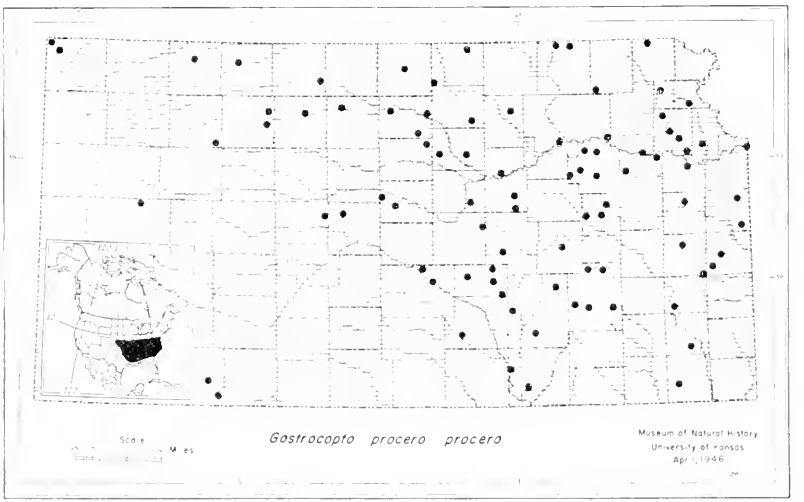


FIG. 78. Distribution of *Gastrocopta procera procera* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

In Kansas distributed generally over the State, but absent in the extreme western portion.

Description: Shell slightly less than ⅛ inch in height (2-3 mm.); cylindrical, apex obtuse, light brown, glossy, finely and irregularly striate; whorls 5-6½, convex, increasing regularly in size; sutures impressed; minutely umbilicate; aperture rounded, lip thin, reflected; crest behind lip; denticles 5-6: angulo-parietal fused, prominent; upper palatal small, tubercular; lower palatal elongate, deeply immersed; basal low; columellar horizontal; subcolumellar present in some specimens, low, tubercular.

Measurements of Figured Specimen (Pl. 10)

Height, 2.8 mm.; diameter, 1.1 mm.; number of whorls, 5½

Recognition Characters: This species superficially resembles *Gastrocopta cristata*, but can be easily distinguished by the bifid angulo-parietal lamella.

the less prominent crest behind the lip, and the lesser relative diameter of the shell.

Habitat and Habits: This snail is found under leaves, stones, sticks and in and around rotting logs in forested areas as well as in more open situations.

An extended discussion of the problem of how many of the named subspecies should be recognized has been given by Franzen and Leonard (1947:343-344).

Gastrocopta cristata (Pilsbry and Vanatta)

Pl. 10, fig. 9; text fig. 77

Pupa hordacea Gabb, of authors, *non* Gabb, *Pupa hordacea*, 1866.

Bifidaria procera cristata Pilsbry and Vanatta, 1900, Proc. Acad. Nat. Sci. Philadelphia, p. 595, pl. 22, figs. 4, 5; Hanna, 1909, Nautilus, 23:94.

Gastrocopta cristata, Leonard, 1943, Trans. Kansas Acad. Sci., 46:239, pl. 1, figs. 9, 10; Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 2, fig. 7; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:344, pl. 19, fig. 1, pl. 20, fig. 1, text fig. 5; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:911, fig. 493:6, 8-12.

Range: Kansas, Oklahoma, Texas, Arizona.

In Kansas, irregularly distributed in the state, rare in extreme eastern portion, and records are lacking in central-western counties.

Description: Shell slightly less than ⅛ inch in height (2-3 mm.); cylindrical, apex obtuse, brownish, translucent, glossy, finely and irregularly striate; whorls 5-6, convex, increasing regularly in size; suture impressed; minutely umbilicate; aperture rounded, lip thin, reflected; thin callus present; strong, whitish crest behind lip; denticles 6, namely, fused angulo-parietal (not bifid in apertural view), short upper palatal, elongate (more deeply immersed) lower palatal, short columellar; nodose subcolumellar, and tubercular basal.

Measurements of Figured Specimen (Pl. 10)

Height, 3.0 mm.; diameter, 1.2 mm.; number of whorls, 5½

Recognition Characters: This species superficially resembles *G. procera* but is readily distinguished by the angulo-parietal, which does not appear bifid in apertural view, the less prominent crest behind the lip, and the relative greater diameter of the shell.

Habitat and Habits: This snail can be found in timbered areas in both upland and floodplain situations, as well as in grasslands (Leonard, 1943:239).

Gastrocopta pellucida hordeacella (Pilsbry)

Pl. 10, fig. 5; text fig. 74

Pupa hordeacella Pilsbry, 1890, Proc. Acad. Nat. Sci. Philadelphia, p. 44, pl. 1, figs. g-k, type locality New Braunsfels, Texas. Type and paratypes A. N. S. P. # 60460.

Bifidaria hordacella, Hanna, 1909, Nautilus, 23:94.

Gastrocopta pellucida hordeacella, Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:349, pl. 19, fig. 8, text fig. 7; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:913, figs. 494a-d, 495.

Range: United States from New Jersey to Florida, west to Kansas, southeastern Colorado, New Mexico, Arizona and southern California; Mexico.

In Kansas, known only from a few scattered records of occurrence.

Description: Shell slightly more than 1/16 inch in height (2-2.5 mm.); cylindric-oblong, apex obtuse, light brown, translucent, finely and irregularly striate; whorls 5-5½, convex increasing regularly in size; sutures impressed; minutely umbilicate; aperture oval, lip thin, reflected; no callus; weak crest behind lip; denticles 5, namely, angulo-parietal (fused, bifid), tubercular upper palatal, lower palatal (prominent, elongate, more deeply immersed), tubercular basal, prominent and stout columellar.

Measurements of Figured Specimen (Pl. 10)

Height, 2.6 mm.; diameter, 0.9 mm.; number of whorls, 5

Recognition Characters: Gastrocopta pellucida hordeacella superfically resembles both *G. procera* and *G. cristata*, but differs from both in more distinctly elongate, cylindric shape; *G. p. hordeacella* differs from *G. cristata* in more distinctly bifid angulo-parietal lamella, and from *G. procera* in less deeply immersed palatal lamellae.

Habitat and Habits: The few records of occurrence in Kansas do not allow generalizations; known colonies are small, and situated in relatively open situations near stands of trees and shrubs.

Genus *Pupoides* Pfeiffer

Pupoides albilabris (C. B. Adams)

Pl. 10, fig. 17; text fig. 79

Cyclostoma marginata Say, 1821, Jour. Acad. Nat. Sci. Philadelphia, 2:172, type locality "Upper Missouri"; *non* G. Fischer, 1807.

P [upa] albilabris, C. B. Adams, 1841, Amer. Jour. Sci., 40:271 (new name for *cyclostoma marginata* Say, no description).

Pupoides marginatus, Hanna, 1909, Nautilus, 23:94; Hanna and Johnson, 1913, Univ. Kansas Sci. Bull., 8:113; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 46:239, pl. 1, fig. 12; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:421, pl. 32, fig. 30; Leonard and Leonard, 1946, Univ. Kansas Sci. Bull., 31, pt. 1:120; Franzen, 1947, Trans. Kansas Acad. Sci., 49:413, 418, pl. 1, fig. 11; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:370, pl. 21, figs. 3, 4, text fig. 2.

Pupoides albilabris, Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:921, fig. 499:1-7; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1035; pl. 101, fig. 22.

Range: Eastern North America from southern Canada to the Gulf of Mexico, west to the Dakotas, Colorado and western Arizona; northern Mexico, Cuba, Haiti, Puerto Rico, Bermuda.

In Kansas, this snail is distributed generally over the state, but records are lacking in extreme western counties.

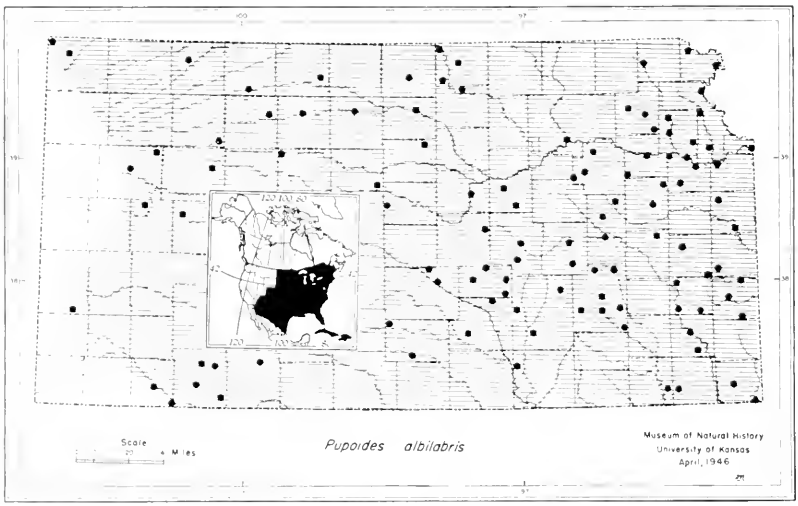


FIG. 79. Distribution of *Pupoides albilabris* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell about ¼ inch high (4-6 mm.); elongate-conic, apex obtuse; brownish, somewhat translucent, glossy; sculpture of fine, irregular closely spaced striae on all but first 1½ whorls; whorls about 6, convex, increasing regularly in size, body whorl more than ½ total height; sutures impressed; umbilicus deep, small; aperture ovate, edentate, pronounced angular sinulus at upper corner of outer lip; lip pale, thickened, widely and flatly reflected; a thin callus.

Measurements of Figured Specimen (Pl. 10)

Height, 4.8 mm.; diameter, 2.3 mm.; number of whorls, 5¾

The foot of the animal is long and narrow, almost equalling the shell in length, blunt in front, tapering behind; forepart of body black, remainder lighter.

Recognition Characters: This snail can be distinguished from all others in the state by the conical shape of the shell, the white, expanded lip, and the lack of dentition.

Habitat and Habits: To the east of Kansas in Indiana and Illinois this snail lives under sticks, logs and leaf-litter in wooded areas as well as in drier situations such as open pastures, railroad embankments and rocky, open country (Goodrich and van der Schalie, 1944; Baker, 1939). It is to be looked for in similar situations in Kansas, but is a very hardy animal and has been collected from sagebrush flats in the western part of the state (Leonard, 1943:239). Its tolerance to aridity and high temperatures account for its wide distribution in Kansas.

Pupoides hordaceus (Gabb)

Pl. 10, figs. 14, 15; text fig. 80

Pupa hordacea Gabb, 1866, Amer. Jour. Conch., 2:331, pl. 21, fig. 7.

Pupoides hordaceus, Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 2, fig. 5; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:372, pl. 21, fig. 2, text fig. 12; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:924, fig. 499:11, 12.

Range: Rocky Mountain region and adjacent eastern plains area, Colorado, New Mexico, Arizona, Utah, Kansas.

This species has extended into Kansas along the Arkansas River to about the center of the State; otherwise intermittently in the western third.

Description: Shell about ¼ inch in height (3-4 mm.); cylindric, apex obtuse, brownish, dull; sculpture of low, conspicuous, widely spaced ribs; whorls 5½, convex; sutures impressed; imperforate; aperture oval, somewhat oblique, edentate; lip pale, thin, reflected.

Measurements of Figured Specimen (Pl. 10)

Height, 4.1 mm.; diameter, 1.6 mm.; number of whorls, 5½

Recognition Characters: *Pupoides hordaceous* differs from *P. albilabris* by its smaller size, less conical spire, and the spaced, slender, obliquely radial riblets; *P. hordaceous* is larger than *P. inoratus*, which also lacks distinct riblets on the surface.

Habitat and Habits: The status of *P. hordaceous* as a permanent inhabitant of Kansas is uncertain. This species is characteristic of the arid plateaus and foothills of the montane region, but not the more humid montane areas. All of the specimens in the K. U. collection are from drift, but appear to be Recent material, not Pleistocene fossils. "Since the Arkansas River heads in the Rocky Mountains, it is possible these shells were in drift which originated near the headwaters. Nevertheless, the Arkansas River heads east of the Rocky Mountain divide" (Franzen and Leonard, 1947:373).

The specimens from Healy, Lane County, are not so easily accounted for. "The town of Healy is not located near a major stream in which the shells could have been found in drift" (Franzen and Leonard, 1947:372).

Pupoides inornatus Vanatta

Pl. 10, fig. 16; text fig. 80

Pupoides inoratus Vanatta, 1915, Nautilus, 29:95, type locality, drift of White River, Washington Co., South Dakota, type A. N. S. P. # 110977; Franzen, 1947, Trans. Kansas Acad. Sci., 49:418; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:374, pl. 21, fig. 1, text fig. 12; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:926, fig. 499:10.

Range: Irregularly distributed in the western United States: South Dakota, Colorado, New Mexico and one record in Kansas.

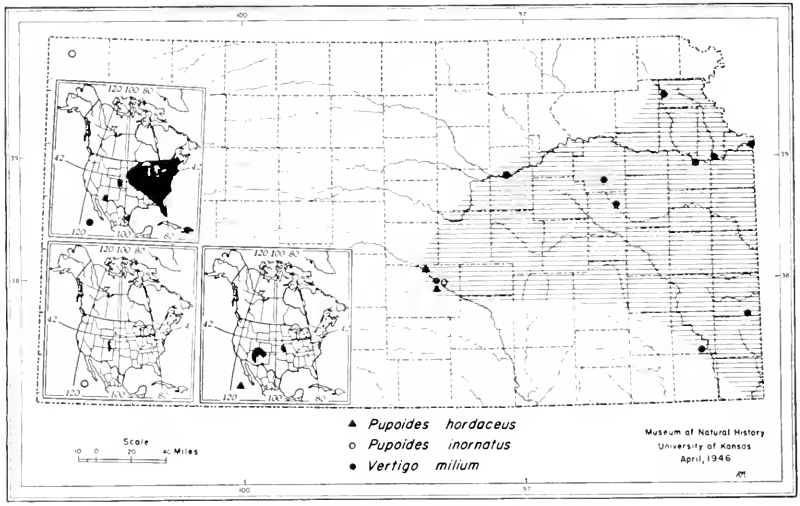


FIG. 80. Distribution of *Pupoides hordaceus, Pupoides inornatus* and *Vertigo milium* in Kansas. Locality records are shown by symbols. Inset maps show approximate distribution of these species in North America.

Description: Shell about ⅛ inch in height (3.5 mm.); cylindric, tapering slightly toward apex, light brown; surface smooth or having few irregularly developed ribs; whorls 5½, convex; sutures impressed; minutely umbilicate; aperture oval, oblique, edentulate; lip thin, reflected; thin callus present.

Measurements of Figured Specimen (Pl. 10)

Height, 3.7 mm.; diameter, 1.6 mm.; number of whorls, 5½

Recognition Characters: This species resembles *Pupoides hordaceus* but has a more tapering spire, lacks pronounced ribs, and generally is smaller.

Habitat and Habits: Of the single specimen from the Arickaree River, Cheyenne County, Franzen and Leonard (1947:374) state, "The flood plain of the Arickaree River had been recently flooded when this shell was taken, so it is not unlikely that this shell may have been brought down from eastern Colorado." The specimens from the flood-plain of the Arkansas River in Reno County may have also been carried into the State in this manner.

Genus *Vertigo* Müller

Vertigo milium (Gould)

Pl. 10, fig. 10; text fig. 80

Pupa milium Gould, 1840, Boston Jour. Nat. Hist., 3:402; 4:359, type locality Oak Island, Chelsea, near Boston, Massachusetts.

Vertigo milium, Hanna, 1909, Nautilus, 23:95; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:365, pl. 20, fig. 8, text fig. 11; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:944, fig. 509.

Range: Eastern and central North America from southern Canada to the Florida Keys, west to South Dakota; Mexico; Jamaica; Santo Domingo.

This snail is irregularly distributed in the eastern half of the State.

Description: Shell about 1/16 inch in height (1.5-1.8 mm.); ovate, spire obtuse, brownish, finely and irregularly striate; whorls 4-5, rounded but not inflated, gradually increasing in size, body whorl more than ½ total shell height; sutures impressed; umbilicus a chink; aperture ovate, somewhat oblique, slightly more than ½ height of body whorl; lip slightly thickened, reflected; callus thin; 6-7 denticles. The denticles are as follows: a high, long, deeply entering parietal, a high, short angular, a strong columellar, a somewhat immersed short, high basal, an upper and lower palatal that are very long and that extend far backward into the aperture. Sometimes a tubercular suprapalatal fold is present.

Measurements of Figured Specimen (Pl. 10)

Height, 1.7 mm.; diameter, 1.0 mm.; number of whorls, 5

Recognition Characters: Readily distinguished from the other species of *Vertigo* in Kansas by small size, ovate shape, and deeply entering palatals.

Foot of animal broad near center, tapering rapidly to point; dirty white, darker on upper surface; eye-peduncles moderately long, somewhat enlarged at tips.

Habitat and Habits: Found in numbers under sticks, stones and leaves in moist situations along flood-plains and wooded stream borders. *Vertigo milium* is the smallest pupillid snail found in the State.

Vertigo ovata ovata Say

Pl. 10, fig. 11; text fig. 81

Vertigo ovata Say, 1822, Jour. Acad. Nat. Sci. Philadelphia, 2:375, type locality Philadelphia, Pa.; Hanna, 1909, Nautilus, 23:95; Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pt. 1, fig. 3; Leonard 1943, Trans. Kansas Acad. Sci. 46:239, pl. 1, fig. 13; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:420, pl. 32, fig. 28; Franzen, 1947, Trans. Kansas Acad. Sci., 49:416, pl. 1, fig. 7; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:354, pl. 19, fig. 6, text fig. 9; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:952, fig. 513:1-4, 7; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1034, pl. 101, fig. 14.

Range: North America from Tigalda and Kodiak Islands, Alaska, and Labrador, south to Florida Keys and West Indies.

In Kansas, widely distributed over the State, where local habitat situations are favorable.

Description: Shell slightly more than 1/16 inch high (2-2.5 mm.); roundly ovate to elongate, spire convexly conic, obtusely pointed; brownish, glossy, translucent; sculpture of very fine, irregular striae; whorls 5, rounded, increasing rapidly in size, body whorl about 3/5 of total height; umbilicus a small chink; sutures impressed; aperture large, semicircular, oblique; lip thin, narrowly reflected; strong, opaque light-colored crest behind lip, distinct sulcus on outer margin: denticles varying in number, usually 6 to 9.

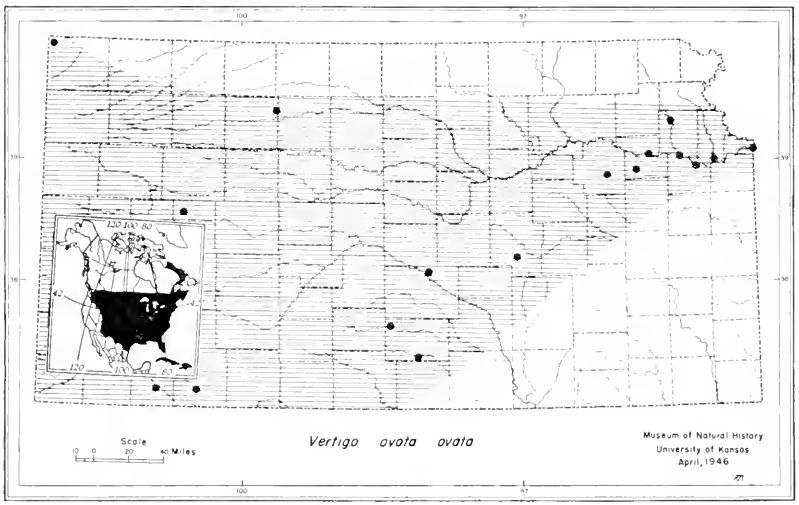


FIG. 81. Distribution of *Vertigo ovata ovata* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

The denticles are as follows: 1-3 sharp, pointed teeth on parietal wall, the central one (parietal lamella) always the largest, constant; 1 small pointed tooth on middle of columella (columellar tooth), constant; 1 small, conical tooth at the turn of the peristome, left corner (basal fold), constant; 2 long, narrow teeth placed on the oblique base and outer lip (upper and lower palatals), constant; a small, conical, deeply seated tubercle placed between the two teeth on the base (infrapalatal), variable; and a very small tubercle placed above the highest tooth on the outer lip (suprapalatal fold), variable.

Measurements of Figured Specimen (Pl. 10)

Height, 2.3 mm.; diameter, 1.3 mm.; number of whorls, 5

Animal having a thick, short, foot, trilobed in front and broadly rounded behind; eye-peduncles short, thick, club-shaped, bulbous at their extremity; eyes black; body reddish on upper surface, base of foot white.

Recognition Characters: *Vertigo ovata ovata* resembles *V. milium* in its ovate contour, but differs from that species in much larger size, and less deeply entering palatal lamellae.

Habitat and Habits: This snail inhabits moist, or marshy areas where it is found under sticks, stones, leaf litter, or dead grass. Enormous populations occur, for example, near the artesian springs in Meade County. We have utilized the method of "trapping" suggested by Call (1900:401) by placing old boards or other flat objects on the ground in suitable habitat situations. The snails aggregate in large numbers on the lower surfaces of such objects. This method can be used of course, for other small gastropods.

Vertigo tridentata Wolf

Pl. 10, fig. 12; text fig. 82

Vertigo tridentata Wolf, 1870, Amer. Jour. Conch., 5:198, pl. 17, fig. 4, type locality Canton, Illinois. Type A. N. S. P. # 58008; Hanna, 1909, Nautilus, 23:95; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:421, pl. 32, fig. 29; Franzen, 1947, Trans. Kansas Acad. Sci., 49:414; Franzen and Leonard, 1947, Univ. Kansas Sci. Bull., 31, pt. 2:361, pl. 20, fig. 5, text fig. 10; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:965, fig. 518:1-3.

Range: Eastern North America from southern Canada to Texas, absent from Coastal Plain area; west to Minnesota and Kansas.

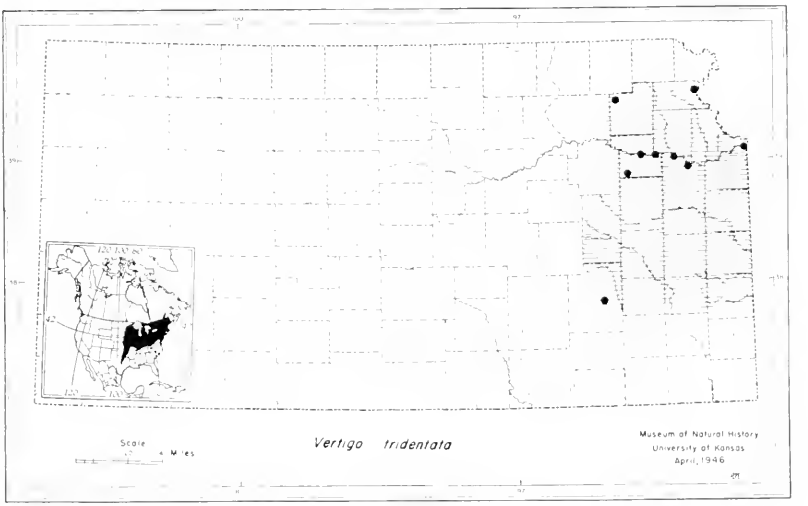


FIG. 82. Distribution of *Vertigo tridentata* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

This snail is limited to the eastern fourth of Kansas.

Description: Shell slightly more than $^1/_{16}$ inch in height (2 mm.); oval to oblong, apex obtuse, yellowish to brownish, glossy, finely and irregularly striate; whorls 5, rounded, increasing rapidly in size, body whorl more than ½ total shell height; sutures impressed; umbilicus a chink; aperture pyriform, oblique, lip slightly thickened, reflected; callus thin; a narrow but usually distinct crest behind lip; sinus near middle of outer lip; denticles 3-4.

They are as follows: always a blunt, downwardly directed, columellar lamella; a high, rather short parietal lamella; and a strongly developed lower palatal fold; sometimes a small upper palatal fold present.

Measurements of Figured Specimen (Pl. 10)

Height, 2.5 mm.; diameter, 1.3 mm.; number of whorls, 5½

Recognition Characters: *Vertigo tridentata* differs from both *V. milium* and *V. ovata* by its larger size, more elongate spire, and by fewer and more poorly developed apertural denticles.

Habitat and Habits: In and among ground debris in forested areas as well as grass and weeds in more open situations. Wolf (quoted by Pilsbry, 1948:966) observed it on stalks of green weeds as high as three feet above the ground.

Family VALLONIIDAE Pilsbry

The family Valloniidae is comprised of minute animals, having discoidal to ovately-conical shells, which do not bear internal lamellae. The shells are perforate or umbilicate, and are characterized by bearing spaced cuticular ribs, although these are reduced in a few examples. The genus *Vallonia*, the only representative of the family in Kansas, is widely distributed in North America, Europe and Asia.

Several species of the genus *Vallonia* occur in Pleistocene sediments in the State; *V. gracilicosta* is especially numerous in deposits of late Kansan and early Wisconsinan ages. *V. gracilicosta* (Pl. 11, figs. 13, 14) has been obtained in a nearly fresh condition from drift on the flood-plain of the Arickaree River in Cheyenne County, and there is the possibility that this species, which is known to live in Colorado, may actually occur in western Kansas. At present, however, its occurrence in the State, except as a fossil, is doubtful.

Genus *Vallonia* Risso

Vallonia parvula Sterki

Pl. 11, figs. 15, 16; text fig. 83

Vallonia parvula Sterki, 1893, Man. Conch., 8:254, Pl. 32, figs. 23-26; Hanna, 1909, Nautilus 23:95; Leonard, 1943, Trans. Kansas Acad. Sci., 46:240, pl. 1, fig. 7; Pilsbry, 1948, Land Mollusca of North America (north of Mexico), vol. 2, pt. 2:1027, fig. 547; Leonard and Goble, 1952, Univ. Kansas Sci. Bull., 34, pt. 2:1037, pl. 101, figs. 18, 19.

Range: Eastern North America from southern Canada, west to South Dakota, south to Texas.

Widely distributed in Kansas but absent in southwestern counties.

Description: Shell about 1/16 inch in diameter (1.5-2.0 mm.); heliciform, depressed, spire low; waxy-white; dull, sculpture of somewhat irregularly spaced ribs; whorls about 3, rounded; sutures impressed, last whorl descending somewhat to aperture; umbilicus contained slightly less than 3 times in shell diameter; aperture rounded, oblique, edentate; lip pale, reflected; thin callus present.

Measurements of Figured Specimen (Pl. 11)

Height, 1.0 mm.; greater diameter, 2.3 mm.; number of whorls, 3¼

Recognition Characters: This species closely resembles *Vallonia gracilicosta*, which may occur in extreme western Kansas, but is smaller (diameter, 1.9 mm.) and the ribs are more numerous.

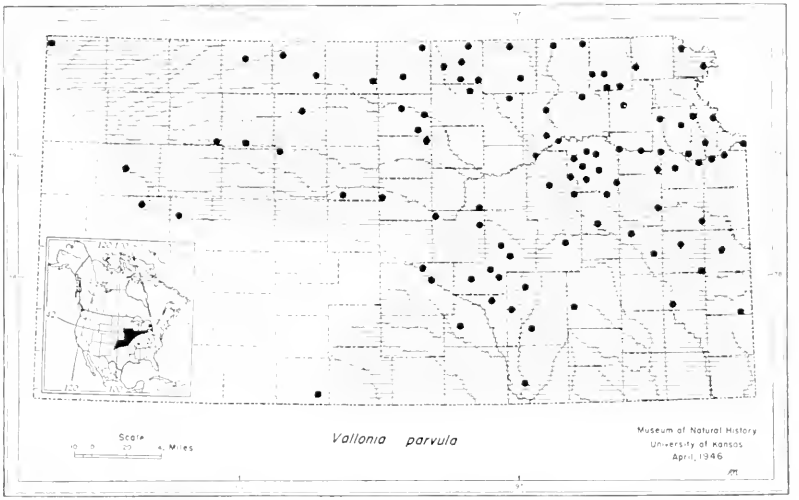


FIG. 83. Distribution of *Vallonia parvula* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Habitat and Habits: Vallonia parvula inhabits wooded areas in both upland and floodplain situations. It has been found in and about logs, sticks, rocks and similar niches, and often buries itself in the ground to a depth of several times its diameter. Goodrich and van der Schalie (1944:280) state that . . . "it is found usually in large colonies when observed in the middle west."

Family CIONELLIDAE Kobelt

Shells of members of the Family Cionellidae are small, rarely more than 5 millimeters high, imperforate, elongate, with a smooth and glossy surface; lip not expanded, but thickened within. The shape of the shell is not unlike that of some members of the Pupillidae, but the smooth, glossy surface, and translucent shell, which lacks apertural denticles, is quite unlike that of any pupillid.

The family is largely Palearctic in range, with the single genus *Cionella* present in North America, where it first appears in middle Pleistocene deposits. In older literature the name of the genus frequently appears as *Cochlicopa*.

Genus *Cionella* Jeffreys

Cionella lubrica lubrica (Müller)

Pl. 8, fig. 18; text fig. 84

Helix lubricus Müller, 1774, Verm. Hist., 2:104, type locality Denmark.
Ferussacia subcylindrica, Call, 1887, Bull. Washburn College Lab. Nat. Hist., 2:16.

Cochlicopa lubrica, Hanna, 1909, Nautilus 23:93; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:424, pl. 30, fig. 1.

Cionella lubrica, Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:1047, fig. 560 a, b.

Range: Holarctic. In North America from Alaska (Kodiak Island), Labrador and Newfoundland and southward to Washington, D. C., in the east and southern Missouri in the midwest; extending into Mexico in the Rocky Mountain region; absent from California.

In Kansas this snail is largely limited to the eastern third of the State. Its western limits are uncertain, specimens from Shawnee, Wabaunsee and Riley counties being either drift material which may be fossil or badly weathered Recent material. A set from Reno County, while somewhat weathered, appears to be Recent, thus doubtfully extending the range into the central part of the state.

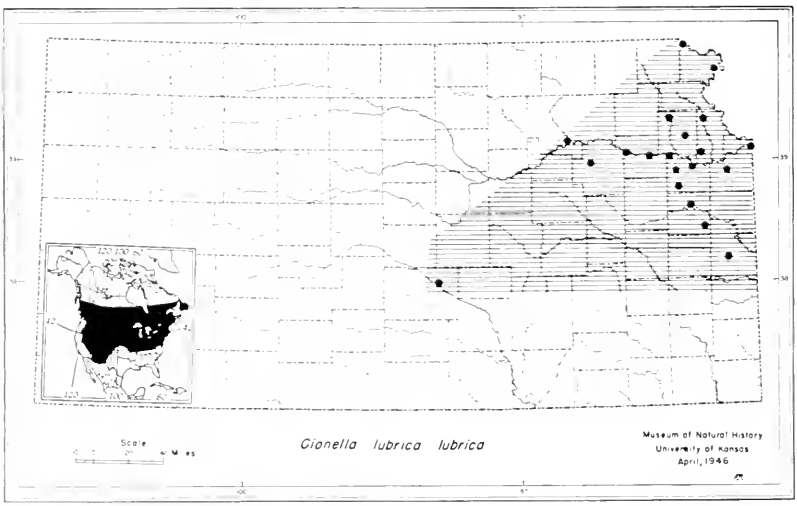


Fig. 84. Distribution of *Cionella lubrica lubrica* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of this species in North America.

Description: Shell about ¼ inch high (5-6 mm.); oblong, spire tapering to an obtuse apex, about three times as high as wide; thin; yellowish or greenish, glossy, subtransparent; imperforate; whorls 5½ to 6, moderately convex; sutures impressed; aperture subvertical, ovate, less than ½ total height of shell; lip thickened, not reflected, edentate; parietal callus thin.

Measurements of Figured Specimen (Pl. 8)

Height, 5.7 mm.; diameter, 2.5 mm.; number of whorls, 6

The animal has a short, wide foot, obtuse in front and pointed behind. It is dark above, and lighter beneath. The tentacles are very small, and the eye-peduncles are long and enlarged at the tip. The genital orifice is situated behind the right eye-peduncle.

Recognition Characters: This snail is readily recognized by its elongate, smooth, shiny shell. The elongate aperture without denticles of any kind will distinguish it from similarly shaped Pupillidae and Carychiidae.

Habitat and Habits: Cionella l. lubrica inhabits moist places under leaves, stones, and other litter. Individuals have been recorded as being especially active in periods of high humidity before rainstorms; at such times they tend to form aggregations on stone and concrete surfaces. It has been suggested (Naut. 60:72, 1946, anonymous, possibly H. A. Pilsbry) that these and similar aggregations may be for the purpose of breeding.

Baker (1902:247-248) states that "It is an interesting species in captivity, the animal being very bold and readily crawling over one's hand. In progression it is very rapid, probably exceeding, in comparison with its size, all other species in the rapidity with which it crawls."

Family CARYCHIIDAE Jeffreys

The family Carychiidae is comprised of minute, terrestrial snails, having elongate to cylindrical shells of several whorls. The lip of the peristome is usually expanded and thickened, and the peristome is oblong to ovate.

The Carychiidae, unlike most terrestrial pulmonate gastropods, belong to the order Basommatophora; that is to say, the eyes are sessile instead of borne on peduncles, and are situated at the base of the tentacles.

The family comprises four genera, only one of which, *Carychium*, occurs in North America. This genus is widespread also in Europe and Asia.

Genus *Carychium* Müller

Carychium exiguum (Say)

Pl. 11, figs. 22, 23; text fig. 85

Pupa exigua Say, 1822, Jour. Acad. Nat. Sci. Philadelphia, 2:375, type locality, Harrigate, Philadelphia.

Carychium exile, Franzen and Leonard, 1942, Trans. Kansas Acad. Sci., 45:339, pl. 1, fig. 5; Pilsbry, 1948, Land Mollusca of North America (north of Mexico) vol. 2 pt. 2:1052, fig. 561, a, b, fig. 562.

Range: Newfoundland to Colorado, south to Mobile Bay, Alabama, and southwest to New Mexico.

In Kansas irregularly distributed over the eastern half of State.

Description: Shell about 1/16 inch high (1.5 mm.); cylindrical, spire long and conic, less than 2/3 of total shell height; white, surface shiny, lines of growth numerous, minute; whorls 4½, regularly increasing, convex, somewhat oblique; sutures deeply impressed; umbilicus round, deep; aperture ovate,

PLATE 11

All figures enlarged approximately 8 times natural size.

1, 2, 3. *Punctum minitissimum* (Lea), 4 mi. W, and 4 mi. N Garnett, Pottawatomie Creek, Anderson County, Kansas. Collected by E. J. Reese and G. R. Webb, 18 November 1950. Catalogue number 6938.

4, 5, 6. *Striatura milium* (Morse), leaf-litter from banks of Cedar Creek, 3 mi. NW of Garnett, Anderson County, Kansas. Collected by R. W. Reese and G. R. Webb, 18 November 1950. Catalogue number 6715.

7, 8, 9. *Striatura meriodionalis* (Pilsbry and Ferriss), leaf-litter from banks of Cedar Creek, 3 mi. NW of Garnett, Anderson County, Kansas. Collected by R. W. Reese and G. R. Webb, 18 November 1950. Catalogue number 6715a.

10, 11, 12. *Helicodiscus singleyanus* (Pilsbry), SE ¼ sec. 21, T. 23 S, R. 2 W, Harvey County, Kansas. Collected by E. J. Roscoe, 20 November 1951. Catalogue number 7336.

13, 14. *Vallonia gracilicosta* Reinhardt, NW ¼ sec 10, T. 1 S, R. 42 W, Cheyenne County, Kansas. Drift, Arickaree River. Collected by A. B. Leonard, 13 June 1944. Catalogue number 3949.

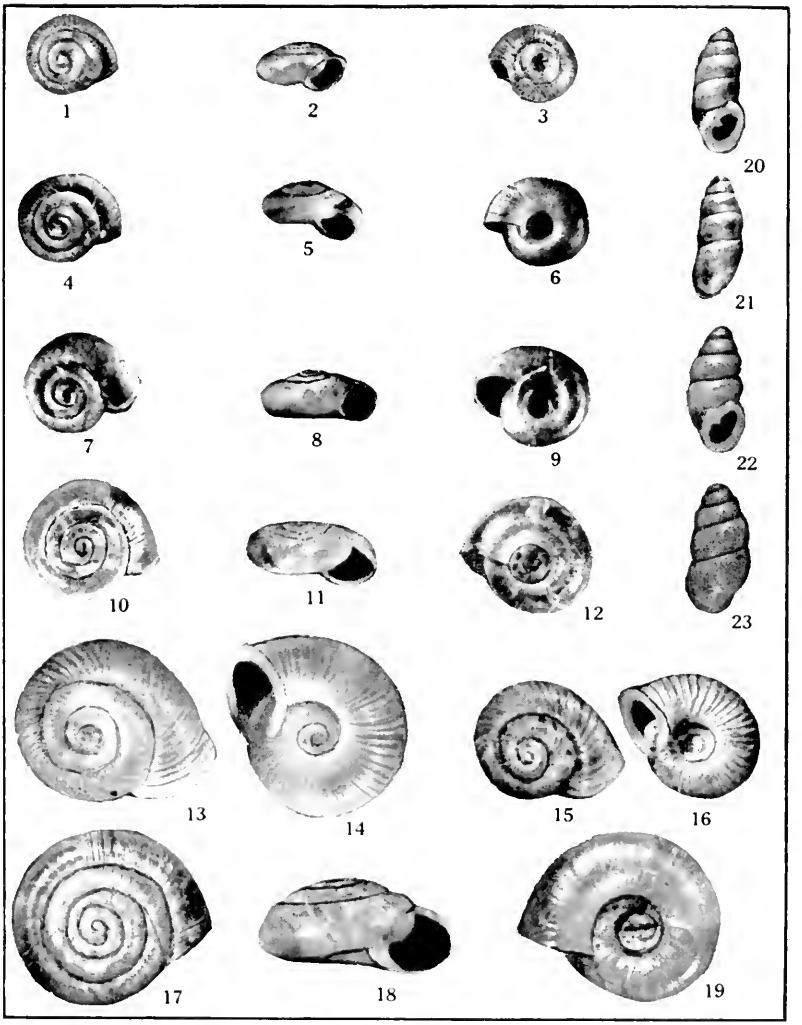
15, 16. *Vallonia parvula* Sterki, University of Kansas Natural History Reservation, 5½ mi. NNE Lawrence, sec. 4, T. 12 S, R. 20 E, Douglas County, Kansas. Collected by G. R. Webb, 11 November 1950. Catalogue number 6791.

17, 18, 19. *Hawaiia minuscula* (Binney), NW ¼ sec. 8, T. 11 S, R. 19 E, 3.2 mi. NE Perry, Jefferson County, Kansas. Collected by E. J. Roscoe, 2 July 1950. Catalogue number 8940.

20, 21. *Carychium exile* Lea, 2 mi. N Atchison, Atchison County, Kansas. Collected by A. B. Leonard, E. J. Roscoe, and G. R. Webb, 28 October 1950. Catalogue number 6752.

22, 23. *Carychium exiguum* (Say), NE ¼ sec. 15, T. 6 S, R. 17 E, 1.5 mi. S Muscotah, Atchison County, Kansas. Collected by G. R. Webb, 28 October 1950. Catalogue number 6484.

PLATE 11



more than ⅓ total shell height; parietal wall with large plait midway between termination of peristome and axis; lip thickened, flat, reflected, the terminations joined by a thin callus.

Measurements of Figured Specimen (Pl. 11)

Height, 2.0 mm.; diameter, 0.8 mm.; number of whorls, 4½

Recognition Characters: May be readily distinguished from similarly shaped Pupillidae by pallor and presence of spiral fold in place of discrete denticles. *Carychium exiguum* differs from *C. exile* in having an almost smooth surface; *exile* has strong radial striae.

Habitat and Habits: This species and its relative *C. exile* are found under and about old logs, sticks, twigs and vegetation in marshy areas around ponds and creeks. The snails sometimes are submerged in water, but not in ponds or creeks in the same situations as *Physa* or *Lymnaea*. Both of the mentioned species of *Carychium* are gregarious, although frequently overlooked because of their small size. In the field, their white shells contrast well against dark, wet wood.

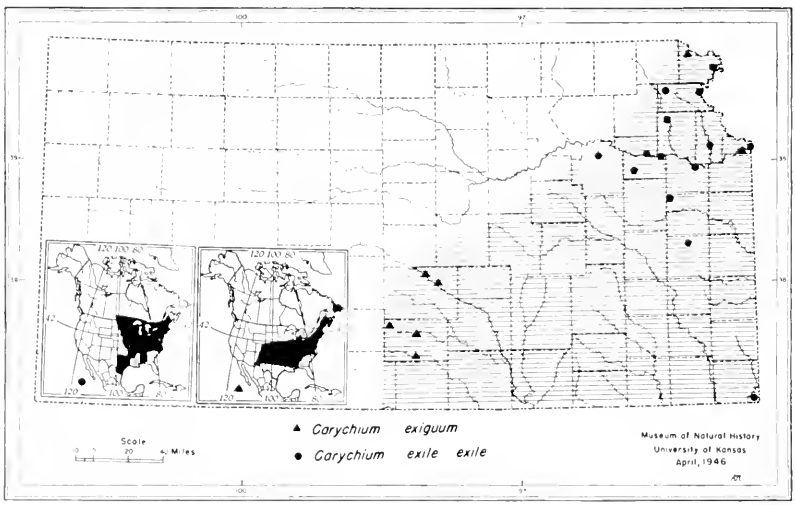


FIG. 85. Distribution of *Carychium exile exile* and *Carychium exiguum* in Kansas. Locality records are shown by symbols. Inset map shows approximate distribution of these species in North America.

Carychium exile exile H. C. Lea

Pl. 11, figs. 20, 21; text fig. 85

Carychium exile, Lea, 1842, Amer. Jour. Sci. and Arts, 42:109, pl. 1, fig. 5; Call, 1886, Bull. Washburn College Lab. Nat. Hist., 1:205; Hanna, 1909, Nautilus 23:96; Franzen and Leonard, 1943, Univ. Kansas Sci. Bull., 29, pt. 2:407, pl. 30, figs. 3, 4; Pilsbry, 1948, Land Mollusca of North America, vol. 2, pt. 2:1058, fig. 561 c, 566 a.

Range: Maine and Ontario to Manitoba, south to Mobile, Alabama, and Texas.

In Kansas this species is limited to the eastern third of the State. The published records from Kingman County are based on misidentifications judging from sets in the University of Kansas Collection.

Description: Shell about 1/16 inch high (1.75 mm.); elongated, apex obtuse; white, somewhat shiny, with regular and distinct striae; whorls 5½, regularly increasing, somewhat shouldered; sutures deeply impressed; umbilicus small, deep; aperture less than ⅓ total shell height; parietal wall with a large plait; lip thickened, reflected, callus thin.

Recognition Characters: The small size, whiteness, and single columellar plait in the aperture distinguish *Carychium exile* from pupillids with which it might be confused. From *C. exiguum*, *C. exile* differs in having radial striae, whereas the surface of the shell of the former is almost smooth.

Habitat and Habits: The preferred habitat of *Carychium exile* is not unlike that of *C. exiguum*, both having a strong preference for moist situations. *C. exile* exists, for example, in large numbers in a marsh produced by artesian springs in northwestern Atchison County. Here this minute snail is found in heavy carpets of moss, which are saturated with water, and the micro-environment is actually aquatic.

GEOGRAPHICAL RELATIONSHIPS OF THE TERRESTRIAL GASTROPODS IN KANSAS

The terrestrial gastropod fauna of Kansas has a complex composition, but in general the principal components are eastern in origin, and characteristic of the deciduous forest habitats of eastern North America. Most of the genera and species from the east reach their western limits of distribution in eastern Kansas. A considerable portion of this eastern group of genera and species is specifically Ozarkian in origin. A few elements of the fauna are western species, and one or two species have entered Kansas from the south. There are, of course, other species having a general distribution in the United States, including Kansas.

Eastern components of the fauna: Among the Polygyridae, species of *Mesodon*, *Stenotrema*, and *Allogona* are all eastern, and in general northeastern in distribution, whereas the species of *Triodopsis* in Kansas, save for *Triodopsis albolabris* and *T. multilineata*, have entered from the Ozarkian complex of polygyrids, as have the several species of *Polygyra*. *Retinella indentata* is northeastern in range, but *R. electrina* is extended into more northerly latitudes. *Striatura milium* and *S. meridionalis* are essentially eastern in distribution, except that *S. meridionalis* ranges well to the south. Other

eastern or northeastern components of the gastropod fauna of Kansas include *Punctum minutissimum* (which also ranges into the Rockies), *Carychium exile*, *C. exiguum*, *Philomycus carolinianus*, *Strobilops labyrinthica*, our three species of *Vertigo* (*V. ovata* is extended westward also), all of our species of *Gastrocopta* save two, *Pupoides albilabris*, which is also southwestern, and *Ventridens ligera*.

Ozarkian Influences on the Fauna: The Ozarkian influence has been felt from the extension into Kansas of species that are more or less strictly limited to the Ozark Plateau, together with a few species of more widely eastern distribution that enter our fauna from the Ozarks. Among the latter may be included *Stenotrema stenotrema*, *Mesodon inflectus*, *Haplotrema concavum*, *Polygyra dorfeuilliana dorfeuilliana*, *Triodopsis cragini*, *Paravitrea capsella*, and *Ventridens ligera*.

Rather closely related to the Ozarkian gastropod fauna, and entering Kansas only in the extreme southeastern part of the state, are *Polygyra dorfeuilliana sampsoni*, *P. jacksoni*, *Triodopsis neglecta*, *T. divesta*, *Mesomphix cupreus ozarkensis*, *Paravitrea significans*, and *P. simpsoni*. Among the Ozarkian elements of the gastropod fauna of Kansas should also be mentioned the aquatic branchiate, *Goniobasis potosiensis plebius*, which is a true Ozarkian snail, while *Campeloma subsolidum* and *Pleurocera acuta*, although much more widely distributed, seem to have entered Kansas with the Ozarkian fauna. It is obvious, therefore, that the influence of the Ozarkian gastropod fauna on that of Kansas has been, and is, profound.

Western Elements of the Fauna: Strictly western influences on the gastropod fauna of Kansas are few, although many of the essentially eastern components of the fauna also extend their range somewhat westward in the State. Only three species enter our fauna from the west or southwest; these are *Pupoides inornatus*, *P. hordaceous*, truly western in range, and *Gastrocopta cristata* that can be thought of as a member of the gastropod fauna of the southwest.

Southern Elements of the Fauna: Only two species among the members of the gastropod fauna of the state can be considered southern in origin. Most conspicuous of these, is of course, *Bulimulus dealbatus*, belonging to a family that is Mexican and South American in distribution. *B. dealbatus* is judged to be a recent immigrant into the State, since fossil shells are not found, even in

late Pleistocene deposits. *Gastrocopta pellucida hordeacella* is the second member of the southern group in the State.

Others: A few gastropods in our fauna are almost universally distributed in the United States, and do not fall into any well-defined regional category. Prominent among these are *Zonitoides arboreus* and *Deroceras laeve*, which are found almost anywhere that local habitat conditions permit. To these may be added *Striatura milium* that is somewhat less widely distributed, and *Cionella lubrica* that is not found in the southeastern or extreme western parts of the country. *Vertigo ovata* is also widely distributed over the United States, but is absent in the extreme west.

Vallonia parvula should be classified as central, with regard to its geographic range in the United States.

REFERENCES

ABDEL-MALEK, E. T.

1954. Morphological studies on the family Planorbidae (Mollusca: Pulmonata). 1. Genital organs of *Helisoma trivolvis* (Say). Trans. Amer. Micros. Soc., vol. 73, pp. 103-124, 4 pls.

ANONYMOUS.

1923. Zonitoides arboreus deleterious to cane. Nautilus, vol. 39, p. 70.

1946. (No title.) Nautilus, vol. 60, p. 72.

ANTHONY, J. G.

1850. Description of sixteen new species. Proc. Boston Soc. Nat. Hist., vol. 3, pp. 360-363.

BAKER, F. C.

1902. The Mollusca of the Chicago area. Chicago Acad. Sci. Nat. Hist. Survey, Bull. 3, pt. 2 (the Gastropods), pp. 137-410, pls. 28-36, figs. 13-137.

1904. Spire variation in *Pyramidula alternata*. Amer. Naturalist, vol. 38, pp. 661-668, 4 figs.

1909. Mollusks from Kansas and Oklahoma. Nautilus, vol. 23, pp. 91-94.

1939. Fieldbook of Illinois land snails. Illinois Nat. Hist. Survey Manual 2, xi + 166 pp., illus.

1911. The Lymnaeidae of North and Middle America Recent and fossil. Chicago Acad. Sci. Special Pub. no. 3, 539 pp., 63 pls., 51 figs.

1928. The freshwater Mollusca of Wisconsin, pt. 1, Gastropods. Wisconsin Geol. and Nat. Hist. Survey, Bull. 70, 476 pp., 28 pls., 202 figs.

1935. The generic position of *Planorbis umbilicatellus* Cockerell with the description of a new group of Planorbidae. Nautilus, vol. 49, pp. 46-48.

1945. The Molluscan family Planorbidae; Collation, revision and additions by Harley Jones Van Cleave. Univ. Illinois Press, Urbana, 235 pp., 141 pls.

BARTSCH, P., and QUICK, M. E.
1926. An anatomic study of *Zonitoides arboreus* (Say). Jour. Agri. Res., vol. 32, pp. 283-91.

BERRY, E. G.
1943. The Amnicolidae of Michigan: Distribution, ecology, and taxonomy. Misc. Publ. Mus. Zool., Univ. Michigan, no. 57, pp. 1-68, pls. 1-9, figs. 1-10, 10 maps.

BINNEY, W. G.
1865. Land and fresh-water shells of North America, pt. 2, Pulmonata, Limnophila, and Thalassophila. Smithsonian Misc. Coll., no. 143, 155 pp., 261 figs.

BINNEY, W. G., and BLAND, T.
1869. Land and fresh water shells of North America. Smithsonian Misc. Coll. 194, pt. 1, xii + 316 pp., 544 figs.

BINNEY, W. G., and GRAY, A. F.
1885. Notes on the land shells of Kansas. Bull. Washburn College Lab. Nat. Hist., vol. 1, pp. 55-56.

BONDESON, P.
1950. Egg capsules of river limpet snails: material for experimental biology. Science, vol. 113, pp. 603-605.

CALL, R. E.
1885a. Contributions to a knowledge of the fresh-water Mollusca of Kansas, 11, fresh-water univalves. Bull. Washburn College Lab. Nat. Hist., vol. 1, no. 2, pp. 51-54.
1885b. Contributions to a knowledge of the fresh-water Mollusca of Kansas, IV, Bull. Washburn College Lab. Nat. Hist., vol. 1, no. 4, p. 115.
1886. Notes on the land Mollusca of the Washburn College Biological Laboratory of Kansas. Bull. Washburn College Lab. Nat. Hist., vol. 1, pp. 201-205, 1 fig.
1886. Fifth contribution to a knowledge of the fresh-water Mollusca of Kansas. Bull. Washburn College Lab. Nat. Hist., vol. 1, no. 4, p. 177.
1887. Sixth contribution to a knowledge of the fresh-water Mollusca of Kansas. Bull. Washburn College Lab. Nat. Hist., vol. 2, no. 8, pp. 14-17.
1900. A descriptive catalogue of the Mollusca of Indiana. Dept. Geol. Nat. Res. Indiana (annual rept. for 1899), vol. 24, pp. 335-535, Indianapolis.

DALL, W. H.
1904. *Gundlachia* and *Ancylus*. Nautilus, vol. 17, pp. 97-98.

ELLIS, A. E.
1926. British snails. The Clarendon Press, Oxford, 275 pp., frontispiece, 14 pls., 11 figs.

FRANZEN, D. S.
1944. New state records of Mollusca from Kansas. Kansas Acad. Sci., vol. 47, pp. 261-273, 1 pl., 1 fig.
1947. Fossil and living Pupillidae (Gastropoda: Pulmonata) in Kansas. Univ. Kansas Sci. Bull., vol. 31, pp. 311-411, 6 pls., 15 figs., 1 table.

FRANZEN, D. S., and LEONARD, A. B.
1942. A preliminary survey of the Mollusca of Kingman County, Kansas. Trans. Kansas Acad. Sci., vol. 45, pp. 334-343, 2 pls., 1 map.
1943. The Mollusca of the Wakarusa River Valley. Univ. Kansas Sci. Bull., vol. 29, pp. 363-439, pls. 28-32, figs. 1-5.

GOODRICH, C.
1932. The Mollusca of Michigan. Univ. Michigan Press, Ann Arbor, 120 pp., 8 pls.
1939a. Pleuroceridae of the Mississippi River basin exclusive of the Ohio River system. Occas. Papers Mus. Zool., Univ. Michigan, no. 406, pp. 1-4.
1939b. Aspects of depauperization. Nautilus, vol. 52, no. 4, pp. 124-131.
1944. Pulmonates of the Coosa River. Nautilus, vol. 58, no. 1, pp. 11-15.

GOODRICH, C., and VAN DER SCHALIE, H.
1944. A revision of the Mollusca of Indiana. Amer. Midland Naturalist, vol. 32, pp. 257-320.

HANNA G. D.
1909. The Mollusca of Douglas County, Kansas. Nautilus, vol. 23, pp. 81-82, 94-96.

HARLAN, J. A., and SPEAKER, E. B.
1951. Iowa fish and fishing. State Conservation Comm., Des Moines, 2nd ed., 237 pp., 22 pls., 9 figs.

HEDLEY, C., and PILSBRY, H. A.
1895. On the Australasian *Gundlachia*. Nautilus, vol. 9, no. 6, pp. 61-68, fig. 2.

HICKMAN, C. P.
1931. The spermiogenesis of Succinea ovalis Say, with special reference to the components of the sperm. Jour. Morph., vol. 51, pp. 243-289, 8 pls., 2 text figs.

HOFF, C.
1936. Studies on the Lymnaeid snail, *Fossaria parva* (Lea); part I, winter habits. Trans. Illinois State Acad. Sci., vol. 29, no. 2, pp. 259-262.
1937. Studies on the Lymnaeid snail *Fossaria parva* (Lea); part II, seasonal life history. Trans. Illinois State Acad. Sci., vol. 30, no. 2, pp. 303-306, fig. 3.

INGRAM, W. H., and HEWETT, O. H.
1943. Sporocysts of Leucochloridium in *Succinea* from New York State. Nautilus, vol. 56, pp. 92-95.

JEWELL, D. D.
1931. Observations on reproduction in the snail *Goniobasis*. Nautilus, vol. 44, pp. 115-119, fig. 5.

JONES, D. T.
1935a. Burrowing of snails. Nautilus, vol. 48, pp. 1-3.
1935b. The formation of shell in the tiger snail. Jour. Morph., vol. 57, pp. 547-568.

KAGAN, I. G.
1949. *Quickella* (family Succineidae) a new host for sporocysts of Leucochloridium (Trematoda: Brachylaemidae) in southeastern Michigan. Jour. Parasit., vol. 35, no. 6, suppl., pp. 38-39.

LEA, I.

1869. New Unionidae, Melanidae, etc., chiefly of the United States, article 3. Jour. Acad. Nat. Sci. Philadelphia, vol. 6, 2nd ser., pp. 113-187, pl. 3, fig. 118.

LEE, C. B.

1951a. The Molluscan family Succineidae in Michigan. Considerations of anatomy, early embryology, and distribution. Unpublished Doctor's dissertation, Univ. Michigan, 269 pp.

1951b. *Succinea vaginacontorta* (Section Calcisuccinea), a new amber snail from Kansas. Occas. Papers Mus. Zool., Univ. Michigan, no. 533, pp. 1-7, 2 pls., 1 text fig.

LEONARD, A. B.

1950. A Yarmouthian Molluscan fauna in the midcontinent region of the United States. Univ. Kansas Paleont. Contrib., art. 3, pp. 1-48, 6 pls., 4 text figs.

LEONARD, A. B., and GOBLE, C. R.

1952. Mollusca of the University of Kansas Natural History Reservation. Univ. Kansas Sci. Bull., vol. 34, pt. 2, pp. 1013-1055, 5 pls., 1 table.

LEONARD, A. E.

1943. The Mollusca of Meade and Clark counties, Kansas. Trans. Kansas Acad. Sci., vol. 46, pp. 226-240, 2 pls., 2 text figs.

LEONARD, A. B., and LEONARD, A. E.

1946. Mollusca from Greenwood County, Kansas. Univ. Kansas Sci. Bull., vol. 31, pt. 1, pp. 115-122.

MILES, C. D.

1958. The family Succineidae (Gastropoda: Pulmonata) in Kansas. Univ. Kansas Sci. Bull., vol. 38, pp. 1499-1543, 1 pl., 9 figs.

OUGHTON, J.

1948. A zoogeographical study of the land snails of Ontario. Univ. Ontario Press, Toronto, xi + 126 pp., frontispiece, 1 map, 3 tables.

PILSBRY, H. A.

1939. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci., Philadelphia Monographs, no. 3, vol. 1, pt. 1, xvii + 573 pp., 377 figs., December 6.

1940. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci., Philadelphia Monographs, no. 3, vol. 1, pt. 2, pp. i-vi, 575-994, figs. 378-580, August 1.

1946. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci., Philadelphia Monographs, no. 3, vol. 2, pt. 1, vi + 520 pp., frontis., 281 figs., December 6.

1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci., Philadelphia Monographs, no. 3, vol. 2, pt. 2, pp. i-xlvii, 521-1113, figs. 282-581, March 19.

QUICK, H. E.

1933. The anatomy of British Succineae. Proc. Mal. Soc. London, vol. 20, pp. 295-318.

SHIMEK, B.

1935. The habitats of Iowa Succineas. Nautilus, vol. 23, pp. 6-10.

SIMPSON, C. B.
1901. Anatomy and physiology of *Polygyra albilabris* and *Limax maximus* and embryology of *Limax maximus*. Bull. New York State Mus., vol. 8, no. 40, pp. 241-314, pls. 1-28.

STRANDINE, E. J.
1941. Quantitative study of a snail population. Ecology, vol. 22, pp. 86-91, 4 figs., 5 tables.

TRYON, G. W.
1866. Monograph of the terrestrial Mollusca of the United States. Amer. Jour. Conch., vol. 2, pt. 3, pp. 218-277, 4 pls.

WALKER, B.
1907. Notes on *Gundlachia*. Nautilus, vol. 21, no. 2, pp. 14-17, pl. 1, fig. 12.

WEBB, G. R.
1943. The mating of the landsnail *Haplotrema concavium* (Say). Amer. Midland Nat., vol. 30, pp. 341-345.
1948. Notes on the mating of some Zonitoides (*Ventridius*) species of land snails. Amer. Midland Nat., vol. 40, pp. 453-561.
1953. Anatomical studies on some midwestern Succineidae and two new species. Jour. Tennessee Acad. Sci., vol. 28, pp. 213-220, 5 pls.
1954. Pulmonata, Succineidae: *Succinea* (Desmosuccinea) *pseudavara*, new species. Gastropodia, vol. 1 (no. 2), pp. 10, 18-19, 12 figs.

APPENDIX

SCIENTIFIC NAMES OF GASTROPODS

By international agreement, scientific names consist of two essential parts, the genus and species, written in that order, to which is added the name of the authority. He or she is the person who first published a valid name for the kind of animal or plant concerned. To be valid the name, when proposed, must have been accompanied by a description or reference to one.

As an example, we can take the name of one of our gastropods, *Allogona profunda* (Say). The name of the genus is *Allogona*, and the name of the species is *profunda;* the name of the authority is (Say), because Thomas Say, an early American conchologist, first named and described this particular species of gastropod. His name is enclosed in parentheses because Mr. Say placed this snail in a genus other than the one in which it is now. He placed it in the genus *Helix*. Subsequently, students of the internal anatomy of snails, decided that *Helix profunda* actually belonged in the genus *Allogona*, but only after previous students had placed it in the genus *Mesodon* and later in the genus *Polygyra*. These changes do not result from whims of conchologists, but from honest attempts to group similar animals together; at one time, practically all snails having shells resembling that of *Allogona profunda* (Say) were placed in the genus *Helix* until it was discovered that this huge assemblage was actually composed of many groups of dissimilar snails, only superficially alike. By agreement among themselves, zoologists place the name of the authority for a species in parentheses if the currently accepted generic name is different from that in which the species was originally described.

Reasons for latinized names: Scientific names are derived from Latin, Greek, or even other languages, but they are all treated as if they were Latin. The reasons for this are several: (1) long ago, at least, most scientists were conversant with both the Latin and Greek languages, and the two, therefore, were more or less universally in use, and (2) neither language was in use as a common, everyday, spoken language, and therefore had little tendency to change. Thus the language of scientific names is actually universal, even though many scientists cannot read Latin or Greek. Even in scientific literature published, say, in Chinese or in He-

brew symbols, scientific names are written in Roman characters and in Latin words. Thus the name *Allogona profunda* (Say) is written in the same form in all scientific literature regardless of the native language of the writer.

Above the level of the species, higher categories are designed to show relationships of larger and larger groups. Again taking *Allogona profunda profunda* (Say) as an example, if we consult a standard treatise, such as that of Pilsbry (1940), we learn that there are several kinds of snails, each with a name beginning with *Allogona*. There is also *Allogona townsendiana* that inhabits lowlands in the far northwestern part of the United States, and *Allogona ptychophora* that lives in the mountainous regions of the northwest. Thus we see that the genus, *Allogona*, serves to unite a group of snails that bear certain resemblance to one another, and at the same time differ among themselves. The shells of each of the species are umbilicate, have a reflected white peristome, and no more than a single, low blunt, tooth; these species also share certain common features in their soft anatomy. The three species differ in size, color, and ornamentation of the shell, as well as in details of the internal anatomy.

Genera that seem to be related because of anatomical and physiological features that they share in common, are grouped in a catagory called a *Family*. In Kansas, the genera *Mesodon*, *Polygyra* and *Stenotrema*, together with *Allogona* (and others not found within the State), all belong to the family *Polygyridae*. The family (the name of which always terminates in -idae) unites a group of genera possessing certain common anatomical and physiological attributes. In this instance, shells are of little value in recognizing family relationships, although all polygyrids have lense-shaped to globose shells with a reflected lip on the peristome. The common anatomical features that demonstrate relationship in the family Polygyridae are mostly concealed in the soft anatomy, and can be detected only by careful dissection.

In like manner, families of snails that can be shown to be related are grouped into *Orders*. The family Polygyridae, together with a great many other families, belongs to the order Pulmonata. This order comprises all snails in which a chamber of the mantle serves as a lung. The snails that have developed such a chamber for breathing air are divisible into two great groups, one of which has sessile eyes, and the other having eyes borne on stalklike appendages. On this basis, the order Pulmonata is subdivided into

two groups, the Basommatophora, having sessile eyes, and the Stylommatophora, having stalked eyes. Inasmuch as the members of the family Polygyridae have stalked eyes, they are assigned to the subdivision (sub-Order) Stylommatophora. This example serves to illustrate the fact that subdivisions of the principal categories are sometimes made in an effort to group together animals possessing common traits.

Snails of the order Pulmonata are grouped with snails of other orders into a still broader category, the Class, all members of which share such features as a broad creeping foot for locomotion, and usually a single, generally spiral shell. Such animals, because of the character of the foot, form the Class *Gastropoda*. The Latin term, Gastropoda, literally translated means "stomach-foot."

In turn, the Class Gastropoda is one of five such classes of animals, all of which possess a mantle that secrets a shell, and a foot that is variously modified. These common traits allow all of these animals to be treated as a large group, the *Phylum*. The Gastropoda, along with the chitons, of the Class Amphineura, the tusk-shells of the Class Scaphopoda, the clams and mussels of the Class Pelecypoda, and the squids and octopi of the Class Cephalopoda, form the Phylum Mollusca.

Finally, since the members of the Phylum Mollusca are animals, that phylum together with twenty or more other Phyla are grouped in the *Animal Kingdom*, which distinguishes them from plants.

In review, and listing the most inclusive categories first, we have for *Allogona profunda profunda* (Say) the following scheme for showing the relationships of that subspecies.

Kingdom: Animal
Phylum: Mollusca
Class: Gastropoda
Order: Pulmonata
Suborder: Stylommatophora
Family: Polygyridae
Genus: *Allogona*
Species: *profunda*
Subspecies: *profunda*

The table of contents, beginning with the "Accounts of species," will serve as a check-list, showing the higher taxonomic categories to which each kind of snail in Kansas belongs.

COLLECTION, IDENTIFICATION AND PRESERVATION OF GASTROPODS

Where to Collect

Success in collecting as wide a variety of kinds of snails as possible from a given habitat depends largely upon a good knowledge of the habits and habitats of these animals. Such knowledge comes largely with experience. The best rule for the beginner to follow is—*look everywhere*. The reader may gain a good idea of the variety of molluscan habitats by glancing through the sections on habits and habitats under the various species accounts in this volume.

The most favorable times in which to collect are spring and early summer. Aquatic snails can be obtained at any time of the year except during the coldest part of the winter when the surface of the water is frozen. During the hot, dry months of summer, land snails are difficult to find in daytime. Sometimes collecting in early morning or late evening is profitable at this time of year. If hibernation sites are known, winter collecting can be very interesting although as a rule quite undependable.

Almost any material, natural or artificial, that is lying on the surface of the ground may provide shelter for one or more kinds of land snails. Some of the places in which these animals are to be looked for include the underside of logs, sticks and boards, beneath loose or started bark of fallen trees, accumulations of dead leaves and brush, the base and undersurface of rocks and on the trunks and leaves of growing trees and shrubs. Isolated patches of woodland in the middle of cultivated fields afford favorable snail habitats. Probably the most favorable areas are the forested river valleys. Drier situations, such as rocky hillsides with northern or eastern exposure, thick grass, and railroad embankments should not be overlooked. Land snails may be found in situations more closely associated with aquatic forms, for example, clinging to reeds in swamps and marshes. Gardens, pastures and the debris scattered around abandoned home sites should be investigated.

In collecting aquatic snails, any object in, on or emerging from, the water should be examined carefully. Likely niches for snails in streams, rivers, ponds and lakes include the stems and leaves of plants growing in the water, the underside of rocks on the bottom and of leaves, wood or paper found floating on the surface.

Sifting the mud from the margins and bottoms of aquatic situations is frequently productive, especially in the case of the smaller kinds. Aquatic snails occur in a wide variety of habitats; the only general rule that can be laid down is to look everywhere there is water.

How to Collect

If one has only a little time to spend and wishes to collect from as many habitats as possible, large quantities of litter, vegetation and other debris may be gathered and placed in paper or cloth bags. This material may then be sorted over at leisure. Such a method should be used only when absolutely necessary, since it does not allow the collector to observe snails closely in their native habitat.

The larger kinds of gastropods can be picked up by hand and the smaller ones with forceps. Small and fragile specimens are best handled by moistening one blade of the forceps or a small brush and allowing the shell to adhere to the wet surface. An excellent way to obtain quantities of the smaller land snails is to shake leaves, rotting wood or other material over a piece of plain white paper. The individual shells may then be picked out, or the entire mass of siftings can be placed in a suitable container and sorted at a later time. A similar method applicable to aquatic snails consists of vigorously shaking vegetation in a bucket of water. The snails will fall to the bottom of the bucket and may be picked out after the excess water has been drained off. Minute kinds such as *Ferrissia* or *Gyraulus* can sometimes be found by placing aquatic vegetation in a white enameled container. After an hour or more, the dark-bodied snails can be seen easily on the white surface of the container.

Although rocks and logs can be turned over by hand, we have found a geologist's pick to be exceedingly useful for such tasks and at the same time it affords more protection against snake bite. The Ferriss hoe, an ordinary garden hoe which has been cut so that the blade forms a sharp-pointed triangle, may be similarly used. One advantage of the pick is that it can be carried attached to the belt whereas the hoe must be carried in the hand. For aquatic specimens a long-handled dip net and a strainer (3 or 4 inches in diameter) are useful aids. A stout-bladed pocket knife is another very useful tool in the field.

Several styles of forceps are available from the various biological supply houses. Some persons prefer straight points, and others

prefer the curved points. In either style the most important quality is that they close easily. This enables the operator to exert just the right amount of pressure to retain the specimen without crushing it. In order to avoid misplacing the forceps in the field it is well to tie a string to them which may in turn be attached to a coat button or worn around the neck.

Snails may be brought home from the field either alive or preserved. It is usually desirable to bring the larger land snails back alive and the aquatics back preserved unless living material is specifically wanted. Land snails can be kept alive easily for extended periods merely by placing them in metal, cardboard or glass containers of appropriate size. It is desirable to keep minute gastropods separate from the medium-sized and large individuals. Several vials can be placed in a single metal container. The field label is temporarily attached to the tin with transparent tape. It is preferable to bring living aquatic snails back from the field in large jars (fruit jars serve very well) partially filled with water. It is possible, however, to keep these specimens alive for short periods of time in smaller metal or glass containers.

Alcohol is the usual preservative used in malacological work. It should be at least 70 to 75% in strength. Common rubbing alcohol can be used for this purpose. The collecting containers may be partially filled before leaving home, or a bottle of alcohol may be carried into the field. Formalin may be used if necessary, but it is not to be recommended due to its corrosive action on the shell after prolonged exposure.

The following list includes all items regarded as essential, in collecting land snails and fresh-water snails, as well as several items also taken into the field by most collectors. It is advisable to keep these items together in one place so that they are readily accessible when an opportunity to get into the field suddenly arises.

- Alcohol
- Bucket
- Containers
  - boxes
  - jars
  - vials
- Dip net
- Forceps
- Geologist's pick
- Hand lens
- Pocket knife
- Strainer
- Paper or cloth bags
- Field labels
- Notebook
- Pen or pencil
- Maps

FIELD LABELS AND RECORDS

Specimens without data are worthless except as curios. On the other hand, any collection is of scientific value, regardless of size, if the proper data accompany the specimens. It should be regarded as essential, therefore, that a label be prepared for each set of specimens collected, giving the following information: date,

precise location, and collector. The field label used by us is shown in Figure 86. In most private collections these labels are entirely handwritten. The essential qualities are that they be accurate and legible. When the specimens are finally identified, permanent labels will be prepared from the field labels.

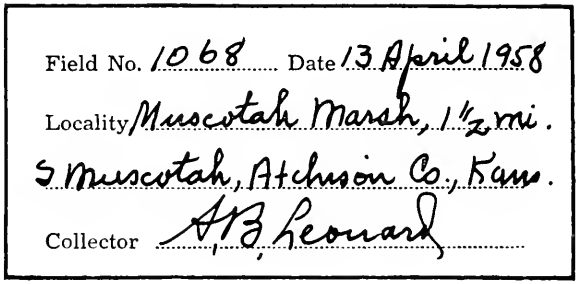


FIG. 86. Example of field tag. Note that it bears the date of collection, and designation of the precise place where a group of mollusks were collected, together with the name of the collector and the number corresponding to that in the collector's field notebook.

For convenience and to insure that all necessary data are obtained and recorded, field record sheets may be prepared in order to allow a variety of information to be recorded rapidly and conveniently. These data can be supplemented by notes entered on a good grade of note paper. When such notebooks are used it is customary to assign a number to each locality from which specimens are obtained. This field number is also entered on the field label and serves as a convenient index to the information on that particular set of specimens. It does not seem appropriate here to lay down any rules regarding the content of these notebooks. In general, it may be said that it is better to err on the side of including too much detail than on the side of too little.

Since location is the most important information on the label it will not be amiss here to consider this point in some detail. The location should be stated as precisely as possible. It is sometimes very important that either the original collector or someone else be able to return to the exact place where a set of specimens was collected. If the locality is given, for example, as "near Topeka" neither the distance nor direction is known. One acceptable method of citing a location is to give the distance in miles from the nearest town (or other permanent landmark) in two directions, say, "5 mi. S, 3 mi. E Topeka." This is read "5 miles south of and 3 miles east of Topeka." Or again, "4 mi. N Topeka, along U. S.

Hwy. 75." These methods have several disadvantages. It is usually not known whether the distance has been measured from the center of the town, or from some other place in the town, or from the nearest city limits. If measured from the city limit, changes in the limits frequently are made and probably will defeat subsequent attempt to locate the original locality. Highways are subject to change of number and name and commonly are torn up and abandoned in favor of new routes. Highways, therefore, should *not* be used in defining localities.

A more accurate designation can be made by use of the township and range system of survey adopted by the U. S. government in 1785. This system consists of a network of north-south and east-west lines which in effect divide the land into essentially rectangular blocks, each of which is six miles square. Ranges are numbered east and west from a principal meridian, while townships are numbered north and south from a base line, and each of these is numbered in a conventional manner. Each township is subdivided into numbered sections, 36 in all.

Thus a locality can be designated by giving the section number and numbers of the township and range in which the section is located, for example, "sec. 36, T. 5 S, R. 16 E, Brown County, Kansas." Even more precise location of a station can be achieved by dividing the section into fourths, and if desired the fourths into fourths. For example, a set of specimens from a certain locality could be recorded as being from "SW ¼ of NE ¼ sec. 36, T. 5 S, R. 16 E, Brown County, Kansas."

A map showing the township and ranges in Kansas can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., or from the Kansas Geological Survey Office at Lawrence. The Kansas State Highway Department issues a set of county maps showing townships, ranges and sections as well as roads, buildings, lakes, streams and other features for each of the counties in the state.

Preparation of Specimens

All specimens must undergo some preparation after they are brought in from the field before they are ready to be placed in a permanent collection. The exact procedure varies depending upon the nature of the specimens and the collecting technique used.

Larger land snails: If the diameter of the shell exceeds ¼ of an inch the specimen should not be placed in alcohol because it is extremely difficult to remove the animal after it has become hard-

ened. The animal is removed from the shell of these larger specimens by a process known as "pulling." This consists of dropping the living animal, preferably while it is fully extended from the shell, quickly into the boiling water and allowing it to remain there for 10 to 60 seconds. The exact length of the time depends upon the size of the animal—the larger the snail the longer the treatment. Boiling water detaches the animal from its shell, allowing the body to be withdrawn with forceps (curved tips are preferable) or a dissecting needle. If neither of these instruments is available a bent pin will serve.

Only a few individuals should be boiled at a time since they can be extracted most easily while still warm. A pair of long-handled forceps may be used to remove the animals from the boiling water, but a more convenient method is to place several snails in a wire strainer, then submerge the strainer in the boiling water. Care should be taken to remove all parts of the animal from the shell since any remaining portions will create a disagreeable odor and discolor the shell. After the animal has been removed the shell should be rinsed in cool water, brushed if necessary, and allowed to dry in a warm, but not hot, place. Shells should not be set directly in the sun or where artificial heat hastens the drying process, because the shells, when empty, may crack.

Larger aquatic snails: These may be extracted from the shells either by the method described above or by allowing them to stand in 50 to 75 per cent alcohol for a few hours. As mentioned in a previous paragraph it is desirable to put all aquatic snails in alcohol in the field unless living material is specifically desired. If this has been done, the specimens are usually ready for "pulling" when they are brought home from the field, or at the end of the day. It is especially important that shells of aquatic snails be prepared as soon as possible to prevent unpleasant odors and discoloration of the shells.

Smaller land and aquatic snails: Small or minute snails should be allowed to stand in alcohol for a few hours (they may remain in the alcohol indefinitely), washed in running water for a few minutes, removed and placed in a warm place to dry. The body of the snail will shrivel, but remain in the shell. If it is wanted for subsequent anatomical study or for the radula that is to be mounted on a glass slide the shell can be crushed and the dried body softened in a solution of trisodium phosphate. After a time in this solution the body will resume almost normal proportions.

If the bodies of freshly collected material are desired for anatomical study they may be treated in the same manner as the larger specimens. For very small individuals it will be necessary to crush the shell in order to extract the animal.

Slugs: Immersion of living animals directly in alcohol causes considerable contraction of the body. Such contraction is undesirable and it is preferable, therefore, first to drown the animals in a bottle of water. They may then be placed in alcohol which should be about 95 per cent in strength.

Identification

Identification is a means to an end, not an end in itself. The scientific name of an animal is the key to the accumulated information, about that particular kind of animal, which is to be found in books and technical papers in various scientific journals. The student is justified, therefore, in making use of every available aid in identifying his specimens.

Since it is impossible to provide each reader with a set of specimens with which he could compare his own material and arrive at an identification, we have done the next best thing by providing keys, photographs and descriptions. A key is essentially an abbreviated description that highlights those characteristics that most readily distinguish one group from another. The general procedure in keying out a specimen is as follows: Begin with the key to families and determine to which family the unidentified shell belongs. Then turn to the proper key and determine the genus to which the specimen belongs, and finally the species or subspecies.

All of the keys are based fundamentally on a process of elimination. A pair of contrasting statements will be found associated with each number at the left hand side of the key. After examining the specimen, you have to decide, in using a key, which of the two statements best fits the shell in hand. A number at the right-hand side of the key indicates which pair of statements are to be consulted next. Continue this procedure until the name of the group sought appears on the right-hand side of the key.

Although the use of these keys is fairly simple a few precautions should be observed. The keys are designed only for specimens from Kansas. Their application to material from outside the State may result in an incorrect identification. The keys are based on characteristics of adult specimens. Two things may happen when keying out juvenal individuals: (1) at some stage in the key

both or neither of the contrasting statements will fit the specimen, or (2) the specimen may key out but the detailed description does not correspond to the actual specimen. Shells of juveniles can be accurately identified only after long experience.

Each of the keys should be studied carefully before using them. Consult the glossary on page 215 for terms which are not clearly understood.

It is important to remember that no key is infallible. Keys are short-cuts leading to approximations only. All determinations should be checked against full descriptions and illustrations, and if possible, against authentically identified material. Because most kinds of snails vary individually, the greater the number of specimens available for examination the safer the determination.

Labeling, Cataloguing and Arranging the Collection

After the specimens have been prepared and identified it is necessary to prepare a permanent label to be placed in the container holding the specimens. All of the data appearing on the field label should be placed on this permanent label. It is important that this final label be as neat as possible; it will remain permanently with the specimens. An example of the permanent label is shown in figure 87.

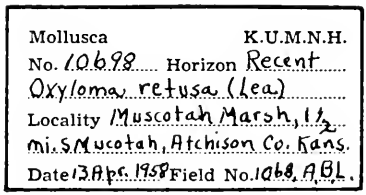


FIG. 87. Catalogue tag used to label a collection of gastropods, of a single species, made at a single time and at a single place. Note that it bears the collector's field number, so that his corresponding field notes can be referred to without difficulty.

Whatever the size of the collection, a general catalogue should be kept. A substantially bound notebook of good quality paper makes the best catalogue. The various types of ledger books sold at most stationary stores will be found to be suitable. If these cannot be obtained good quality bond paper punched for a loose-leaf notebook is preferable to cheaper notebooks. The catalogue should be ruled to allow space for the following information:

Catalogue number, name of shell (genus, species, and authority) and the collector's field number.

The type of arrangement of the collection itself is not so important, as is an arrangement that permits sets of specimens to be found in a reasonable length of time. For a small local collection an alphabetical arrangement may best serve this purpose. Most large collections are arranged according to some standard scheme of classification, that reflects present knowledge of the relationships of the various kinds.

Preservation of Soft Parts and Preparation of Radulae

Material for anatomical study should be preserved in 90 per cent to 95 per cent alcohol. Since it is desirable to have the body in as extended a condition as possible, the animal should be drowned in water before removal from the shell. Drowning requires about 6 to 24 hours. It may be hastened somewhat by using warm but not hot water. Care should be taken to see that the snails are not left in the water until they begin to decompose. After drowning, the animals are pulled in the usual manner by immersion in boiling water.

Although radular characteristics are of importance in systematic work on gastropods, especially at the generic level and above, it is unnecessary to study the radulae in order to identify most Kansas specimens. For those persons having a microscope at their disposal the six steps in the preparation of radulae slides are listed below.

1. Place the animal (or only the anterior portion of a larger specimen) in a 10 per cent solution of potassium hydroxide (KOH). Allow the animal to remain in this solution until the flesh has disintegrated; heating the solution will speed the reaction.

2. Carefully pour off the clear portion of the KOH. Place the remainder in a watch glass or similar container and look for the radula under the low power lens of a microscope. With experience the radula can be located with the aid of a hand lens or even the unaided eye. If the watch glass is laid on a dark background the radula is more easily recognized.

3. Wash the radula in water, and then immerse it in 95 per cent alcohol.

4. Spread the radula out as flat as possible on a glass microscope slide. A portion may be teased apart with dissecting needles so that the individual teeth can be observed.

5. Stain the radula if desired. A number of different radular stains and directions for their use can be found in any standard

work on microtechnique. A simple staining procedure consists of adding eosin to the alcohol used to remove the water.

6. Temporary slides can be prepared by simply placing a drop or two of glycerine on the slide and placing over this a cover slip. Permanent slides are obtained if Canada balsam is used in place of glycerine, but in this case, the balsam must be preceded by immersion of the radula in benzine or zylene.

Care of Live Material

It is not our purpose here to give an extended discussion of setting up and maintaining aquaria and terraria. For detailed information we refer the reader to the leaflet series available from The General Biological Supply House, Chicago, Illinois. One of the interesting aspects about keeping living specimens of snails and slugs is that one can experiment with the various environmental components, such as light, temperature, humidity, and foods. One may learn more through failure of a terrarium or aquarium than through its success. The directions given below are intended as a general guide only.

For terrestrial snails and slugs a rectangular glass aquarium-tank makes an ideal terrarium. The size of the tank will depend upon the available space and the amount of money one wishes to invest. Other types of containers may be successfully used. The bottom of the tank should be covered with a layer of gravel to a depth of about one inch. Two inches of soil is placed over the gravel and a layer of leaf litter and small twigs is spread over the surface. Pour in water at one corner until the gravel is covered. This will keep the soil above moist, but it should not be allowed to become too wet. The snails will eat the leaf litter, but this should be supplemented by lettuce leaves, raw carrots, bran or oats and similar items. Lime should be provided in some form, egg shell fragments being recommended by some authors for this purpose. Cover the top of the terrarium with a piece of glass, but allow a space between the cover and the tank for the free circulation of air. The terrarium should not be placed in direct sunlight because the temperature may rise above the point lethal for the snails.

Directions for setting up aquaria for fish culture, except for tropical forms, will suffice if aquatic snails are to be maintained. A layer of gravel and sand should be spread on the bottom. This serves as a support for the roots of the aquatic plants. Tap water may be used if it is allowed to stand for several days before plac-

ing snails it it. Water from a pond or clear stream is preferable. A good general rule to follow is that of using the water from which the snails are obtained in the field. If plants are allowed to grow in the aquarium they not only help replenish the oxygen supply but also serve as food for the snails. Supplementary feeding of lettuce leaves, bits of apple and the like is advisable.

GLOSSARY OF COMMON TERMS

APERTURE. The opening at the larger end of the shell of a gastropod, through which the snail protrudes the foot, head and part of the body when the animal is active.

APEX. The tip, usually acute, at the smaller end of the shell. The term APICAL WHORL(S) is sometimes used as a synonym of PROTOCONCH.

AURICULATE. Term used to describe flattened, "earlike" extensions on the head of some gastropods.

BODY WHORL. Last whorl of the shell; the whorl bearing the aperture. The term *body whorl* is misleading because the organs of the animal are distributed through all the whorls.

CALLUS. A thickening, as, for example, of the lip of the peristome.

COLUMELLA. The central axis around which the whorls of the shell are wound.

DENTICLES. Excresences of toothlike form on the interior surface of the walls of the aperture of some shells, especially those of the Pupillidae. Denticles, folds and lamellae are named according to their position (see figure 17).

DEXTRAL. Said of shells in which the whorls spiral toward the right. In dextral shells, if viewed with the aperture toward the observer, and the spire in dorsal position, the aperture, or the greater part of it, will lie to the right of the central axis.

EMBRYONIC WHORLS. See PROTOCONCH.

EPICOSTRIUM. A corneous epidermal covering on the surface of the shell of some gastropods. It usually is pigmented.

EPIPHRAGM. A film, or several films, of mucous secreted by certain snails in such a manner that the films are stretched across the aperture, where the mucous dries to form a closing membrane or membranes. Many snails protect themselves from excessive loss of water in periods of drouth by thus sealing the aperture of the shell.

EYE-PEDUNCLES. A pair of tentaclelike, retractile appendages on the heads of snails; the eyes are borne at the ends of the appendages. The eye-peduncles are situated dorsal to the tentacles.

FOLDS. Essentially a synonym for LAMELLAE. See also DENTICLES.

FOOT. The fleshy, muscular organ, forming a part of the body of a snail, and by means of which the snail creeps in locomotion.

GENITALIA. The reproductive organs, consisting of the gonads and their ducts, the penis, and seminal receptacle. See figures 18, 19, 58-70 for details of anatomy.

IMPERFORATE. Said of a shell in which the umbilicus is absent or secondarily closed.

LAMELLAE. Elongate, often ribbonlike excrescences found in the aperture of the shell, or within the last whorl. See also DENTICLES.

OPERCULUM. A corneous (or calcareous) plate attached to the dorsal part of the foot of certain snails, arranged so that when the animal withdraws into the shell, the operculum closes the aperture.

PERISTOME. The portion of the last whorl which surrounds the aperture. It is said to be *continuous* if it completely surrounds the aperture, or *discontinuous* if it is incomplete where the aperture lies against the penultimate whorl.

PERFORATE. Said of shell in which the umbilicus is open.

PROTOCONCH. The apical portion of the shell of a gastropod, formed during embryonic development of the animal. Sometimes called APICAL WHORL(S). Sculpture and color of the protoconch frequently differ from those of the remainder of the shell.

PULMONARY ORIFICE. The opening into the lung (air) chamber in the mantle cavity of pulmonate gastropods. The opening is guarded by a sphincter.

RADULA. A tonguelike organ in the floor of the mouth of gastropods. It consists of numerous transverse rows of minute teeth arranged in the form of a ribbon supported by a pad of tissue; the radula is motivated by muscles, and acts as a rasping organ in feeding.

REFLECTED. Said of the edge (or lip) of the peristome, when it is turned outward.

SCULPTURE. Ribs, riblets, costae, grooves, or raised striae which modify the surface of the shell of a gastropod.

SINISTRAL. Said of a shell in which the whorls spiral toward the left. In sinistral shells, if the shell is viewed with the aperture toward the observer, and the spire in a dorsal position, the aperture, or the greater part of it, will lie to the left of the central axis of the shell.

SINULUS. An embayment in the aperture of the shells of pupillid gastropods, produced by an indentation of the peristome (as in many species of *Vertigo*) at the level of the upper palatal denticle.

SPIRE. All the whorls of a shell save the last, which is sometimes inappropriately called the BODY WHORL.

SUTURE. The line of junction between two contiguous whorls of the shell of a gastropod.

TENTACLES. A pair of elongate, fleshy, generally retractile appendages on the head of snails. They are sensory in function; in basommatophorous snails, the eyes are situated at the bases of the tentacles.

WHORL. A single volution of the spiral shell of a gastropod.

Transmitted April 30, 1959.

ERRATA

Page 75, bryozoa, not bryza.
Page 92, *albolabris*, not *albilabris*.
Page 106, *carolinianus*, not *coralinianus*.
Page 109, *Hawaiia*, not *Hawaii*.
Page 134, *Strobilops*, not *Stribilops*.
Page 141, *Q. wandae*, not *G. wandae*.
Page 178, Leonard, not cLonard.
Page 180, *hordeaccila*, not *hordacella*.
Page 183, *P. inornatus*, not *P. inoratus*.
Page 183, *Pupoides inornatus*, not *Pupoides inoratus*.

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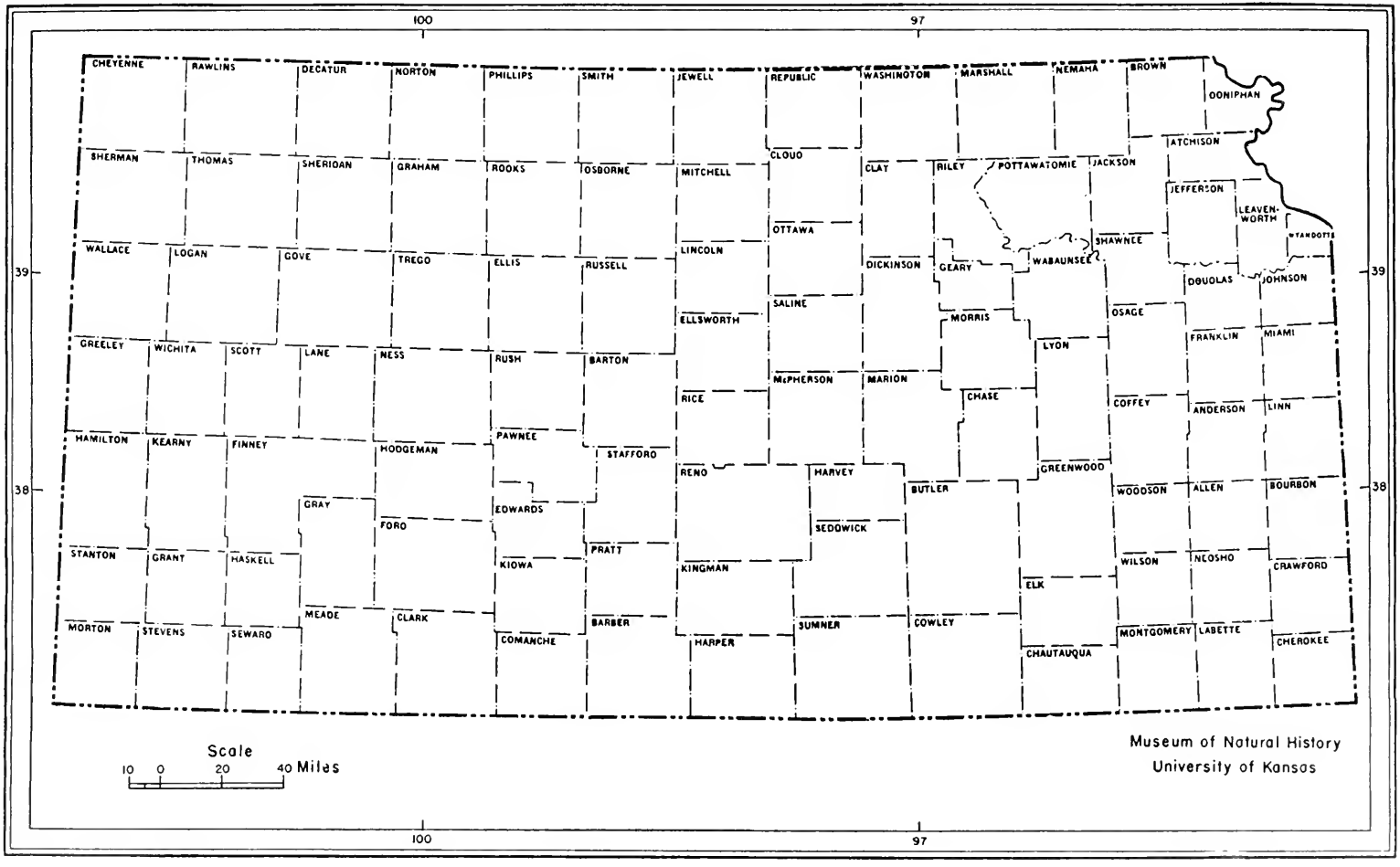
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*2. Handbook of Amphibians and Reptiles of Kansas. By Hobart M. Smith. Pp. 1-336, 233 figures in text. September 12, 1950.

3. In Memoriam, Charles Dean Bunker, 1870-1948. By E. Raymond Hall. Pp. 1-11, 1 figure in text. December 15, 1951.

*4. The University of Kansas, Natural History Reservation. By Henry S. Fitch. Pp. 1-38, 4 plates, 3 figures in text. February 20, 1952.

5. Prairie Chickens of Kansas. By Maurice F. Baker. Pp. 1-68, 4 plates, 15 figures in text. March 10, 1953.

6. The Barren Ground Caribou of Keewatin. By Francis Harper. Pp. 1-163, 28 figures. October 21, 1955. Copies, paper bound, $1.50 postpaid from the Arctic Institute of North America, 1530 P Street NW, Washington 5, D. C.

7. Handbook of Mammals of Kansas. By E. Raymond Hall. Pp. 1-303, illustrated. December 13, 1955. Paper bound, $1.50 postpaid (cloth $4.00).

8. Mammals of Northern Alaska, on the Arctic Slope. By James W. Bee and E. Raymond Hall. Pp. 1-309, Frontispiece colored, 4 plates, 127 figures in text. March 10, 1956. Paper bound $1.00 postpaid.

9. Handbook of Amphibians and Reptiles of Kansas. 2nd [revised] edition. By Hobart M. Smith. Pp. 1-356, 253 figures in text. April 20, 1956. Paper bound $1.50 postpaid (cloth $4.00).

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16. Natural History of the Prairie Dog in Kansas. By Ronald E. Smith. Pp. 1-36, 4 plates, 9 figures June 17, 1958.

17. Birds of the Ungava Peninsula. By Francis Harper. Pp. 1-171, 6 plates, 26 maps. October 15, 1958. Paper bound, $2.00 postpaid from the Arctic Institute of North America, 1530 P Street NW, Washington 5, D. C.

18. Furbearers in Kansas: A Guide to Trapping. By Howard J. Stains and Rollin H. Baker. Pp. 1-100, illustrated. November 19, 1958. Paper bound, 50 cents postpaid.

19. The Natural History Museum . . . The University of Kansas. By Roy R. Moore and E. R. Hall. Pp. 1-8, illustrated. May 30, 1959.

20. Handbook of Gastropods in Kansas. By A. Byron Leonard. Pp. 1-224, 11 pls., 87 figures in text. November 2, 1959. Paper bound, $1.00 postpaid (cloth $2.00).

* Out of print.