ZETEK

# The General Ecology of the Forest-Inhabiting Mollusca

General Science

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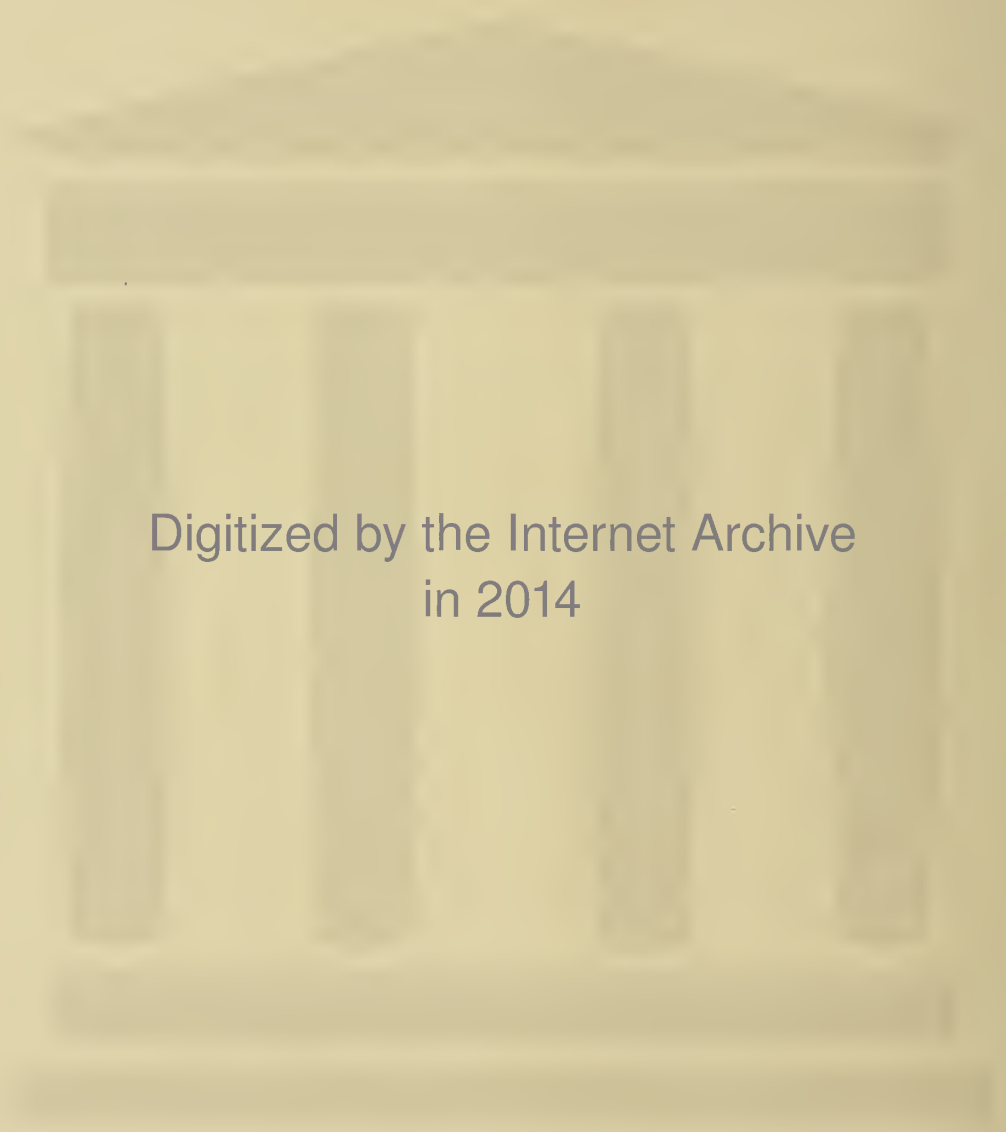
1911



# THE GENERAL ECOLOGY OF THE FOREST-INHABITING MOLLUSCA



BY JAMES ŻETEK

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## THESIS

FOR THE

DEGREE OF BACHELOR OF ARTS

IN

GENERAL SCIENCE

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COLLEGE OF SCIENCE

UNIVERSITY OF ILLINOIS

JUNE, 1911

UNIVERSITY OF ILLINOIS

June 1st 1911.

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

James Zetek

ENTITLED "The General Ecology of the Forest Inhabiting Mollusca"

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Arts in Gen. Science, College of Science.

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# I N T R O D U C T I O N.

## Aim of the Study.

This thesis presents the results of a study of the molluscan habits, life histories and habitats as found in a few woodland areas near Urbana, Illinois. In this study I have considered the subject from three points of view, (1) the environment, (3) the organism and (3) the associations of snails.

## Localities studied.

The principal locality studied was a patch of woods belonging to Mr. T. Brownfield, located at Augerville (see U.S.G.S. topographic map), and locally known as the "Brownfield Woods", and less commonly as the "Blacksmith Woods". This grove occupies an area of eighty acres and is 3 1/4 miles north-east (measured along roads) from the Champaign County Court House, located at the County Seat, Urbana, Illinois.

Another patch of woods, the Cottonwood Grove, of equal acreage, located about 1 1/2 miles south-east of the Brownfield woods, was studied to some extent. Additional data was obtained from patches of woods near St. Joseph, Champaign Co., Illinois; woods bordering Stony Creek at Muncie, Vermilion Co., Illinois; a grove along the old right of way of the Big Four R.R., east of Oakwood, Vermilion Co., Illinois; and woods along the Middle Fork branch of the Vermilion River, south of Hillery (Hilliary), Vermilion Co., Illinois.

## Methods of Study.

In the field, the aim was to secure definite knowledge concerning the physical and biotic factors of the snail environment.

Collections were made of the mollusca inhabiting the forests, and the associated organisms. Photographs were also taken of the different habitats.

In the laboratory, snails were kept in confinement in order to study their habits, and life histories, and the literature was studied for facts bearing upon the problem.

Acknowledgements.

I wish to express my gratitude to Dr. C. C. Adams, of the University of Illinois, under whose direction this study was made, for valuable suggestions and for his interest in the work.

To Mr. Frank C. Baker, Curator of The Chicago Academy of Sciences, I am grateful in many ways. He examined all the snails and verified their determinations and has also given me valuable suggestions.

Had it not been for the timely financial assistance from the "Matice Vyššího Vzdělání", a Bohemian educational organization, I would not have been able to complete this study. I take this opportunity to express my thanks to this society.

My thanks are also due to the following persons who have assisted me in various ways: Dr. S. A. Forbes, Director of the Illinois State Laboratory of Natural History, for the use of the library; Dr. J. W. Folsom, Hugh Glasgow, R. D. Glasgow and M. C. Tanquary, of the Department of Entomology, University of Illinois; C. A. Hart, Office of the State Entomologist; J. D. Hood and A. G. Vestal, of the University of Illinois.

# I. THE ENVIRONMENT.

## A. The Hardwood Forest of the S-E United States as a Snail Environment.

This forest province corresponds very closely with Binney's "Interior Region" of the "Eastern Province" ('78, p. 28). It is an old land mass which was not disturbed by glaciation except along its northern part. It is noted for the richness of its land snail fauna, particularly those of the genus Polygyra. Binney ('78, p. 34) inspeaking of the richness of this fauna, states that "in the Cumberland Subregion we find the largest numbers of species of any portion of North America. This Subregion is equally prolific in individuals and the individuals are highly developed..... Low mountains thickly shaded, well watered, and with a genial climate and proper soil, offer in their thickets and ravines innumerable safe breeding grounds for the land shells."

Plant ecologists recognize three general types of forest within this area,- (1) the xerophytic or dry upland plant associations, (2) the hydrophytic or wet lowland plant associations, and (3) the mesophytic or well-drained plant associations. Since most land snails are dependant on plants for food or shelter, it seems advisable to use these botanical distinctions instead of making new ones to describe the larger environmental units of these snails.

### 1. The xerophytic plant associations and their snails.

Such associations of vegetation occur in places where the organic content of the soil and the available moisture are low. Such conditions are met with on rock outcrops, dry uplands and sandy places. Typical trees of this association are Quercus marylandica (black jack oak), Q. alba (white oak), Q. coccinea (Scarlet oak),

Q. macrocarpa ( bur oak), and Hicoria glabra (shag-bark hickory). The undergrowth among such trees is scanty. Such conditions are unfavorable to most land snails. The paucity of debris and undergrowth, and the small amount of humus mean to the snail almost no shelter, very little food, and insufficient moisture. The mollusks found in this association are few in number, and are represented by such species as Vallonia pulchella Mull., V. parvula St., Bifidaria corticaria Say, B. armifera Say, B. holzingeri St., B. pentodon Say, Pupoides marginatus Say, and Polygyra monodon Rackett (= leaii Ward).

2. The hydrophytic plant associations and their snails.

This association is characterized by an overabundance of moisture. River-bottoms, borders of swamps and marshes are usually of this type. The typical trees and shrubs of this association are: Platanus occidentalis (Sycamore), Salix spp. (willows), Populus deltoides (poplar), Ulmus americana (elm), Acer saccharinum (soft maple) and Cephalanthus occidentalis (button-bush). The herbaceous undergrowth is profuse and of a hydrophytic character. This association is, from the standpoint of snails, transitional between the stream and pond types and the drier land associations. The abundance of water is favorable to those snails which are more or less amphibious. The shade and moisture, together with sufficient food and shelter favor many of the land forms.

The snails typical of this association are Carychium exile, Succinea avara, S. retusa, P. multilineata, P. thyroides, Zonitoides arboreus, Vitrea indentata, Bifidaria contracta, Agriolimax campestris and Pomatiopsis lapidaria. On the mud-flats and in ponds which become dry in summer, the following aquatic pulmonates occur: Galba caperata Say, G. humilis modicella Lea, Physa gyrina Say, Segmentina

armigera Say, and Sphaerium spp.

3. The mesophytic plant associations and their snails.

This association is characterized by a rich, moist soil, a relatively humid and cool atmosphere, a deep humus, plenty of leaf mould and sufficient shade. The following trees and shrubs are found in this association: Acer saccharum (hard maple), Acer rubrum (red maple), Aesculus sp. (buckeye), Quercus bicolor (swamp white oak), Juglans cineria (butternut), Asimina triloba (papaw), Ulmus americana (white elm), Gymnocladus dioica (coffee tree), Fagus americanus (beech), Quercus imbricaria (shingle oak), and Benzoin aestivale (spice bush). The undergrowth is profuse. In this sort of woods we have sufficient moisture, food, shade and shelter for land snails. As a result, most of the land snails are found in this association. Nearly all the species studied in this report belong to this type. The following will serve as examples: Polygyra thyroides, P. albolabris, P. hirsuta, P. pennsylvanica, Circinaria concava, Pyramidula alternata, P. perspectiva, Vitrea indentata, V. hammonis, Paravitrea significans, Agriolimax campestris, Philomycus carolinensis, Bifidaria contracta, Zonitoides arboreus, Z. nitidus, Z. minusculus.

## B. The Brownfield Woods as a Molluscan Environment.

### General Description.

This patch of woods occupies an area of 80 acres, and is practically the only piece of timber in this vicinity which is undisturbed by clearing or pasturing. This year and part of last, one horse was kept in this grove, and in the northern portion, a few chickens were allowed to run. The grove is bordered on the south

and east by a public road. Cultivated fields border the other two sides. The difference in elevation in this woods is about 30 feet, the lowest areas being in the north-west and the south-east. A morainic ridge extends from the north-west to the south-east. The lowland areas are not very large compared with the rest of the woods. During spring, and following heavy rains, a narrow stream forms in the north-west and pursues a somewhat sinuous course to the south-west of the woods from where it is drained by tile into the Salt Fork. This stream is usually about six feet wide, and hardly ever more than eighteen inches deep. The north-west portion is low and flat and in spring is quite marshy. The slopes of the ravine are gradual.

Raccoons are reported to be found in this woods and I have found hair of this mammal in hollow tree trunks. It is doubtful, however, that many individuals exist here. Probably all have been killed off. Rabbits also occur here. I inquired of old inhabitants of Augerville if they recalled any other animals, however, none could give me definite information.

Many birds frequent this woods, however, the different species have not been listed. In the marshy places I found in the year 1907, one garter snake, Thamnophis sirtalis sirtalis . No snakes have been seen since, nor have I observed any toads or frogs in this woods. Of the smaller mammals I have trapped several species,- the short-tailed shrew, Blarina brevicauda Say, the white-footed mouse, Peromyscus leucopus var. noveboracensis Fisher, the vole, Microtus austerus Lec., and another mouse, undetermined as yet. The insect fauna is very abundant in species and individuals.

The woods is composed chiefly of members of the mesophytic plant association. The trees and shrubs are principally Tilia ameri-

cana, (bass wood), Aesculus sp. (buckeye), Quercus rubra (red oak), Q. alba (white oak), Q. macrocarpa (bur oak), Q. prinus (chestnut oak), Cornus florida (dogwood), Juglans cineria (butternut), J. nigra, (walnut), Ulmus americana (white elm), U. fulva (slippery elm), Hicoria glabra (hickory), Morus rubra (mulberry), and Acer saccharum (hard maple). Many of the trees are very high, and there is in this woods considerable second growth (Plate 1.). The highest trees are from 50 to 65 feet. The crowns begin at from 45 to 55 feet from the ground, and form a very close mat so that very little sunshine penetrates, and very little moisture escapes. As a result of this, the atmosphere is cool and humid, and the shade is dense.

The depth of humus varies in the different parts of the woods. On the ravine slopes it is from 6 to 12 inches. Below this is glacial clay. The leaf mould is about 1- 1 1/2 inches thick. The humus is always moist and cool. ~~The relation of these three layers to each other [illegible] is shown by diagram in figure ___, plate ___.~~

Fallen trees, broken limbs and smaller branches are plentiful on the forest floor. There is a yearly deposit of dead leaves. All these are in various stages of decay. I have not been able to observe the length of time required to reduce a log to humus. Tree seedlings and young trees occur in this woods.

Snails are very sensitive to moisture in the air. If the humidity is low, they retreat to moister places, such as the soil, under logs, etc. When the atmosphere is saturated with moisture, as after a good rain, the snails crawl about on the logs and vegetation. No records were taken for the comparative evaporation within this woods, however, work on this subject has been done by Transeau and Shimek, and their data are applicable to the conditions met

with in this woods.

Transeau ('08, p. 224), using porous cup evaporimeters, compared the evaporation in various habitats with that in open, exposed regions. He kept one of these evaporimeters in an open place, and others in various habitats. Evaporation in the open was the unit, or 100%, and by comparing the evaporation in the different habitats with this unit, he obtained values, in percents, for the comparative evaporation in the areas studied.

He gives the evaporation for a forest which is somewhat similar to conditions in the Brownfield woods. The data are for the period from June 5th to July 2d. The highest evaporation was 48.2 % and the lowest 33.6 %, or an average of 40.1 %, i.e., 4/10 of that in the open. In a densely wooded ravine with a rich herbaceous vegetation, it was only 13%, or a little more than 1/10 of that in the open. The Brownfield woods is probably intermediate between Transeau's forest and his ravine. This would indicate an evaporation of about 25 %, or 1/4 of that in the open. The relative humidity is then about 75%.

Shimek ('10, p. 466) has shown by his experimental data for Iowa that "evaporation is most rapid from surfaces exposed to the prevailing summer winds and to the afternoon sun, and that both are necessary to cause maximum evaporation; that in rough territory these surfaces are chiefly southwesterly and hence exposed as stated, and this at the time of the day when the relative humidity of the air is the lowest; that the effect of wind upon evaporation is best brought out and is greatest when the temperature is sufficiently high to produce rapid evaporation; that evaporation varies with the direction of the wind and the position of protective barriers such as ridges; and finally that upon all the areas exposed to maxi-

mum evaporation a prairie flora, largely xerophytic, is developed, while the mesophytes of the grove and forest develop in our territory only in places sheltered from the chief evaporating agencies".

The high and closely matted crowns shut out the heat rays of the sun, and act as a blanket in keeping the moisture in the woods. The winds as they sweep against the woods are deflected upwards, and pass mostly over the crowns of the trees. The forest is thus a conservator of moisture. This moisture in the air and soil is necessary for the life activities of the forest snails.

In this woods is a small sample of wet lowland association. The soft maple (Acer saccharinum) and the spice bush (Benzoin aestivale) are found here, together with many herbaceous plants of a hydrophytic nature. Several species of mollusca are found here which belong to the wet lowland associations, and of these, Carychium exile and Succinea avara are good examples.

Conditions which determine the Mollusk Habitats.

During the time that forests have been here, leaves had fallen yearly to the ground, trees were broken by lightning, and branches were broken off by the wind. Insects and mammals have added to this accumulated material by boring and gnawing into tree trunks, and so weakening the trees that they broke of their own weight. The carcases of birds, mammals, insects and other animals added their share. This matter, thru the process of decay, became converted into humus. The present forest is the result of years and years of development which result in the present molluscan habitats.

Since man's habitation in this region, many changes have

been wrought in the biotic constituents of the area. The cultivated fields produced an abundance of grain, and parallel to this came an abundance of rodents. In the spring and summer they are in the fields. As soon as the cold days of winter approach, they invade the forests. (Wood, '10, p. 541). Their runways open under almost every log, and the larger helices, especially when hibernating, are helpless prey for these ~~rodents~~ mammals. The arboreal and subterranean snails are the only ones that escape in part this kind of enemy.

Man's influence has been detrimental in other ways. At Hillery, Illinois, was a very rich forest, a favorable locality for large helices. Last winter a fire begun in the woods and the entire undergrowth burned away. Upon the ground could be seen hundreds of dead Polygyras, their shells calcined and burned. A number of these have been photographed (Plate 5, fig. 7).

The clearing away of undergrowth and debris in a woods, as well as pasturing, is detrimental to land snails because it takes away from them their food and shelter.

There are many factors involved in the environment. I shall consider the following: moisture, soil, light, temperature, food, and associated animals.

Moisture: The dense crowns of the trees reduce evaporation by shutting off the hot rays of the sun, and by shutting in the moisture. The rich humus holds water. The majority of forest snails prefer a moist, cool woods. The decreased evaporation and the moisture conserved in the soil and air, bring about cool, moist situations. Since the evaporation is low, considerable amount of moisture is in the air, as is shown by Transeau's experiments. At times, during rain, the air is saturated with water. During the spring and summer, the relative humidity of the woods is probably

as high as 75 or 80 %.

Soil: The humus and leaf mould form a layer about 12 inches thick. This soil is black or brownish-black, and is rich in organic and inorganic elements. The humus is not very compact, in most cases it is crumbly in nature. As was stated above, the moisture content is large. In this latitude the ground does not freeze far below the surface. The discovery of such snails as Helicodiscus lineatus by Motter, 6 to 9 feet below the surface of the ground, would indicate that some of these forms at least were active also during the winter months.

Light: The compact cover of the trees, besides shutting out heat rays, shuts our a ~~great~~ large proportion of the light. Snails are usually nocturnal or semi-nocturnal. They are not usually seen crawling about in the daytime, excepting when the day is cloudy and during rains. In the woods they are most abundant in the shaded areas, and those found in open places are usually among roots of plants.

Temperature: In the zone where most of the snails live, the temperature is rather low when compared with that in the open. If the temperature becomes too ~~hot~~ high, the snails retreat to cooler and moister places. If the temperature becomes too ~~cold~~ low, these snails secrete usually an epiphragm and pass the winter in a dormant state.

Food: Most snails are herbivorous, eating the vegetation growing in the woods. Some eat fungi. A few are carnivorous. The Brownfield woods is rich in undergrowth so that there is an abundance of food. There is not much competition for food. The lepidopterous larvae are usually found eating the leaves of trees. A few eat the vegetation sought by snails. Rabbits also eat vegetation, but they are not abundant enough to cause any great disturbance. The vegetable eating mammals eat usually the roots of plants.

Associated forms: In general, snails are associated with snails. Very few species are solitary. The competition for food is not so severe because there is an abundance of it, excepting in times of drought. In addition to snails, many insects are present, but most of these have no intimate connection with the snails excepting that they occupy the same retreats. Some of these forms may be found to be enemies of snails, eating the young or eggs. The important forms that are enemies of snails are,- shrews, mice, birds, parasites, man, etc. It is these that produce oscillations in the snail associations.

The Mollusk Habitats.

I have classified the mollusk habitats occuring in the Brownfield Woods into three divisions: (1) the arboreal habitats, (2) the log habitats, and (3) the subterranean habitats. These habitats are present in all types of plant associations; they vary somewhat as the physical conditions of the association vary. I, therefore, shall treat separately the habitats of the wet-lowland type, giving the differences between them and those of the mesophytic woods.

Arboreal habitats. I shall follow the cycle of decay of a tree. Many standing trees are killed by various causes. The bark becomes loosened in time. Under this bark occurs usually Philomycus carolinensis, observed by Baker at a height of 50 feet. With it is found sometimes Pyramidula alternata and insect larvae. This habitat is not trully arboreal since the snails do not perform their functions in the trees.

Log habitats. When a tree or branch fall, there is the beginning of the log habitat (Plate 2 , Fig. 2 ). Under the "started" bark may persist Philomycus carolinensis. In the earlier stages of this habitat this may be the only mollusk, associated with the

black ant, Camponotus americanus, and larvae of Pyrochroa flabellata. As the decay advances, several species invade the "under bark" habitat. Among the first of these is Pyramidula alternata, followed by such forms as Vitrea indentata, Zonitoides arboreus, Bifidaria contracta, etc .

The "under bark" habitat is only a part of the log habitats. A rather rich molluscan fauna is found under logs. This situation I designate as the "under log" habitat. Two sorts of mollusks are found in this zone,- 1, the terrestrial surface forms, and 2, the subterranean forms. The first occur mostly upon the surface of the leaf mould under the log, in the interstices of the bark, and at times, in the leaf mould itself. Such species are Bifidaria contracta Strobilops labyrinthica, Euconulus chersinus, etc. In the second sort are such species as Z. arboreus, V. hammonis, H. lineatus, Z. minusculus, C. concava, P. solitaria and P. alternata. They are found in the interstices of the bark, on the surface of the leaf mould and in the leaf mould, but in addition to this, they are found deep in the soil. The first four were found by Motter in graves. Some of these species are found in several habitats,- Pyramidula alternata, is found under logs, arboreal, and also subterranean.

Thru the process of decay, accelerated by the borings of such larvae as Scoleocampa liburna Geyer, the log is ultimately reduced to a heap of debris consisting of humus, pieces of well decayed wood, animal remains, etc. This final state is shown in Plate . The only signs of a former log is the somewhat raised mound, covered with dead leaves and leaf mould, and consisting of decomposed matter. The only snails I found in such a habitat were Pyramidula alternata, Zonitoides arboreus, Vitrea hammonis, and Helicodiscus lineatus,- forms which are also subterranean.

Thus, beginning with arboreal habitats, there is a succes-

sional change to log habitats, and from these, to subterranean ones.

Subterranean. This habitat has received but little attention by investigators, in fact, the soil is seldom looked upon as a life zone. In this woods several species were noted to be in the humus. Motter in his study of the fauna of the grave found several species of shells in graves from three to nine feet deep, and from three to seventy-nine years old. It is likely that some of these snails live upon the dead bodies of subterranean animals, and also, upon the mycelium of fungi which may grow in the soil. The presence of snails in graves (some of which were over 21 years old and hence all animal matter decomposed) is probably an indication of their food, because upon the stripped bones, the wood of the coffin, and the clothing, mould will develop and this may be eaten by these snails.

In the wet lowlands, the same habitats are duplicated. The species differ, however, as will be seen in the table of associations (Part III). The subterranean zone, owing to the extreme wetness of the ground, will not be as extensive as that in the well-drained regions. The arboreal zone will be more extensive because of the greater humidity of the atmosphere at those levels. The decay of the log is more rapid in this association because water, as an agent of decay, is present in greater degree.

## II. THE ORGANISM.

I shall consider here the general characteristics of forest-inhabiting snails. Twenty seven species are represented in the Brownfield woods, all of them are air breathers, or pulmonates. With the exception of Carychium exile, which is semi-amphibious, all belong to the suborder Stylommatophora. In the treatment of this subject I shall consider five broad features,- 1, General activities; 2, Senses; 3, Food; 4, Reproduction; and 5, Enemies.

### 1. General Activities.

These snails are nocturnal or semi-nocturnal. In the daytime they are usually concealed under bark, under logs and stones, among leaves, etc. At twilight and at night they are active, crawling about (except during drought) upon logs, leaves and trees. It is during this period that they feed and that the reproductive functions take place. If during the day the atmosphere becomes saturated with water, as during a heavy rain, these snails leave there retreats and crawl about.

Slugs usually find concealment and shelter under boards and stones, in contact with the cool earth, but as soon as the atmosphere becomes dry, they abandon these retreats for moister situations, and "in seasons of drought they penetrate deeply into the earth". (Binney, '78, p. 4).

Snails have a great tenacity of life. "The eggs of Limax have been so entirely desiccated that their form has dissapeared, and there remained only a thin skin, friable between the fingers. In this condition they have been kept for years; and yet a single hour's exposure to humidity was sufficient to restore their form and elasticity.(Bouchard-Chantereaux). They have been dried in

a furnace eight successive times, until they were reduced to an almost invisible minuteness, yet in every interval have regained their original bulk in a moist situation. (Leuchs). In all these instances the young have been developed in the same manner as in other eggs not subjected to the experiment." (Binney '79, p. 6) Binney states also of finding "Helix eggs" in snow, protected only by a single leaf. The shell-bearing snails themselves withstand condiderable freezing. Succinea has been frozen in ice, and on thawing out, was as active as if nothing had happened to it. Several specimens of Succinea luteola were sent me from Brownsville, Texas. They were kept in a dry bottle for one month, and for another month lay upon a hot radiator. When I placed them into a moist stender dish with lettuce, they revived and crawled about, and in five or so minutes were feeding on the lettuce. These same Succineas, however, died when left in a very moist cage. They are desert forms, peculiarly adapted to withstand the dry atmosphere of the arid plains of the south-west. In Europe many experiments were performed upon Helix, by cutting off the eye-peduncles, portions of the foot and head, etc. In all cases the severed parts were restored.

The larger helices have been observed often in warm and sunny situations, especially just as they leave their winter quarters. Binney ('78, p. 7), speaking of this characteristic, says: "In the early days of spring, they sometimes assemble in considerable numbers, in warm and sunny situations, where they pass hours in indolent enjoyment of the warmth and animating influence of the sunshine. Whether these meetings serve any useful purpose in the economy of the animal, or are caused by the pleasurable sensation, and renewed strength derived from the warmth of the situation after the debility of their winter's torpidity, is uncertain; it is pro-

bable, however, that they precede the business of procreation. It is certain that they last but a short time, and that after early spring the animals are to be found in their usual retreats".

Some of the slugs have the power of suspending themselves from a thread of mucus. Concerning this phase of activity, Binney ('78, p. 12-13) writes: "This they effect by accumulating a quantity of tenacious mucus at the posterior extremity of the foot, which they attach to the object from which they are to begin their descent; then, loosing their hold, they hang suspended by this point. Continuing the secretion, their own weight attenuates the mucus attachment, and draws it out into a thread. As this dries and hardens a fresh supply is afforded, the thread is lengthened, and the animal lets itself down any considerable distance. At this time the margin of the foot pours out mucus freely, and during the whole operation the locomotor disk is in active undulatory motion, in the same manner as when in ordinary progression. It appears in this way to guide and force towards the extremity the mucus which is secreted on its surface, and which, collected at the extreme point, forms the thread. The slug often pauses in its descent, and extends its eye-peduncles and its whole body in various directions as if seeking some object on which to make a lodgement." Binney believes that this habit indicates that they pass part of their time in the trees. The full grown slugs are rarely seen in this attitude. The young are the ones which use this method of "progression". Unlike spiders, they cannot draw themselves up again. Binney believes also that this may be a means of evading enemies such as "birds".

When the cold days of winter set in, the vegetation is gone, the crowns of the trees are bare, the moisture is crystalized, and the activities of the snails , as a result of these

adverse conditions, cease. The helices secrete an epiphragm and hibernate thru the winter months. They often congregate in great numbers in the same retreat, often several species being together. Some burry deep in the soil, others are simply in the leaf mould, while still others remain under logs. The process of forming the epiphragm is carefully described by Binney ('78, p. 9) as follows: "The animal being withdrawn into the shell, the collar is brought to a level with the aperture, and a quantity of mucus is poured out from it and covers it. A small quantity of air is then emitted from the respiratory foramen, which detaches the mucus from the surface of the collar, and projects it in a convex form, like a bubble. At the same moment the animal retreats farther into the shell, leaving a vacuum between itself and the membrane, which is consequently pressed back by the external air to a level with the aperture or even farther, so as to form a concave surface, where, having become desiccated and hard, it remains fixed. These operations are nearly simultaneous, and occupy but an instant. As the weather becomes colder, the animal retires farther into the shell, and makes another septum, and so on, until there are sometimes as many as six of these partitions; the circulation becomes slow; the pulsations of the heart, which in the season of activity vary from forty to sixty in a minute, according to the temperature of the air, decrease in frequency and strength, until at length they become imperceptible; the other functions of the body cease, and a state of torpidity succeeds, which is interrupted only by the reviving heat of the next spring's sun." I doubt if a vacuum is produced, and as to the successive layers being formed as colder days come, it is likely to be not a protection against cold, but some other reason not yet known. The snail when it begins its activities, eats away the epiphragm. There

is no drain, practically, upon the strength of the snail while it is dormant, and hence there is no exhaustion of its forces. The eating of the epiphragm is probably necessary that the activities be restored.

Snails crawl by a slow gliding motion produced by the muscles of the foot. Mucus is secreted and leaves a trail wherever the snail has travelled.

## 2. Senses.

The special organs of sense are probably five in number,- touch, taste, smell, sight, and hearing. There is a possible sixth sense,- the sense of direction.

Touch. The integument of snails is very sensitive, especially the eye-peduncles and the tentacles. This snail is no doubt very acute and is perhaps the most useful sense possessed by the snail, as it is by means of it that the animal crawls.

Taste and Smell. These two chemical senses are closely related to each other, and probably in snails are more nearly combined in a single sense,- smell. Taste, so far as I have been able to ~~tell~~ learn, is not well developed in these forms.

Smell is perhaps one of the most important senses. The observations recorded by Simpson ('01, pp. 273-4) are as follows: He kept individuals of Polygyra albolabris without food for several days, and then placed in the cage a head of lettuce, concealing it with leaves. "In a short time the snails would appear from under the leaves, and on the surface would raise the anterior portion of their bodies in the air, with extended tentacles, turning from one side to the other, having exactly the appearance of a quadruped sniffing the air in the endeavor to locate some object. Having de-

cided on the position of the lettuce, they would invariably move directly toward it, and this sometimes from a distance of 18 inches". The lettuce was so concealed that they could not have detected it by means of vision. Snails are known also to discriminate in regard to food. This discrimination, according to Simpson is made by ~~sense~~ smell alone since none of the forms tried tasted of the food. The sense of smell is probably located in the tentacles because when the snail is in motion, these are usually bent down toward the object on which it is moving.

Sight. I placed obstacles, such as upright pieces of wood, in the paths of Agriolimax campestris, Polygyra thyroides, P. albolabris, and P. pennsylvanica. It would seem that if the animal could see these obstacles, it would change its course. On the contrary, however, they kept crawling in the same direction. As soon as the body or tentacles touched the obstacle, the animal stopped, the tentacles were drawn in, then the eye-peduncles would be stretched out and moved in different directions. The animal would then either climb the obstacle, or else move along its edge. I repeated this experiment using colored screens,- green, black and red. The results were the same. This would indicate that sight was not a well developed sense. As a sourse of error in this experiment, I would say that the direction of light was ignored, however, the light in the room was not intense.

Hearing. So-called auditory organs are situated beneath the sheath of the supra-esophageal ganglia, and are connected with nerves from the cerebral ganglia. Simpson ('01, p. 276) tried to ascertain if the snails responded to noise. He found that if the noise produced did not jar the animal, it had no effect on it. It may be, however, that this organ is adjusted to respond to sounds

of a certain number of vibrations, and hence loud noises may not affect the snail.

Sense of Direction. The validity of this sense is in question. I refer to it simply because Simpson ('01, p. 276) accredits it to Polygyra albolabris. He took from his breeding cage (which he had for several months stocked with about a hundred shells) three seemingly dead shells and laid them on a window ledge opposite from the box, the distance being 12 feet. Several hours later he looked for them, but they were gone. He discovered a trail of mucus which led in "an absolutely straight direction to the box in which they had been kept". He tried this several times and "they almost invariably returned to the box".

### 3. Food.

The food of most forest snails is vegetable. Some forms are also cannabalistic, eating besides their own, other species. However, the slowness of their movements prevents this habit from being a general one. The vegetable food consists of the succulent leaves of herbaceous plants, of fruits, and fungi. Atkinson and Shore ('05, p. 424) mention "snails" as being fond of mushrooms,- the mushroom treated in that report is Agaricus campestris Linn. and since this is grown in cellars, the "snail" is in all probabilities a slug, Agriolimax. I observed Philomycus carolinensis in a shallow groove on the under side of Fomes sp., a wood fungus, and a mucus trail leading to the groove. I found Vitrea indentata in small cavities in the pileus of Russula emetica? This same snail I found within the lamellae of Pleurotus ostreatus, a white fleshy wood fungus. The "under log" snails and the subterranean forms most likely eat the mycelium of fungi.

Ford ('90, p. 85) observed Agriolimax agrestis feeding upon A. campestris. Webster ('96, p. 53) observed Agriolimax campestris feeding upon Aphids,- Phorodon maheleb Fonsc. Circinaria concava has been observed by various writers (Binney, Morse, Baker, etc.) to feed upon other snails. I have observed this species eating the epidermis of Zonitidae. Simpson ('01, p. 248) records an observation by John Walton, in which Omphalina fuliginosa has been seen eating young of Polygyra albolabris, P. sayii, P. thyroides, and P. palliata. This was in July, and Simpson believes it to have something to do with the season. Simpson records his own observations upon the carnivorous habit of P. albolabris. This form, according to him devoured the eggs of its own kind. He attributes this to the fact that the season was exceedingly dry and the snails were without food for several weeks. Some snails,- none of which occur here,- are reported to eat earthworms. (Binney '78, p. 85).

## 4. Reproduction.

Eggs are laid usually soon after the snails leave their winter quarters, and probably continue till frost. These eggs are often fifty or more in number, their size depending upon the size of the species. They are deposited in the humus, or in the leaf mould. Sometimes they may be found under stones or bark. They are usually agglutinated, In general, snail eggs are white or translucent, and nearly sphaerical. When deposited, they are flaccid, but soon absorb moisture and become distended. Exclusion takes place usually from 20 to 30 days. Eggs deposited in late fall do not hatch, as a rule, until next spring, when they hatch ~~with~~ as the first generation. "The young snail gnaws its way out of the shell

and makes its first repast of the shell which it has just left". (Binney, '78, p. 8). Usually the newly emerged young has 1 1/2 whorls. The growth of the young slugs is very rapid, and within the same year in which they hatched, they are able to produce eggs. They deposit eggs before they are full grown.

Snails are hemaphroditic, however, the complex male and female organs are so situated that self-impregnation is impossible. The process of coitus in snails is not well known. Baker ('97, p. 29) observed coitus in Circinaria concava . His description of it has been copied entire in the Annotated List. It appears that during sexual union, the individuals are passive. I observed Agriolimax campestris deposit eggs. During this act the animal was also passive.

I obtained eggs of four species,- Pyramidula alternata, Philomycus carolinensis, Agriolimax campestris and Vitrea indentata. The data for these eggs has been given under each species in the Ecologically Annotated List, and hence is not duplicated here.

## 5. Enemies.

The enemies of snails are numerous. The short-tailed shrew, Blarina brevicauda Say, has been observed to eat the larger helices (Shull '07). Under a log in the Cottonwood grove, I noticed the opening to a shrew burrow, and around it and in it were a large number of snail shells,- dead and some of them broken. I collected all of them and the following table on page 25 , gives the statistical data for them. Plate 5 , fig. 6., is a photograph of this lot of shells, and Figs. 16 a,b,c, plate 16 ., are individual shells from this lot showing scratches made by the shrew. It is

interesting to note how few of the thyroides were broken as compared to pennsylvanica. More stress will be given this in the discussion of those species.

Birds are reported to feed upon "snails". Zonitoides minusculus has been found in the stomach of the flicker (Beal '11, p. 56). Other forest inhabiting birds no doubt eat the animals of snails. Some birds in Florida eat the small Pupidae. It is quite possible that these snails are food for birds in this woods as well.

Dall ('92, p.11) reports a millepede, Julus, as "feasting upon slugs and snails", however, he is not certain if these were in a healthy condition.

Circinaria concava is known to eat its own kind as well as other snails.

Agriolimax campestris has been observed by Ford to be eaten by A. agrestis.

Omphalina fuliginosa is reported to eat the young of Polygyra albolabris, P. sayii, P. thyroides and P. palliata. (Simpson,'01,p. 248).

Polygyra albolabris is reported by Simpson as eating eggs of its own kind.

Townsend (1892) describes a sarcophagid, Sarcophaga helices Towns. from Polygyra thyroides, bred by H.A. Surface. Quite likely the snail was dead and putrid when the eggs were deposited.

A mite, Hypopus unicolor Hald. infests Polygyra pennsylvanica. (Binney, '78, p. 322).

Cryptobia helices Leidy is found in the spermatheca of Polygyra albolabris and tridentata, and Pyramidula alternata, by Leidy (1846).

Contents of one Shrew Nest.

Cottonwood Grove.

Urbana, Ill.

Collected March 1911.

| | NOT BROKEN | BROKEN | TOTAL OF ENTIRE & BROKEN. | % BROKEN | TOTAL % OF ALL SHELLS | % OF ALL BROKEN | % OF ALL ENTIRE |
|---|---|---|---|---|---|---|---|
| Polygyra thyroides, | | | | | | | |
| adult, non-dentate* | 89 | 15 | 104 | 14 | | | |
| " , dentate | 28 | 4 | 32 | 13 | | | |
| Juvenile | 14 | 4 | 18 | 22 | | | |
| T O T A L | 131 | 23 | 154 | 16 | 59 | | |
| Polygyra pennsylvanica | | | | | | | |
| Adult shells | 48 | 39 | 87 | 46 | | | |
| Juvenile shells | 3 | 3 | 6 | 50 | | | |
| T O T A L | 51 | 42 | 93 | 48 | 36 | | |
| Pyramidula alternata | 6 | 2 | 8 | 25 | 3 | | |
| Circinaria concava | 1 | 4 | 5 | 80 | 2 | | |
| T O T A L S | 189 | 71 | 260 | .... | 100 | 27 | 73 |

*This refers to the tooth on the parietal wall which is present in some individuals of P. thyroides.

Ascaris cylindrica Leidy, occurs in the small intestine of Pyramidula alternata. (Leidy, 1846).

Distoma appendiculata Leidy has been found in Zonitoides arboreus.

Leucochloridum paradoxum is mentioned by Baker as occuring in Succinea.

Man is an important enemy of snails. By means of forest fires he destroys hundreds and thousands of shells, destroys their habitat and their food. By pasturing, he keeps away the undergrowth. By allowing hogs in a woods, and chickens as well, he places the snails at the mercy of these animals.

## III. THE HABITATS and ASSOCIATIONS of WOODLAND SNAILS.

This section summarizes the results of my studies of the habitats and interrelations of these snails. I have prepared two tables, using my own data and such other data as I could obtain from the literature. Table I indicates the snail inhabitants of the different habitats. Table II. shows which snails ~~were~~ are found together.

In the discussion of the snail habitats, I recognized three general groups,- 1. Arboreal habitats, 2. log habitats, and 3. subterranean habitats. These occur in every type of forest. In the Brownfield Woods, which is for the most part mesophytic, 5 species of snails were found to be in some degree arboreal, 9 species were subterranean, while 27 species belonged to the log series. All of the arboreal and subterranean forms were found in the log habitats as well. The log habitat contains the largest number of snails. From this ~~zone~~ situation some forms ascend trees while others enter the soil. I divided the log habitat into two parts,- A. "Under bark", and B. "Under log". There were collected 26 species under the log and in the leaf mould, and of this number, 12 occured also under bark.

Practically all woodland snails are vegetable feeders. A few are carnivorous, and some of these are omnivorous. The carnivorous Circinaria concava has been found associated with Polygyra pennsylvanica, P. thyroides, P. hirsuta, Pyramidula alternata, Vitrea indentata, Paravitrea significans, Zonitoides arboreus and Philomycus carolinensis. Only one or two individuals ~~are~~ were found in a given situation. This species is known to eat the animals of helices and has been observed eating the epidermis of Zonitidae. It prefers deep and shaded woods. Agriolimax agrestis has been observed to eat its neighbor A. campestris. The latter slug was seen by another observer to eat Aphids. During drought, Polygyra albolabris may eat

its own eggs. The numbers of carnivorous snails in the Brownfield Woods is not large, and their effect is only local. The depredations of shrews and birds is of greater importance.

Vitrea indentata, Zonitoides arboreus, Bifidaria contracta, and Polygyra hirsuta were nearly always found together. With these were found at times six or seven other species. Most of the small snails occur together. The helices, on the other hand, are rarely found in ~~great~~ larger numbers under logs, nor do several species inhabit the same situation. The exception to this is Pyramidula alternata which is gregarious. In the wet portions of the Brownfield Woods, Carychium exile is often found in great numbers under a single log, with no other snail ~~with it~~. Sometimes one individual of Agriolimax campestris shares this habitat. On one occasion I found Bifidaria contracta in as great numbers under a single log with C. exile. Philomycus carolinensis is in most cases the only snail to be found under "started bark". Sometimes it is associated with Pyramidula alternata.

The snail inhabitants of the different habitats vary with the physical conditions, principally shade, food, moisture and temperature. Certain species are found only in dry-uplands, such as Vallonia pulchella and Pupoides marginatus. Others are found only in wet-lowlands, for example, Pomatiopsis lapidaria, Carychium exile, and Succinea retusa. These relations are brought out in Table I on page 26e between the Xerophytic and Hydrophytic Associations to the Mesophytic ones. This table shows also transitional stages. Bifidaria armifera is found in dry-upland woods. It is rare in woods transitional between the dry-upland and the mesophytic type, and is found in these woods in exposed places. With it may occur such forms as Polygyra hirsuta, Strobilops labyrinthica and Bifidaria tappaniana, forms which are absent in the dry and open woods, but which occur in the

well-drained woods.

The transition from dry-upland woods to mesophytic woods is by gradual ~~steps~~ stages. The accumulation of leaves, twigs, branches, fallen trees and carcasses of animals, which decay and form humus, tends to make the woods more mesophytic. The humus retains moisture and makes it possible for the more tolerant mesophytic plants to invade this association. The presence and increase of this herbaceous vegetation, together with the increase in humus, moisture and shade, and a decrease in temperature, allows a greater number of species of forest snails to live in this forest.

In the typical dry-upland or xerophytic forest, the following snails are known to occur: Vallonia pulchella, V. parvula, Bifidaria corticaria, B. armifera, B. holzingeri, B. pentodon, Pupoides marginatus and Polygyra monodon. Such deep forest loving forms as Polygyra thyroides, Paravitrea significans, Circinaria concava and Pyramidula alternata are absent. When the association becomes less xerophytic, and consequently more mesophytic, Vallonia pulchella and Pupoides marginatus dissapear. The other forms remain in the more exposed places in ~~this~~ such woods and As ~~this woods~~ it becomes more and more damp and shady, snails typical of the mesophytic woods creep in. Pioneers of this group are Vitrea indentata, Zonitoides minusculus, Strobilops labyrinthica, S. virgo, Vertigo tridentata, V. milium, Polygyra hirsuta, P. fraterna and Zonitoides arboreus.

The wet-lowland plant association presents a less evident succession. Thru the silt deposited by ~~the~~ a stream, ~~or river,~~ the ~~land~~ surface is elevated and hence in time may become better drained. It becomes drier and approaches the mesophytic type. In this wet-lowland association many fresh-water forms which are able to withstand desiccation occur. Such snails are Segmentina armigera, Pomatiopsis lapi-

daria, Galba humilis modicella, G. caperata and several Sphaeriums. The semi-amphibious Carychium exile is typical of this association. Upon the reeds and stems of plants occur several species of Succinea. The land snails are further represented by such forms as Polygyra thyroides, P. multilineata, V. indentata, Z. arboreus, B. contracta, Agriolimax campestris etc. Most of these occur also in the mesophytic associations. P. multilineata is a member of the bog association. C. exile and S. avara are almost wholly restricted to the wet-lowlands, but they are sometimes found in mesophytic woods where local conditions are favorable to them. In the Brownfield Woods exile is restricted mainly to the north-west portion. S. avara in this woods is found along the entire course of the intermittant stream.

The mesophytic or well-drained woods is probably the most favorable association for snail development. Not only is there an increase in species, but in individuals as well. The thick humus, plenty of shade, moisture, relative humidity, debris, herbaceous vegetation, etc, and a cool atmosphere, are necessary conditions for snails. These conditions are dominant in mesophytic woods.

From table I it is seen that 10 species of snails occur in the xerophytic woods, and 17 species in hydrophytic woods. Some of these snails are not confined to the extreme conditions, but their range extends somewhat into mesophytic woods. The mesophytic woods is represented by 36 species, some of which are confined to the deep, shady and damp situations, whereas others have a much broader range so that they include semi-xerophytic and semi-hydrophytic habitats.

TABLE I. Habitats of Forest Snails.

| | C. exile | B. contracta | B. holzingeri | B. tappaniana | B. armifera | B. coritcaria | B. procera | P. marginatus | V. ovata | V. tridentata | S. avara | S. retusa | A. campestris | P. philomycus | P. thyroides | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry-upland or Xerophytic Asso. | | | x | | x | x | | x | | | | | | | | |
| Transitional | | | r | r | r | | | | | x | | | r | | | |
| Wet-lowland or Hydrophytic Asso. | x | x | | | | | | | | | x | x | x | | x | |
| Transitional | r | x | | x | | | x | | | x | r | | x | | x | |
| Well-drained or Mesophytic Asso. | | | | | | | | | | | | | | | | |
| Arboreal | | | | | | | | | | | | | x | x | x | |
| On land | | | | | | | | | | | | | | | | |
| Under bark | | x | | | x | | | | | | | | x | x | | |
| Under log and leaf mould | | x | x | x | x | | | | x | x | | | x | x | x | |
| Subterranean | | | | | | | | | | | | | | | | |
| In deep shade, in forest | | x | | | | | | | r | x | | | x | x | x | |
| In open places, in forest | | r | x | r | r | | | | x | x | | | x | x | x | |

x = present.

r = present but rare.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | x | | x | | | | | | | | | P. elevata |
| | | x | | x | | | | | | | | | P. pennsylvanica |
| | x | x | | x | x | | | | | | x | | P. fraterna |
| | x | | | x | | | | | | | x | x | P. monodon |
| | x | x | | x | x | | | | | | x | | P. hirsuta |
| | x | x | | x | | | | x | x | | | | P. multilineata |
| | | x | | x | | | | | | | | | P. clausa |
| | x | | | x | | | | | | | | | P. profunda |
| | x | x | x | x | x | | | | | | | | C. concava |
| | | x | x | x | x | | | x | x | | | | V. hammonis |
| | | x | x | x | x | | | x | x | x | | | V. indentata |
| | | x | x | x | | | | | | | | | P. significans |
| | | x | | x | x | | | x | x | | | | Z. nitidus |
| | x | x | x | x | x | | | x | x | x | | | Z. arboreus |
| | x | x | x | x | | | | x | | x | | | Z. minusculus |
| | x | | | x | | | | | | x | | | S. virgo |
| | | x | | x | | | | x | | x | | | S. labyrinthica |
| | x | x | | x | | | | | | | | | E. fulvus |
| | | x | | x | | | | x | | | | | E. chersinus |
| | | | | | | | | | | | x | | V. pulchella |
| | | | | | | | | | | x | x | | V. parvula |
| | x | x | x | x | x | x | | x | | | | | P. alternata |
| | | x | x | x | | | | x | | | | | P. solitaria |
| | x | x | | x | x | | | x | | | | | P. perspectiva |
| | | x | | x | | | | x | | | | | P. striatella |
| | x | x | x | x | x | | | x | x | | | | H. lineatus |
| | | x | | x | | | | | | | | | P. pygmaeum |
| | x | x | | x | | | | | | | | | S. edentulum |
| | | | | | | | | x | x | | | | P. lapidaria |
| | | | | | | | | | x | | | | S. armigera |
| | | | | | | | | | x | | | | G. caperata |
| | | | | | | | | | x | | | | G. h. modicella |
| | | | | | | | | | x | | | | P. gyrina |

# TABLE II. CORRELATION TABLE FOR SNAILS FOUND TOGETHER.

| | C. exile | S. labyrinthica | B. contracta | B. holzingeri | B. tappaniana | V. tridentata | S. avara | P. zaleta | P. elevata | P. pennsylvanica | P. thyroides | P. hirsuta | C. concava | V. hammonis | V. indentata | P. significans | E. chersinus | Z. nitidus | Z. arboreus | Z. minusculus | A. campestris | P. carolinensis | P. alternata | P. solitaria | P. perspectiva | H. lineatus | S. edentulum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Carychium exile | G | | x | | x | | | | | | | | | x | x | | | | x | | x | | | | | x | |
| 2 Strobilops labyrinthica | | | x | | | | | | | | | | | | x | | x | | x | | | | | | | x | |
| 3 Bifidaria contracta | x | | G | x | x | x | | | | | | x | | x | x | x | x | x | x | x | | | x | | x | x | x |
| 4 " holzinger | | | x | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 " tappaniana | x | | x | | | | | | | | | | | | | | | | | | | | | | | x | |
| 6 Vertigo tridentata | | | x | | | x | | | | | | | | | | | | | | | | | | | | | |
| 7 Succinea avara | | | | | | | G | | | | | | | | | | | | | | | | | | | | |
| 8 Polygyra zaleta | | | | | | | | | x | | | | | | | | | | | | | | | | | | |
| 9 " elevata | | | | | | | | x | | | x | | | | | | | | | | | | | | | | |
| 10 " pennsylvanica | | | | | | | | | | | | | x | | | | | | x | | | | | | x | | |
| 11 " thyroides | | | | | | | | | x | | | x | x | | x | | | | x | | | | | | | | |
| 12 " hirsuta | | | x | | | | | | | | x | | x | | x | | | | x | | | | x | | x | | |
| 13 Circinaria concava | | | | | | | | | | x | x | x | | | x | x | | | x | | | x | | | | | |
| 14 Vitrea hammonis | x | | x | | | | | | | | | x | | G | x | | | x | x | | x | | | | | x | |
| 15 " indentata | x | x | x | | | | | | | | x | x | x | x | G | x | x | x | x | | x | x | x | | x | x | |
| 16 Paravitrea significans | | | x | | | | | | | | | | x | | x | | x | | x | | | | x | | | x | |
| 17 Euconulus chersinus | | | x | | | | | | | | | | | | x | x | | x | x | | | | x | | | x | x |
| 18 Zonitoides nitidus | | | x | | | | | | | | | | | x | x | | | G | x | | x | | | | | | |
| 19 " arboreus | x | | x | | | | | | | x | x | x | x | x | x | x | x | x | G | | x | x | x | | x | x | |
| 20 " minusculus | | | x | | | | | | | | | | | | | | | | | | x | | | | | | |
| 21 Agriolimax campestris | x | | x | | | | | | | | | | | x | x | | | x | x | x | | | | | | | |
| 22 Philomycus carolinensis | | | | | | | | | | | | | x | | x | | | | | | | | x | | | x | |
| 23 Pyramidula alternata | | | x | | | | | | | | | x | | | x | x | x | | x | | | x | | x | x | x | |
| 24 " solitaria | | | | | | | | | | | | | | | | | | | | | | | x | | | | |
| 25 " perspectiva | | | x | | | | | | | x | | x | | | x | | | | x | | | | x | | | x | |
| 26 Helicodiscus lineatus | x | x | x | x | | x | | | | | | | | x | x | x | x | | x | | | x | x | | x | | |
| 27 Sphyradium edentulum | | | x | | | x | | | | | | | | | | | x | | | | | | | | | | |

G = Gregarious forms.

# IV.

## ECOLOGICALLY ANNOTATED LIST.

### MOLLUSCA.

### GASTROPODA.

### SUBORDER BASOMMATOPHORA.

### SUPERFAMILY GEHYDROPHILA.

### Family AURICULIDAE.

### Genus Carychium Mull.

### Carychium exile H. C. Lea.

Habitat: It is believed by many writers that the terrestrial pulmonates have descended from a form closely related to this genus, or to the allied genera Alexia and Melampus. C. exile is almost amphibious. I have found it plentiful in wet places under logs and pieces of wood, in wet moss, and quite often I found it in standing water under a log. At Hillery, Illinois, I found it to be the domminant mollusk of a swamp lowland.

Habits: This form is gregarious, and where one specimen is found, dozens are likely to occur. On one occasion I collected over a hundred specimens from a log which was about two feet long and a foot in diameter. The movements of this snail are slow and erratic, the long shell seemingly ~~being~~ too heavy for the animal. It is carried at an angle of nearly 55 degrees from which position it is elevated to nearly perpendicular by some individuals. In climbing the sides of the glass cage the shell was carried nearly flat. I was unable to induce the animals to eat in confinement.

Associated forms: I found this form associated usually with Bifidaria contracta, and occasionally with B. tappaniana, Agriolimax campestris, Vitrea hammonis, V. indentata and Zonitoides arboreus.

Baker ('02, p. 256) mentions that C. exile is almost always found with C. exiguum which it closely resembles, and that to every one of exile there are three of exiguum.

SUBORDER STYLOMMATOPHORA.

MONOTREMATA.

VASOPULMONATA.

Orthurethra.

Family PUPIDAE.

Genus Strobilops Pils.

Strobilops labyrinthica Say.

Habitat: This species is not very common. I have found it near the outer border of the woods and in open places in the interior. It occurs under loose bark of logs, in half decayed wood, under logs, among dead leaves and in the sod at the base of trees.

Habits: Only one living specimen was found. ~~living~~ Its movements were always deliberate and slow. The shell is carried flat, occasionally moving from side to side. The snail was kept in confinement with Euconulus chersinus but at no time did it show any inclination to devour its companion. Baker ('02, p. 227) reports an interesting observation: "It has been seen by Mr. Jensen to prey upon Euconulus fulvus." The specimen kept in confinement would not eat leaves of lettuce, dandelion, or apple.

Associated forms: I have found this form associated with Bifidaria contracta, Zonitoides arboreus, Vitrea indentata, and Euconulus chersinus. At Chicago, Illinois, (Bowmanville Woods), I have found it repeatedly associated with Pyramidula cronkheitii

var. anthonyii and Euconulus fulvus. (See p. 70.)

Genus Bifidaria Sterki.

Bifidaria contracta (Say).

Habitat: This is the commonest species of the Pupidae. I have found it in a great variety of situations in both the upland and lowland places. It prefers a moist to wet habitat. It is commonest under logs, and in the interstices of the bark. I observed it plentiful also under loose bark. Quite often it is found in crumbly soil, in the leaf mould, in moss and upon small pieces of bark and twigs. I found fifteen specimens of it on one occasion in a square meter of clear forest floor.

Habits: This is a very interesting form. Its movements are slow and precise. The shell is carried erect and at times appears to be cumbersome to the snail. At such times it sways slowly from side to side. I tried twenty individuals to note how soon after withdrawing into their shells, the animals would come out. To induce them to retract, I touched their foot with a camel's hair brush. Two individuals had to be pricked with a bristle. The time taken before the snails came out again was as follows (in minutes): 2, 1.5, 2, 2, 1, 1.5, 2, 2, 1, 3, 2, 2, 1.5, 2, 2, 1, 2, 1.5, 2, and 2,- an average of 1.75 minutes per individual.

Baker ('02, p.236) writes as follows concerning the movements of this snail. "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." I have never been able to observe this habit.

In confinement this species ate both lettuce and dandelion leaves. It is not a voracious feeder and if the cage is not

kept moist, the snails attach themselves to the glass tops and sides and the animal crowds itself far into the coils of the shell.

Associated forms: I have found this form frequently associated with the following snails: Helicodiscus lineatus, Zonitoides arboreus, Vertigo tridentata, Bifidaria tappaniana, B. holzingeri, Strobilops labyrinthica, Pyramidula perspectiva, P. alternata, Zonitoides nitidus, Z. minusculus, Vitrea hammonis, Paravitrea significans, Vitrea indentata, Euconulus chersinus, Sphyradium edentulum, and young Polygyra hirsuta. All or most of these snails are usually found together under moist logs. In a back yard under a log in Urbana, Illinois, I found contracta associated with B. armifera, Vallonia pulchella, Euconulus fulvus and Strobilops affinis.

In the open, cleared forest floor, I found associated with contracta a few individuals of Zonitoides minusculus.

The north-west end of the woods is particularly wet. Under boards and logs in such places, and especially if standing water is present, or the ground is very wet, I find many specimens of Carychium exile and among them a few B. contracta. Occasionally in this habitat Agriolimax campestris and Zonitoides arboreus occur.

Various species of ground beetles (Carabidae), myriopods (Fontaria, Polydesmus, Geophilids, etc), roaches, encrytiid worms, etc, are plentiful under logs inhabited by contracta.

## Bifidaria holzingeri Sterki.

Habitat: I found this species on one occasion only, under a log. This was in the year 1907 and at that time I did not make detailed habitat notes. Shimek ('01, p. 199) states concerning its habitat: "Quite common under stones, etc. on exposed hillsides."

Habits: Not observed.

Associated forms: I collected this species with Bifidaria contracta and Helicodiscus lineatus.

Bifidaria tappaniana C. B. Adams.(= pentodon of authors, not of Say).

Habitat: This species is rare in the Brownfield Woods. I have found it only in the moist places in the north-west portion. Here it occurs under logs, pieces of bark, on twigs, dead leaves, at base of trees, stones, and rubbish of all sorts. At Hillery, Illinois, I found it under pieces of bark in the river bottoms. Shimek ('01, p. 199) states that it is "quite common on rather open rocky slopes, sometimes on lower grounds, under stones, etc."

Habits: I had only two living specimens, however, for the most part, they remained inactive. The cage was kept quite moist and I found them often in the soft soil. When they fastened themselves to the glass walls they often had accretions of the soil on their shells. The mouth was never seen to be covered with this mud. I was unable to induce them to eat lettuce and dandelion leaves, nor apple. In its movements, the animal is sluggish, carrying the shell almost flat.

Associated forms: I found this species associated with Bifidaria contracta, and Carychium exile. Gould ('70, p. 435) reports it as being found under leaves and boards in damp places "incompany with P. modesta" (= Vertigo modesta Say).

Genus Vertigo Drap.

Vertigo tridentata Wolf.

Habitat: This species is rare in the woods studied. I have found it under the loose bark of a fallen tree. The habitat was

not moist. It was sufficiently dry to shut out such forms as Vitrea indentata and Zonitoides arboreus. The paucity of this species suggests unfavorable conditions for its development.

Binney ('79, p.218) states that "This is one of the more aquatic species, and is found under dead leaves and sticks, and on the stems of plants, at the margin of rivulets and ponds." Shimek ('01, p. 201) states that it is found "locally common, usually on rather exposed rocky, moss-covered banks."

Habits: I have been unable to secure adequate material for study. Binney ('79, p. 218) writes as follows concerning the movements of this Vertigo: "The motion of the animal, when in progress, is rapid, but awkward. The proboscis, which is long and projectile, seems to be thrust forward, and attached, and the rest of the foot drawn up to it, reminding one of the motion of a caterpillar, the shell at the same time rolling from side to side. The adherent forces of the animal evidently lie in the anterior part of the foot". Its very close congenitor, V. ovata is also sluggish in its movements, and the shell rolls from side to side in a peculiar manner.

Associated forms: V. tridentata has been found by me associated with Bifidaria contracta and Sphyradium edentulum.

Heterurethra.

SUPERFAMILY ELASMOGNATHA.

Family SUCCINEIDAE.

Genus Succinea.Drap.

Succinea avara Say.

Habitat: This is the only Succinea found in the woods. It is not common. I have found it always in the creek bottom in the

the Brownfield Woods, attached to plant stems and leaves. At Chicago, Illinois, I found it upon the stems of Typha and Iris, under wet boards at the banks of Chicago River, and also, about fifty feet away from the stream. This last place is marshy about three months of the year. During drought, those specimens were attached to the vegetation. The individuals at the water's edge were active. I believe this species is a member of the Hydrophytic Plant Association. I have never found it in dry uplands. It may occur in wet mesophytic plant habitats.

Shimek ('01, p. 199) says that it is "not rare on more or less exposed rocky slopes. This is the small, typical form which is now found on low grounds."

Habits: The paucity of material prevented me from studying the habits of this species.

Call ('99, p.403) speaking of the group in general, says: "The habits of the Succineae are interesting. They are unable, especially during the nidification season, to withdraw themselves wholly within their shells, and some considerable portion of the animal appears protruding beyond the apertural margin. While they do not ever retract themselves very far within the shells, it is common to find them, in dry weather, so far within the shells that over half of the body whorl is empty; this is the usual condition where they go into hibernation. They are often found adhering, in dry weather, to leaves and plant stems, with a tenacious epiphragm which holds them in place and which entirely covers the aperture".

During December, 1910, I received a number of specimens of Succinea luteola Gould from the arid regions of Brownsville Texas. They were kept in a dry place for one month, and for another month were left accidentally over a steam radiator. On placing them

in a moist cage, they revived and began to crawl about. This habit of withstanding descication is characteristic of the group.

Concerning the eggs of S. retusa Lea, Binney ('79, p. 417) states that "It deposits its eggs, to the number of about twenty, enveloped in a mass of thin, transparent gelatine, at the foot of aquatic plants , in the latitude of Boston, in the warm days of June. The eggs are oval and transparent." Baker ('02, p.222) observed eggs of this same species in the middle of June.

The movements of avara are not energetic. Its near relatives are more energetic in their movements.

Associated forms: In this woods the Hydrophytic Plant Association is but little developed. No forms were found associated with avara on the stems of the plants. In this same plant association are found Carychium exile, Bifidaria contracta, B. tappaniana, Vitrea hammonis, V. indentata, Zonitoides arboreus, Helicodiscus lineatus and Polygyra thyroides.

Baker ('02, p. 222) states concerning the parasites of retusa, "This species, like others of the genus, is infested by a parasite (Leucochloridum paradoxum) which sometimes modifies the eye-peduncles. This parasite changes into Distoma macrostomum in birds." Dall ('92, p.10), speaking of the enemies of snails, says that "A singular sausage-shaped parasite, of which one end is attenuated into a slender tube, is found in Succinea. The soft parts of the snails thus affected are much distorted. The parasite is one phase of a Distoma or fluke-worm, and is of a dark brown color and over an inch in length. It is known as Leucochloridum americanum Dall. An analogous species has been described from French Succineas, which is of a mottled green. This parasite attains it development in the intestines of thrushes which feed on the Succinea,

and may perhaps be fatal to these birds."

About eight years ago I observed a bird picking Succineas from the stems of Helianthus, at Summit, Cook Co. Illinois, but I was unable to identify the species. Dall ('92, p.10) states that thrushes eat Succinea. In this way the parasite enters its second host. The relation of the liver-fluke of sheep to the fresh-water snails, Lymnaea, is another excellent example of such parasitism.

Sigmurethra.

SUPERFAMILY HOLOPODA.

Family HELICIDAE.

Genus Polygyra (Say) Pils.

Polygyra zaleta Binney.

Habitat: Only one specimen was found in the Brownfield Woods, and this was a young form. It is common in the Hillery, Illinois, region. The specimen from the Brownfield Woods was collected at night, May 15, 1908, crawling upon a stump two feet high. At Hillery, where the conditions for their habitat are better developed, this mollusk lives on the wooded ravine slopes, among the dead leaves, twigs and debris of all sorts. It seeks moist and shaded regions.

Habits: The shell of this species is carried tilted slightly to the rear. Baker ('02, p. 153) in speaking of albolabris, a closely related species, says "The animal is slow in movement, but not at all timid, readily allowing itself to be handled without withdrawing into its shell. When crawling up the sides 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. When eating, the head is drawn partly in and the tentacles are laid back and half contracted". This same writer timed the movements of P. albolabris; ~~his~~ the results ~~being~~ were twenty-four inches in 14 seconds.

The eggs of P. exoleta, according to Binney ('79, p.327) are white, one-eighth of an inch in diameter, " and are laid in the earth as deep as the body of the animal will extend, in clusters of about twenty".

Associated forms: This species is associated with three species of Polygyra, albolabris, elevata and fraudulenta.

I found several specimens with scratches upon the body whorl, made, perhaps, by some small mammal. A number of specimens were taken with the spire broken.

Polygyra elevata Say.

Habitat: Two immature specimens were found by me at the Brownfield Woods on May 15, 1908. They were crawling about at night, upon a stump two and a half feet high.

At Hillery, Illinois, it is extremely common on the wooded clay hillsides and among the accumulated leaves and debris in the ravines.

Habits: Call ('99, p. 393) speaks as follows concerning the habits of this species: "This is one of the earliest shells to come out of winter quarters and, since it burrows far into the mud of wet hillsides, when it emerges, it is heavily coated with mud and dirt. It burrows as deeply as six or seven inches. It is always found crawling even in dry weather, on its favorite hillsides, but after a warm and heavy rain it comes out in swarms. Early morning,

or late evening, will disclose hundreds of this animal, and it can then be collected in great numbers..... The fall is the most favorable time to collect this shell, since those which survive the winter and come out in the early spring are devoid of much of their epidermis."

The animal ate both lettuce and dandelion leaves, its appetite is usually voracious. It is not shy and moves about actively.

Associated forms: I found this species associated with P. albolabris, P. zaleta, P. thyroides, and P. fraudulenta.

Remarks: The favorable Hillery region has been practically destroyed by fires in the year 1910. As a result, dead and burned shells of P. elevata, albolabris, thyroides, etc. are plentiful upon the surface of the burned area. Plate 5, fig. 7, shows a number of shells collected from this place.

I have a specimen from Ohio which has been broken and subsequently repaired by the the snail. It is evident that the former tooth was absorbed again and a new one built further in. The umbilicus shows a very peculiar repaired area. Plate 6, fig. 15, is a rather poor photograph of this specimen.

Polygyra pennsylvanica Green.

Habitat: Dead shells were very plentiful in this woods, but live animals were rare. I found these usually among the leaves at the base of logs and tree trunks. A few times (in November) I have noticed them in small cavities in the surface of the soil. Call ('99, p. 391) reports that he collected a hundred specimens one afternoon in a spot a few feet square. I have never found them so abundant.

Habits: In confinement, I observed this species to be very shy. In its movements it is slow and careful, its shell carried back of the center of the animal and almost flat. When I touched the tentacles lightly with a bristle, the animal retracted into its shell and remained there for a period appromimately five minutes. Eight trials were made, the results being as follows: 6, 6, 5, 8, 4, 4, 5, 4.

When the animal comes out of its shell, it does so with apparent caution, and before it crawls, its tentacles are pushed out and moved in all directions. I placed several obstructions in their path and when the tentacles or the body touched these, the animal quickly withdrew into the shell.

This form ate voraciously of lettuce and dandelion leaves, but would not eat apple.

Associated forms: I found dead shells with the spires broken, under logs and under such logs were usually found openings to the runways of small mammals. In one shrew (?) nest I found 154 dead shells of P. thyroides and 93 of pennsylvanica. Of the latter, 42, or 48% were broken, whereas of thyroides, only 16% were broken. This high percent of broken shells of pennsylvanica is in accord with the habits of the animal. P. thyroides is not as timid as this form and hence the shrew breaks a smaller number of shells. In the other form, the shrew, in order to get at the animal, must break the shell of a greater number of ~~forms~~ individuals.

Binney ('78, p. 322) figures and describes a mite, Hypopus unicolor Hald., which occurs upon this form "and many other species".

I have found this form associated with Circinaria concava, Zonitoides arboreus, Pyramidula perspectiva, and Polygyra thyroides.

Polygyra thyroides Say.

Habitat: This is the commonest of the larger helices. I find it in relatively dry places and also in very wet places, more plentiful in the latter. It is commoner in the Cottonwood forest which is marshy in the spring. I quote from Call ('99, p. 394) whose observations on this species are interesting: "It is one of those forms which may always be found in low, marshy stations, under leaves bordering swamps, in the low bottom lands of streams like the Wabash in its lower point, and on wet hillsides where abundant plants grow..... This species also may be found on fairly dry hillsides under flat stones or clinging to trees in bottom lands at a height of from two to six feet above the ground. It sometimes may be taken in alder swamps attached to the leaves of the plants, on the under side. It is an active species after rains and may then be taken as it crawls around in numbers."

Habits: Call ('99, p. 394) states that the eggs "are laid in either moist earth or under leaves next to the ground, or under fallen trees and logs."

This form is very bold. I have had it crawl about in the cage and upon my hand, and it would not withdraw into its shell when the animal was picked up. A few individuals, however, are not as bold, in fact, some of these are very timid. I experimented upon a few of these to determine how long after being forced into their shells they would come out again. Six tests were made with the following results: 3, 2, 3, 2.5, 4, 3 minutes each, or an average of about three minutes.

These snails ate lettuce and dandelion leave voraciously, eating from the edge inward. The excrement was dark in color, sometimes olive-green, long and slender rods, spirally coiled upon

the glass top of the cage upon which the snails crawled.

In early spring as soon as the snails leave their winter quarters, I have seen them upon pieces of bark, logs, on stones, etc, in the direct rays of the sun. Their tentacles were drawn in.

Associated forms: I have found this species associated with Circinaria concava, Polygyra pennsylvanica, Vitrea indentata and and Zonitoides arboreus.

The common short-tailed shrew, Blarina brevicauda Say is a very destructive enemy to this species. On plate 6, fig. 16, are shown a number of shells with scratches upon them, probably made by this shrew. On plate 5, fig. 5, is shown a heap of shells taken under one log. It represents the work of shrews. Of the total number of shells found in that place, 59%, or 154, were thyroides, and of these 154, 16% or 23 were broken. This small percentage of broken shells is due no doubt to the fact that the animal of thyroides is not timid, and those that were broken, represent the occasional individuals which are shy, or which for some reason or other remained in the shell.

In the laboratory I found Circinaria concava within the shell of P. thyroides. The latter was alive at 8:00 o'clock in the morning, and at 6:00 p.m. the same day the entire animal was gone.

Shull ('07, p. 495) has contributed a valuable account on the habits of Blarina brevicauda and its relation to snails. In this paper five species are concerned, Polygyra albolabris, P. multilineata, P. profunda, P. thyroides, and P. fraterna. Of these, albolabris and multilineata were by far the most abundant. He shows that the shrew preys upon these forms in winter and that the shells

are moved to the surface of the ground as the temperature falls and into the ground (burrows) as it rises. However, dead shells brought to the surface were not carried subsequently into the burrow. Dead shells are stored about in the chambers within the burrow. Shull states that the basis for distinguishing between empty and occupied shells is the odor of the snail or possibly odor combined with weight. (see page 69 ~~for~~ of addenda).

Polygyra hirsuta Say.

Habitat: This is a very common snail in the Brownfield Woods. It occurs in damp moist situations, under bark of fallen logs, under loose bark of standing dead trees, under dead leaves and twigs and under stones. Adult specimens in this woods vary somewhat in size.

Habits: The animal is very active. It is not strictly gregarious, though as many as a dozen specimens may be found together, but these are mostly immature. On warm days they crawl about on the vegetation and logs, and were frequently seen about mycelial growths under bark. In confinement they were usually inactive, adhereing to the glass walls of the experiment cages. They ate sparingly of dandelion and lettuce leaves and after each meal, were dormant. The shell is carried at an angle of about 30 degrees from the horizontal.

Associated forms: I have observed the following snails assembled in the same habitat: Bifidaria contracta, Zonitoides arboreus, Vitrea indentata, V. hammonis, Polygyra thyroides, and Pyramidula alternata. At Hillery, Illinois, I have seen Pyramidula perspectiva associated with hirsuta.

SUPERFAMILY AGNATHOMORPHA.

Family CIRCINARIIDAE.

Genus Circinaria (Beck) Pils.

Circinaria concava Say.

Habitat:I found this species in a number of situations. It is usually found burried in the soil to a depth of from four to eight inches. The soil is such cases is crumbly. It is probably a subterranean form which comes to the surface to feed. I found it on several occasions srawling about the surface of logs at night. It prefers a cool and damp woods, and at Hillery, Illinois, I found it rather abundant under debris on the banks of the Middle Fork of the Vermilion River.

Habits: This snail is solitary, but sometimes two individuals are found under the same log. It is very timid. In the laboratory, by lightly touching the eye-peduncles, the animal withdrew into its shell and remained there for a period of about ten minutes. Fifteen observations were made, the following being the individual periods: 12, 15, 10, 12, 15, 6, 10, 6, 10, 8, 9, 11, 10, 9, and 9minutes. When in motion, the shells sways irregularly from side to side due to the fact that the animal is well drawn out of the shell and elongated.

This species is canabalistic, eating also other snails. In the laboratory I noticed one adult Polygyra thyroides (232) kept in confinement with an adult concava dissapear in the period from 8:00 o'clock in the morning to 6:00 in the evening. Binney ('79, p. 93) states concerning its feeding habits as follows: "The animal is voracious in its appetite, almost always preying upon other species with which it may be kept, and so certainly destroying them that I have been obliged to keep them by themselves"

Morse ('68, pp. 412-3) records interesting observations upon this same habit. "It lives on the flesh of other snails. With its long and slender body, it insinuates its head into the aperture of the shell, the inmate of which it is about to devour. The victim withdraws far within the shell, but in vain. Its enemy slowly approaches, and the hapless victim having no barrier to interpose, nor any line of retreat open, is actually devoured bit by bit. We remember collecting a lot of rare snails in the backwoods of Maine. Wishing to study them, they were unsuspectingly placed in a box of moist earth containing a few specimens of our canibal snail. Imagine our astonishment and indignation on examining the box a few days after, and finding our special rarities completely destroyed, only a few empty shells remaining as tokens of the cannibal feast. We could almost see the murderers smacking their slimy chops and begging for more".

I have kept adult Circinaria in cages with the snails Polygyra thyroides, pennsylvanica, Vitrea indentata and Agriolimax campestris. In the winter months the cannibal snail showed no desire to devour the snails. It was not until April that the first Polygyra was eaten.

Concava has also the habit of feeding on the epidermis of other shells. I have found it eating the epidermis of Vitrea indentata, Zonitoides arboreus, and Paravitrea significans. The part of the shell from which the epidermis had been eaten, is white and very crumbly. In one instance nearly one third of the shell of Vitrea indentata was destroyed. In collecting material, I came across many Zonitidae which had the outer whorl whitened and the epidermis removed.

Baker ('02, p. 174) records this species from under

starting bark at a height of four feet.

In a lot of shells collected by Mr. Woodruff, were a number of C. concava. These were kept alive by Baker and were observed one day in copula. The process is described by Baker ('97, p, 29) as follows: "On May 18th two individuals were noted in coitu, the coitus lasting from 8 o'clock a.m. to 6:00 o'clock p.m. During this time both animals were perfectly quiet, the eye-peduncles and tentacles drawn into the head and the foot contracted to form a rounded oval. During ~~the~~ coitus the heart, which normally beats about 75 times per minute, was reduced to 19 very slow and long beats. The foot of the snail taking the active part was partly covered by the passive snail, and the former's head was slightly lifted".

Associated forms: I have found the following snails with concava: Polygyra thyroides, P. pennsylvanica, Vitrea indentata, Paravitrea significans, Zonitoides arboreus, and Philomycus carolinensis.

A few specimens were found with the outer whorl broken, probably the work of a small mammal. C. concava has been found during the winter associated with Polygyra multilineata and P. monodon in a swamp prairie (Surface, '90, p. 135). The same observer remarks that the shells of the prairie form are smaller than those of the heavy timber.

SUPERFAMILY AULACOPODA.

Family ZONITIDAE.

Genus Vitrea.Fitzinger.

Vitrea hammonis Strom.

Habitat: This species prefers a moist situation. It is

found in crevices of the bark of decaying logs, under loose bark and under loosened bark of standing dead trees. It is not as common as Zonitoides arboreus. Shimek ('01, p. 203-4) considers this species as belonging to the lower, shaded, alluvial grounds, under sticks, leaves, etc.

Habits: This species is gregarious. It carries its head and neck far in advance of its shell.

Associated forms: Binney ('78, p. 116) states that hammonis is associated with Euconulus fulvus, Zonitoides arboreus and Vertigo modesta. I have found it plentiful with Zonitoides arboreus and Z. nitidus. Bifidaria contracta and Carychium exile and sometimes Agriolimax campestris are found with this form in the wet places. Helicodiscus lineatus is found burried sometimes with this form.in the soft crumbly soil.

Motter ('98, p. 215) records hammonis from the grave of an infant, the grave being four feet deep in sand. The body was in the grave 20 years and 7 months. In addition to this snail, the following insects were found: Japyx subterraneus Pack? (thysanuran), Diptera,(Phoridae). The grave was dry.

Vitrea indentata Say.

Habitat: This species is almost as common as Z. arboreus, and occurs in almost as many habitats. I have found it in the interior of very soft and wet logs, in small cavities in the pileus of the fleshy fungus Russula, probably emetica Fr. , in the interstices of bark, under logs, in crumbly soil under logs, in the leaf mould, under loose bark of logs and standing dead trees, in moss, under fallen twigs, under stones, etc. in both high and low places. In this woods it seems to prefer moister situations. In the drier

habitats it is found in the crumbly soil. Shimek ('01, p. 199- 200) places this species among those found on higher, more or less exposed, and often rocky slopes, being "more common on drier slopes." He states that it occurs also on lower grounds.

Habits: In bringing material from the field to the laboratory, I sorted it roughly at first, placing all the Zonitidae into one moist tray, Pupidae in another, etc. It was of interest to note the activity of V. indentata. No sooner had they been placed in the tray, they began to crawl about in a hurried manner. The shell was usually carried at an angle of 45 degrees, but their rapid movements caused it to sway from side to side.

They ate voraciously of lettuce and dandelion leaves, and apple. In the latter case I had to procure a soft fruit and cut away a part of the skin. Into this exposed area they would eat until a small cavity was formed. Each individual remained in the cavity it had formed

That this species was found in the pileus of Russula is interesting. It may be that the snail was feeding upon this fungus, but this needs confirmation as the cavity may have been formed by insects or myriopods. In the laboratory I was unable to feed the snails with any fungus because this food could not be kept living. I observed indentata also among the lamellae of the fleshy wood fungus, Pleurotus ostreatus Fr., growing upon fallen logs. This was in September 1909, but there were no traces of eaten areas.

These snails are very bold. Their body was frequently touched with a tooth-pick, but the animal would not retract into its shell. Only after successive and vigorous stimulation of this sort would the animal withdraw into its shell. It would then remain there

for only a brief interval, usually less than one minute.

Associated forms: This form is gregarious. I have found it almost always with Zonitoides arboreus and Z. nitidus. In addition to these two forms, I found it at times associated with Polygyra hirsuta, P. thyroides, P. monodon, P. fraterna, P. fraudulenta, Helicodiscus lineatus, Pyramidula alternata, P. perspectiva, Vitrea hammonis, Paravitrea significans, Euconulus chersinus, Philomycus carolinensis, Strobilops labyrinthica, Bifidaria contracta, and Agriolimax campestris.

On one occasion I observed one individual attached to the back of the centipede Lithobius, while the latter was rapidly moving about.

I noticed several times that Circinaria concava was associated with indentata, and further observation revealed that it was eating the epidermis of the shell of this small snail. On one occasion I saw nearly the entire shell of indentata within the gullet of concava! Sometimes the epidermis of over one half of the body whorl would be eaten away, leaving a white, very crumbly mass. It is quite possible that at times concava eats the animal as well. (see page 69 ~~for~~ of addenda).

Genus Paravitrea Pils.

Paravitrea significans Bland.

This is the first record of this snail in Illinois, and it is the northermost record as well. The nearest other locality is over three hundred miles away. The determination was made by Mr. Bryant Walker, of Detroit, Michigan. Since the shell is new to the State, I give its known distribution, a description of the shell and animal, in addition to the habitat, habits and associated

species. In the past three years I have collected fourteen specimens of this species, nine from the Brownfield Woods and five from the Cottonwood forest. Specimens have been deposited with The Chicago Academy of Sciences, The Philadelphia Academy of Sciences and the University of Illinois.

Distribution: This species is so far recorded from five localities: Fort Gibson, Indian Territory; Union Co., Tennessee; Cade's Cove, Yellow Creek Mountains, Tennessee; Posey Co. Indiana; and Brownfield Woods and Cottonwood forest, near Urbana, Champaign Co., Illinois.

Description of the shell: Flattened, spire but little elevated; discoidal, thin, umbilicus wide, open; whorls six, aperture lunate, oblique; peristome sharp, simple, acute; color light horn. Measurements: greater diameter 5 mm., lesser 4.5 mm.; height 2 mm.

Description of the animal: Dirty white color, foot narrow, short, paler. Eye -peduncles dusky.

Habitat: I found this species rather rare, under logs and large fallen tree limbs, usually in the soft crumbly soil. It prefers a moist and cool situation and in the Brownfiel woods has been found on the north slope of the deepest ravine. In the Cottonwood forest I have found it under split logs and large limbs near the lowest part of the woods.

Habits: It is probably subterranean. I never found more than two or three together in the same situation. It is very shy, behaving in many respects like Circinaria concava. Its movements are slow and careful, the shell tilted about 30 degrees from the horizontal. For the greater part of the time it remained burried in the soil. It ate very sparingly of lettuce leaves.

Associated forms: I found C. concava eating the epidermis

of one individual. (see page 69 for addenda).

Occuring with significans were Vitrea indentata, Zonitoides arboreus, Circinaria concava, and Pyramidula alternata.

This species seems to be a transistional form between Vitrea and Gastrodonta. In many respects it resembles V. indentata. In other respects it can be easily confused with Gastrodonta. It had been considered as a Gastrodonta at one time. The anatomy of this form should present some interesting phylogenetic facts.

Genus Euconulus Reinhardt.

Euconulus chersinus Say.

Habitat: This form is not common in the Brownfield woods. I have found it under damp logs, in the interstices of bark, on fallen leaves and twigs and once under a stone. I have not found it in very moist regions. Speaking of E. fulvus (=trochiformis Montague) Baker ('02, p. 185) says that it requires a moist habitat. It is a circumpolar species very closely related to chersina.

Habits: I had but four living specimens. One of these was kept with Strobilops labyrinthica to see if the latter would try to eat it. Baker ('02, p.227) records that Mr. Jensen observed labyrinthica devour E. fulvus.Since fulvus and chersinus are very difficult to separate, and have long been confused, it is probable that Jensen's fulvus may have been chersina. Further observations upon this phase are needed.

I have fed these snails with lettuce which they ate very sparingly. They did not touch apple nor dandelion. The animal is very shy, a slight jarring of the glass cage being sufficient to cause them to withdraw into their shells. I noted on one occasion that the animal was in its shell at 8:00 o'clock a.m., and on examining the cage at three p.m. the animal was still in the shell.

The movements of this snail are very slow and apparantly uncertain.

Associated forms: I have found it associated with Bifidaria contracta, Paravitrea significans, Strobilops labyrinthica, Vitrea indentata, Zonitoides arboreus, Pyramidula alternata, Helicodiscus lineatus and Sphyradium edentulum. Baker, ('02, p. 185) referring to E. fulvus (=trochiformis Mont.) states that it is "associated with Zonitoides arboreus, Punctum pygmaeum, and Bifidaria curvidens" (the latter = B. pentodon Say, not tappaniana C.B. Adams).

## Genus Zonitoides Lehmann.

### Zonitoides nitidus Muller.

Habitat: I have observed this species under logs and under loose bark. They prefer damp situations and so far I have found them only along the shaded ravines. It often congregates in the interstices of the bark, and in fall enters often the burrows made by insect larvae.

Habits: This snail is gregarious. In the laboratory it ate lettuce leaves, but refused dandelion leaves. When winter approaches this species is found often with Z. arboreus in the same retreat. At Riverside, Chicago, Illinois, I have found this species with arboreus frozen in the ice. On bringing them to my home, they revived and crawled about.

Associated forms: I find this species always associated with Z. arboreus. Sometimes it is found with Vitrea indentata, V. hammonis, Agriolimax campestris, and Bifidaria contracta.

### Zonitoides arboreus Say.

Habitat: This is by far the commonest snail in the woods. It prefers damp situations. It is found in a great variety of habi-

tats,- under bark of fallen trees, in the interstices of bark, under fallen twigs and stones, in leaf mould, under boards, etc. Occasionally I have found it under loose bark of standing dead trees. In winter I observed them concealed in deep crevices, in insect burrows, etc. In tracing a shrew burrow last December, I found a small colony of this species about twelve inches from the opening of the burrow.

This species has been found by Motter ('98, p. 219) in a grave 5 feet deep, in moist sand and clay. The body had been interred for 7 years and 5 months.

Habits: This form is gregarious, and at times also subterranean. In its natural home it is very active, crawling about during the warm months. In confinement, however, I have observed it to be more or less inactive. A few individuals in each lot seemed more active than the others.

I fed this species upon leaves of lettuce. It preferred this food to dandelion or apple. In eating, they usually eat from the edge inward. Sometimes they eat thru the surface, thus forming small holes, irregular in outline.

Baker ('02, p. 189) speaks as follows concerning the movements of this snail: "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 shell." It is of interest to know that one can separate arboreus from its closely allied species, nitidus and hammonis, by the manner in which the shell is carried. In addition to this, the animal of nitidus is decidedly blacker.

The last whorl of hammonis is much wider than in either of the two other species.

Associated forms: This species occurs with the greatest number of snails. I have never found all the snails together, but at times twelve species would occur in compnay with arboreus. The list of associated species is as follows: Vitrea hammonis, V. indentata, Zonitoides nitidus, Paravitrea significans, Agriolimax campestris, Philomycus carolinensis, Bifidaria contracta, Circinaria concava, Euconulus chersinus, Polygyra thyroides, P. pennsylvanica, P. hirsuta, P. monodon, P. fraterna, P. fraudulenta, Pyramidula perspectiva, P. alternata and Helicodiscus lineatus. In the Hydrophytic Plant Association, I have found arboreus associated with Carychium exile, Bifidaria contracta and Agriolimax campestris.

Leidy ('77, p. 202) describes a fluke, Distoma appendiculata, which is sometimes found in considerable numbers in arboreus.

Motter ('98, p. 219), in the grave referred to on the previous page, found in addidtion to arboreus, a spider, Theridion subterranea Banks, a fly, Piophila casei L., a snail, Helicodiscus lineatus, and coleoptera larvae, undetermined. The skeleton was completely stripped.

Zonitoides minusculus Binney.

Habitat: This species is not common, being found in the woods among decayed logs, in humus and dead leaves, and under pieces of bark. It prefers damp and cool habitats. Shimek ('90, p. 61) states that it occurs "both in high rocky places and in low swamps". This same author ('01, p. 198) places this species among those inhabiting the higher, more or less exposed, and often rocky slopes.

I have not found it in the hydrophytic plant association as yet. At Chicago, Illinois, I found it under damp boards in a vacant lot on the corner of Odgen Ave., and 12th Street.

Habits: It was difficult to keep specimens alive in the laboratory. They were very timid and when they were crawling it was with apparant caution.

Motter ('98, pp.214, 215, 216) records this species from three graves, 9 feet, 3feet, and 6 feet deep, all of them in moist sand. This indicates subterranean habits. It is probable that these snails are present to feed on the fungous growths upon the bones and what clothing is left. The bodies were in the grave 16, 21, and 21 years respectively.

Associated forms: In an area one meter square, in the open and cleared forest floor, I found Bifidaria contracta with this species. In other habitats, in addition to B. contracta I found Vitrea indentata and Euconulus chersinus. At Chicago, Illinois, in the vacant lot mentioned above, I found also Vallonia pulchella, Agriolimax campestris and Bifidaria corticaria.

Beal ('11, p. 56) reports that fragments of Zonitoides minusculus were of frequent occurance in the stomachs of the Flicker, Colaptes auratus.

Motter ('98, pp. 214- 6) records three graves containing this snail. The associated forms are as follows:

Grave No. 81, 16 yrs. 5 mo., 9 ft. deep, moist sand. In addition to this snail, there were undetermined species of Vermes, Crustacea, Myriopoda and Thysanura, the pseudoscorpiones, Chelanops tristis Bks., Spiders, Circurina creber Bks., Theridion subterranea Bks. and Erigone albescens Bks., Pselaphidae, Batrisus (ferox ?), Nitidulidae, Rhizophagus sculturatus (fragments), puparia

of Phoridae, and a Phormicid, Lasius flavus DeG. Speaking of the condition of the grave, Motter says :"dry disarticulated bones and a portion of a coat lying in brown powdery debris, fairly swarming with the above animals".

Grave No. 88, 21 years, infant, 3ft. sandy soil. In addition to minusculus there were undetermined worms, a myriopod Isobates (I. minutus Brandt?), and Julus sp., and puparia of Phoridae.

Grave No. 95, 21 years, infant, 6 ft. sandy soil. In addition to minusculus there was Helicodiscus lineatus, the following myriopods, Isobates (I. minutus Brandt?), Julus sp., a spider, Lophocarenum sp., a Thysanuran, Lepidocyrtus sp., and puparia of Phoridae.

Family LIMACIDAE.

Genus Agriolimax Morch.

Agriolimax campestris Binney.

Habitat: This slug is very common. I find it under debris of all kind, under logs, bark, stones, leaves, etc. It is found both in the forest and the prairie. On early spring mornings I found it crawling upon cement walks of Urbana, Illinois. It prefers moist and cool situations.

Habits: This slug has been observed by many writers (Binney, Morse, Baker, etc.) to suspend itself by a thin thread of mucous. It does not have the power to crawl up this thread as do some insect larvae and spiders.

In confinement the individuals ate sparingly of lettuce. Most of the time they were hidden under moss.

In early spring, numbers of these slugs are seen on

cement walks, early in the morning. Later in the morning will be seen many dead slugs at the end of a trail of mucous. This trail of mucous shows many random movements made by the snail ~~to~~ in trying to pass this barrier. The rapid secretion of mucous results in exhaustion, and the lack of sufficient moisture dries up the snail.

I was fortunate to secure several depositions of eggs by this species. During deposition the slug was found under moss or a piece of bark, its tentacles drawn in, the body half contracted and motionless. Gently pricking the skin with a bristle caused no reaction on the part of the snail. The several depositions are tabulated as follows:

| Batch # | Exp. # | Date of Deposition | No. of eggs | Date of Hatching | Duration of egg stage | |
|---|---|---|---|---|---|---|
| | | | | | days | hrs. |
| 1 | 101 | Apr. 10- 8:00 A.M. | 5 | Apr. 23- 12:00 M | 13 | 4 |
| 2 | 101 | " 12- 8:00 " | 3 | " 26- 8:00 A.M. | 14 | |
| 3 | 101 | " 12- 5:00 P.M. | 4 | " 26- 10:00 P.M. | 14 | 5 |
| 4 | 101 | " 17- 8:00 A.M. | 4 | " 27- 8:00 A.M. | 10 | |
| 5 | 101 | " 20- 2:00 P.M. | 1 | May 3- 8:00 P.M. | 13 | 6 |
| 6 | 102 | " 10- 7:30 A.M. | 6 | Apr. 23- 12:00 M. | 13 | 5.5 |
| 7 | 104 | " 10- | 1 | Apr. 23- | 13 | ? |
| 8 | 106 | " 17- | 6 | " 30- | 13 | ? |
| 9 | 107 | " 12- 8:00 A.M. | 1 | " 26- 12:00 M. | 14 | 4 |
| 10 | 109 | " 13- 8:00 " | 3 | " 26- 12:00 " | 13 | 4 |
| 11 | 110 | " 12- " | 1 | " 25- 6:00 P.M. | 13 | 6? |
| 12 | 110 | " 12- P.M. | 1 | " 26- A.M. | 14 | ? |
| 13 | 110 | " 13- " | 1 | " 26- " | 13 | ? |
| 14 | 116 | " 11- A.M. | 1 | " 25- " | 14 | ? |
| 15 | 117 | " 12- | 1 | " 26- P.M. | 14 | ? |
| 16 | 154 | " 20- A.M. | 2 | May 3- A.M. | 13 | ? |
| 16 | | | 41 | Average dur. | 13 | 7 ? |

There were sixteen depotitions of eggs, totalling 41 eggs, and the average stage was 13 days and 7 hours, the longest being 14 days, and the shortest 13 days.

Snail No. 101 deposited five batches of eggs from the 10th of April to the 20th of April, the total number of eggs being 17. The eggs are sphaerical, pearly, semi-transparent, about 2 mm. in diameter (smallest 1.5 mm., largest 2.5 mm.). Occasionally

a larger egg is deposited, being more elliptical in shape and about 2.5 mm. long by 1.75 mm. wide.

The young, after leaving the egg shell, are 3 mm. long, pale dirty white in color, with the tentacles almost white.

Binney ('79, p. 147) speaking of the habits of A. agrestis, states: "A considerable number of individuals often congregate in the same retreat. Their food appears to be the green leaves of succulent plants, and sometimes ripe fruits; they feed during the night, and are rarely found out of their retreats in the day time. Their growth is rapid, the animal excluded from the egg in the spring arriving at full maturity and producing eggs before the succeeding winter. They defend themselves from injurious contact by instantly secreting, at the part touched, a quantity of milky white, glutinous mucus. They are active in their motions, and soon escape when disturbed. Suspending themselves, head downwards, they lower themselves from plants and fences by forming a mucus thread which they attach to the point from which they hang. They are occasionally see in this situation in rainy weather. During the process of excreting the mucus thread the alternate undulating expansions and contractions of the locomotive band of the foot are seen to take place in the same manner as when they are in motion on a plane surface."

"This species is more prolific than the others, the number of eggs deposited during the year being sometimes several hundred; its numbers in favorable localities, are therefore very great. It begins to lay its eggs early in the spring, and continues, with intervals, until checked by the cold of approaching winter. The last deposit of them often remains in the soil until the succeeding spring, when they are hatched with the first generation of the year.

The eggs are semi-transparent, and nearly globular. They produce young in about twenty days after they have been deposited."

"Mr. Bouchard-Chantereaux has observed them to deposit eggs in sixty-six days after their own birth, and to attain their full size in eighty-two days."

Ford ('90, p. 85) records an interesting observation on the carnivorous habits of agrestis: "During a recent stroll in Fairmount Park, I found beneath an old railroad tie about thirty healthy looking Limax agrestis Linn. These I placed in a small collecting box which already contained quite half as many L. campestris Binney.

"On opening the box a half hour later I found, to my surprise, that two of the campestris were rapidly dissapearing within within the jaws of a pair of agrestis.

"Having no means to separate the species I closed the box again and left it so for twelve hours.

"Upon reopening it there was but one campestris living. With exception of a few reddish stains not a vestige of the others could be discovered.

"Of course the living one could tell no tales, but the fact remained that all the rest of its kindred had involuntarily evolved into Limax agrestis Linn."

Dall ('92, p.11) states that "Certain millepedes of the genus Julus are often found feasting upon slugs and snails, but whether they attack specimens in good health is not positively determined."

Webster ('96, p. 53) records a few observations on the carnivorous habits of A. campestris. He observed numbers of

this slug on one of the benches of the insectary upon which were growing lettuce, dock, wheat, etc. One day he saw one of the slugs "stretch out and grasp a plant-louse" and continued disposing of these in quick succession. At one end of the bench was growing a square yard of wheat, and adjoining this and partly among it was a similar plot of lettuce. The latter is reported to be its food at times. The slugs at the lettuce, of which there was an abundance, and also, climbed the leaves and stems of the wheat to a height of eight or ten inches, and crawling on the larger leaves, cleared them of Aphids, most of these being Phorodon maheleb Fonsc. "So then, it would seem that this food was taken of their own volition, and indeed, they made considerable effort to reach it, as they did not, so far as I could see, attack the wheat. The slugs were observed to feed as above stated only during the night and on afternoons of very dark cloudy days." There were aphids present on the lettuce, however, the slugs did not attack these.

Associated forms: I have found this form with Vitrea hammonis, V. indentata, Zonitoides arboreus, Z. nitidus, Z. minusculus, and Carychium exile. At Chicago, Illinois, I have found it with A. agrestis and Philomycus carolinensis. In the Lincoln Park Greenhouse I have found it with Limax maximus, L. flavus, Testacella haliotoidea, and Vitrea draparnauldi.

Genus Philomycus (Raf.) Fer.

Philomycus carolinensis Bosc.

Habitat: This slug is found most frequently under starting bark of fallen trees and standing dead trees. Sometimes it occurs in the interior of decayed trunks. It is the commonest slug found under bark. Binney ('78, p. 182) states that it is found especially

under the bark of basswood, Tilia americana. South of Oakwood, Vermilion Co., Illinois, I found it common under split logs, in a rather moist situation.

Habits: Baker ('02, p. 203) states that this species ascends trees to a height of fifty feet, where it is found under started bark. I have observed it at a height of sic feet, associated with Pyramidula alternata.

It is usually found more or less solitary, two specimens being the usual number in a given situation. However, where the fallen log is large, as many as twelve will be found under the bark. They are not close together.

I found it difficult at first to keep these slugs living in the laboratory. I used ordinary aquaria jars, filling them to a depth of one inch with sand and one inch of garden loam. When the moisture was too great, these slugs moved to the top of the cage and crowded into an area of two square inches. Eight specimens were in this cage. This may be a thigmotropic response combined with negative geotropism. It may also be a hydrotropic response. After confinement of a week or so, these slugs died.

I then devised a different cage, using a large glass rectangular aquaria. I place a one inch layer of fine sterilized sand in the bottom, and on top of this a two inch layer of humus direct from under logs inhabited by this slug. Over this humus I placed a layer of moss and upon the moss pieces of bark from the actual habitat of these forms. In this sort of a cage I could keep living as many as a dozen individuals.

There was sufficient variation in the color of eight individuals so that I could keep track of them. In four of these eight slugs I found that they kept under the same piece of bark.

The other four were found frequently under the same pieces of bark.

May 9, 1911, between noon and six p.m., one of the slugs deposited a batch of twenty eggs (Exp. 166). This mass measured 25mm. long by 11 mm. wide. Fig. 8, Plate 6, is a photograph of these eggs, very slightly enlarged. The mass is unnatural because during the photographing it was damaged.

The eggs were on the average 4.4 mm. long, by 3.2 mm. diameter. (smallest, 4 mm. x 3 mm; largest 4.6 mm. x 3.4 mm.). They were nearly spherical when deposited, but two days later when the measurements were made, they were somewhat elliptical. They were whitish in color, gelatinous, clouded with whiter within; egg shell thick, somewhat leathery.

These eggs hatched at 8:00 a.m. May 26th 1911 to 2:00 p.m. May 26th 1911, the difference between those which hatched ~~soonest~~ earliest and those which hatched latest being was six hours. The egg period was approximately 17 days. The young are as described by Binney. This same author gives the measurement of the eggs as 1/5 of an inch,- this is ~~no doubt~~ probably measured from speciemens in alcohol.

Binney ('78, p. 182) gives a description of the eggs and young, as follows: "An individual of this species was kept in confinement and deposited about 30 eggs, June 20th 1843; on the 10th of July the young made their way out of the shell. The eggs were semi-transparent, oval, about 1/5 inch in greatest diameter. The young when excluded were more than 1/4 inch long, semi-transparent and gelatinous; eye-peduncles and tentacles bluish-black at base, black at tip, the latter very minute and hardly visible. Body broad; back whitish, with two distinct rows of minute black dots down the middle, and other scattering spots on the sides. No perceptable furrow between the mantle and body. They increased very

rapidly in size and in a few days were four times as large as when hatched." (see addenda, p.70 ).

Last October I found two individuals on the under side of a small wood fungus, Fomes sp. They were in a small shallow furrow, and leading from it on one end was a track of mucus which extended to the bark and along this for quite a way. It is probable that the furrows are eaten areas, and that this slug made them. Broad mucus trails were seen on quite a number of fungi.

Associated forms: During early spring I noticed a female black ant, Camponotus americanus , with several workers, under started bark with P. carolinensis. In this same situation are found larvae of Pyrochroa flabellata Fab. Their body is flattened dorso-ventrally, thus "adapting" it to this situation. If the logs are of soft wood, the larvae of Scolecocampa liburna Geyer burrows into them. They produce a large amount of excrement and this often fills up the cavity between the bark and the wood. P. carolinensis has often been found among this excrement.

South of Oakwood, Illinois, I found several specimens of Plethodon erythronotus, Lithobius sp. (centipede), several species of Diplopoda, a few Carabidae, larvae of Pyrochroa flabellata, the large snail, Polygyra albolabris, and the smaller snails, Circinaria concava, Vitrea indentata, Zonitoides arboreus, and Helicodiscus lineatus associated with carolinensis in an area less than eight square feet.

Under very loose bark of standing dead trees is often found Pyramidula alternata, with this slug.

Family ENDODONTIDAE.

Genus Pyramidula Fitz.

Pyramidula alternata Say.

Habitat: I have found this species in a great variety of situations,- under starting bark of fallen logs, in the debris at the base of tree, under leaves and in humus, under stones, and under loose bark of standing dead trees. It prefers moist places. In the laboratory, the individuals died unless the humidity was kept very high. Near Dunning, Cook Co., Illinois, I collected about a dozen specimens under a railroad tie. In the Brownfield Woods, during September, I found young specimens, averaging about 2 1/2 to three whorls each, in the crevices of the bark of a partly fallen tree. They were on the upper half of the bark and also, in the interior of the tree.

Habits: This species is gregarious. The young are found especially in the moist and cool places. They are difficult to distinguish from the surrounding bark. The adults are less abundant, but in the winter I have seen them congregate in large numbers in a common habitat. Call ('99, p. 380) states that "under flat rocks it often congregates in great numbers in the late fall, when the frosts come, and hibernates in such situations."

In the laboratory the movements of this snail were observed to be very slow and deliberate. It is not as timid as some snails are, and when it retracts its body into the shell, a rather abundant flow of reddish mucus results. The individuals remained for the most of the time buried in the soil to a depth of one inch or so.

This species often climbs trees, especially on rainy days. I have seen it on the bark of trees at a height of from eight to ten feet following a rain. By tearing away loose bark of a dead tree, I found specimens of this form together with Philomycus

carolinensis at a height of six feet.

I noticed in this woods that certain individuals were decidedly higher-spired. Others were found with very flat spires. Intermediate forms also were found. I cite the following explanation for the flatness of the spire, from Baker ('02, p. 208): "This variation is in agreat measure due to the habit of crowding itself into narrow crevices, which causes the shell to assume a flat-whorled aspect."

On april 11, 1911, two mature individuals were isolated (Exp. 118), and in the evening one of these was gound burried in the soil to a depth of 1 1/4 inches. On the 17th of April 26 eggs were found deposited in the pocket previously occupied by the snails. They were isolated (Exp. 137), hatching May 16th a.m. The duration of the egg stage of these eggs was about 29 days. Baker ('02 p. 208) states that the egg stage is about 30 days.

The eggs were dull in color, white, opague, agglutinated, almost spherical, measuring on an average of 2.25 mm. greatest diameter. ( minimum 2.00 mm., maximum 2.75 mm.). Baker (02, p. 208) gives the diameter as 2.75 mm. The young were very active after hatching, the shell containing from 1 1/2 to 2 whorls. The eggs when dry were hard and brittle. I was unable to induce the young to eat lettuce or apple.

Associated forms: The individuals under starting and loose bark were often associated with Philomycus carolinensis, and on one occasion, with Pyramidula perspectiva. In this latter case a colony of a small ant, Lasius niger , was present. When this situation becomes too dry, it is then almost devoid of snails. In such a case the roach, Ischnoptera, occupies the habitat. Centipedes and millipedes are almost absent.

P. alternata occurs also with Bifidaria contracta, Helicodiscus lineatus, Polygyra hirsuta, Zonitoides arboreus, Paravitrea significans, and Euconulus chersinus. Numerous insects, mainly Carabidae, and several species of Myriopoda and Diplopoda are likewise present. In some instances the burrows of the short-tailed shrew, Blarina brevicauda Say, open under logs where this species lives, and several specimens were colected with the outer whorl broken, probably the work of this mammal. At Muncie, Illinois, burried in the soil, alternata was found with P. solitaria.

Leidy (1846) describes an entozoon, Cryptobia helices, as inhabiting the spermatheca of this species. This same parasite occurs in the same organ of Polygyra albolabris, and P. tridentata. The same author (1849) describes an entozoon, Ascaris cylindrica, as occuring in the small intestine of alternata. He found it in 15 specimens out of 40.

It is interesting to note that a nearly related species, Ascaris infecta Leidy, is found in the small intestine of Spirobolus marginatus Say, a millepede. This myriopod is found associated with alternata at night, and one time when bringing home a lot of specimens of this snail, I had with them a few specimens of this Spirobolus. The next morning five of the snails were dead, and a quantity of reddish mucus was upon the sides of the can. It is possible that this myriopod attacked this snail. Dall ('92, p. 11) states that Julus (former name for Spirobolus) is often found "feasting" upon slugs and snails, but it is not known whether it attacks healthy specimens or diseased ones. If the Spirobolus does attack parasitised alternata, it is possible for the entozoon to enter this new host.

Pyramidula solitaria Say.

Habitat:Only one juvenile specimen was found in the Brownfield woods. It was burried six inches in the soil. At Muncie, Illinois, I collected six specimens about four inches in the ground. Near Riverside, Chicago, Illinois, I collected one specimen as it was crawling on a log.

Call ('99, p. 379) states that it lives in low, damp or marshy ground, especially on hillsides. In this same paper he states that he collected in one afternoon over 4,000 specimens of this species on the slopes of the hills facing the little Miami River near Cincinnati Ohio.

Habits: It is the earliest form to come out of its winter quarters.(Call'99, p.379). It is reported to have a strong fetid odor. Call also mentions that of the adult specimens collected, most of them have the aperture broken and repaied (p. 380). He also found many albinos.

Associated species: At Muncie, Illinois, I found solitaria associated with P. alternata.

Pyramidula perspectiva Say.

Habitat: In the Brownfield woods this species is not very common. When found, usually two are present. This woods is probably near the northern limit of its extension. It is more abundant in Tennessee and Alabama. It prefers drier situations than most of the Pyramidulae. I found it often under loose bark of standing dead trees. On one occasion specimens were found under a boulder in the glacial drift near a road at Hillery Illinois. At this same place I found a log which contained a dozen specimens under the bark.

Habits: I have not been able to secure ample material for study. The specimens kept in confinement were for the most part inactive, and would not eat lettuce nor dandelion leaves. Their movements are slow and the shell is carried sometimes nearly horizontally, or nearly vertically.

Associated forms: At the Brownfield woods I found this species under the bark of a standing dead tree associated with the small ant, Lasius niger , and with P. alternata. At Hillery Illinois, I found it associated with P. alternata, Polygyra pennsylvanica, P. fraudulenta, P. monodon, P. fraterna, P. hirsuta, Vitrea indentata, Zonitoides arboreus, Bifidaria contracta and Helicodiscus lineatus.

Genus Helicodiscus Morse.

Helicodiscus lineatus Say.

Habitat: This shell is particularly common under logs where it occurs in the crevices of the bark, and in crumbly soil. I have also observed it under very loose bark. It prefers cool places and has been found in both moist and wet situations. It is rare in dry and open areas. I have found it under boards at the water's edge at Crystal Lake, Urbana, Illinois. At Muncie, Illinois, it is quite common. A small colony was found thriving under a log in a back yard in Urbana, Illinois.

Motter ('98, pp. 210, 13, 15, 16, 17, 19, 20) records this snail from eleven graves. The records are as follows:

| | | | | | |
|---|---|---|---|---|---|
| Grave # | 73, | 10 yrs. 4 mo., | 5 ft., | coffin submerged, | sand and clay. |
| " | 47, | 7 " | 4 " | moist, | sand and clay, still-born. |
| " | 89, | 21 " | 3 " | dry, | sandy. |
| " | 91, | 21 " | 4 " | " | " infant. |
| " | 93, | 21 " | 4 " | " | " " |
| " | 95, | 21 " | 6 " | " | " " |
| " | 100, | 71 " | 6 " | " | " |
| " | 121, | 4 " 2 mo. | 3 " | moist, | sand, clay, still-born. |

Grave # 138, 19 yrs. 2 mo., 6 ft. dry, sandy.
" 140, 24 " 5 " 5 " " " .

Habits: This species is somewhat shy, retreating into its shell at the slightest irritation of its tentacles. In its movements the animal is rather slow, carrying its shell well back and almost flat. The eye-peduncles are directed upwar d at an angle of about ninety degrees.

I fed lettuce to this snail and its mode of eating differed from that of other helices. Instead of eating along the edge, this snail nibbles at the surface of the leaf, sometimes eating clear thru and at times simply eating away the first layer. It is not a voracious feeder.

Associated forms: Baker ('02, p. 214) states that this form is "associated with Pyramidula striatella, Zonitoides arboreus, etc".

In the Brownfield woods I found it associated with Zonitoides arboreus, Strobilops labyrinthica, Bifidaria contracta, B. holzingeri, Vitrea indentata, V. hammonis, Euconulus chersinus, and Paravitrea significans. In the Cottonwood forest, in addition to these, Vertigo tridentata is present. In wet places, Carychium exile was present with this form. P. carolinensis was found on one occasion under a log with lineatus.

In the back yard referred to on the previous page, this form was associated with Vallonia pulchella, and Bifidaria armifera. At Hillery, Illinois, I have found it with Pyramidula perspectiva, and P. alternata.

Motter ('98, pp. 210- 220) records the following organisms in graves with H. lineatus: Spiders, Circurina creber Bks., Theridion subterranea Bks., Lophocarenum sp., Lycosa sp.; acarinae, Hypopus sp.; Hymenoptera, Brachymyrmex heeri Forel, Ponera contracta Latr., Myrmicina latreilli Andre, and Camponotus melleus Say; Myrio-

pods, Isobates minutus ?Brandt, Julus sp., Striana sp., Scolopocryptops sexspinosa Say; Trogositidae, Tenebriodes laticollis Horn. (fragments); Scarabeidae, Lachnosterna sp. (probably accidental); Diptera, Piophila casei L., Conicera ? puparia, Phoridae puparia; Pselaphidae, Batrisus ferox Lec.; Staphylinidae, Eleusis pallida Lec.; Thysanura, Lepidocurtus sp.; undetermined vermes, crustacea, thysanura and coleoptera larvae. With # 95 he found Zonitoides minusculus, and with # 121, Z. arboreus.

Since most of these shells were found in graves that were over 19 years old, and hence all flesh gone, it is very likely that they were feeding upon the fungous growth on the bones, clothings and boards.

Genus Sphyradium Charpentier.

Sphyradium edentulum Drap.

Habitat: This species is very rare, only dead shells having been found. Three specimens were collected in the past two years. They were found under logs, not very moist, in the interstices of the bark.

Habits: Not studied.

Associated forms: The dead shells were found with Bifidaria contracta.

# A D D E N D A.

The following notes were omitted by error from the list.

Polygyra thyroides Say. see p. 39.

Townsend ('92, p. 220) describes a sarcophagid fly, Sarcophaga helicis, female, which was bred from Polygyra thyroides by Mr. H. A. Surface while the latter was preparing his Ohio list of mollusca. In a note accompanying the specimens, Mr. Surface says: "The snails were placed in a tight bottle August 25, in Warren County, Ohio, and during the first part of September the pupae were seen. From September 27 to 30, five or six mature flies came forth".

Vitrea indentata Say. See p. 45

Apr. 27, 1911, one small, nearly spherical egg was found in cage 142. The egg measured 1.2 mm. longest diameter, by .99 mm. shortest. On May 18th egg hatched, the egg stage lasting 21 days.

Apr. 21, 1911, found 28 eggs in a cage containing specimens of this species from Hillery, Illinois. These eggs showed a decided flattening, so that a cross-section thru the smallest diameter was a circle. The average measurement was 1.01 mm. long by .94 mm. wide ( varied from .96 mm. x .82 mm. to 1.15 mm. x 1.05 mm.). Three of these eggs are shown in the upper right hand corner of fig. 8 , plate 6 . These eggs hatched May 4, 1911, but since the exact date of deposition is unknown, the exact duration of the egg stage cannot be known. The young after hatching were very transparent, and the shell consisted of 1 1/2 whorls.

Paravitrea significans. Bld. See p. 47.

The following record was omitted. "Yellow Creek Mountains",

Tennessee, in company with Gastrodonta walkeri Pilsbry. (Ferriss, ('00, p. 52.).

Philomycus carolinensis Bosc. See p. 58.

May 31st 1911, I examined a cage and found in it a mass of eggs of this species, concealed under bark. The eggs were of the same size as those previously recorded. The next morning I found six young slugs crawling about. By noon, eight more had hatched. The total number of eggs was 14. The date of deposition is unknown.

Strobilops labyrinthica Say. see p. 28.

Forbes ('79, pp.154, 160) records this species from the stomachs of the Wood Thrush and the Alice Thrush, representing about 1/100 of the food of these birds.

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Fig. 1. View in the interior of the Brownfield woods, showing to the right the gently sloping ravine. The trees are mainly second growth. Very little undergrowth. February 1911.

Fig. 2. This is to show a log habitat in the early stages of decay, the bark loose and off in places. The snails under this bark were Philomycus carolinensis Bosc. and Pyramidula alternata Say.

Fig. 3. A small log half decayed, also showing the fallen leaves, twigs and branches. Febr. 1911.

Plate 3.

Fig. 4. This shows the last stage in the decomposition of a log. The remains form a mound, indicated by a hatchet, composed of a brownish-black debris. Over it is a layer of leaf mould. The snails found here are Helicodiscus lineatus, Pyramidula alternata and Zonitoides arboreus.

Plate 4.

Fig. 5. This shows a log which has been turned over, under which the opening to a burrow of some small mammal, possibly the short-tailed shrew. Located near the moranic ridge. Febr. 1911.

Plate 5.

Fig. 6. Dead shells found under a log where the burrow of a shrew opened. These are the shells listed in the table on page . Cottonwood Grove, Febr. 1911.

Fig. 7. A collection of shells taken from the forest floor at Hillery, Illinois, after a forest fire. The principal snails are Polygyra albolabris, elevata, fraudulenta thyroides, and zaleta.

Plate 6.


Fig. 8. Eggs of Philomycus carolinensis, slightly enlarged. In upper right hand corner of the soil are three eggs of Vitrea indentata.

Fig. 9. Polygyra zaleta, Juvenile, Brownfield Woods.
Fig.10. Polygyra elevata, " " "
Fig.11. Paravitrea significans, Brownfield Woods, x 1 1/4.
Fig.12. Zonitoides nitidus, " " x 1 3/4
Fig.13. Zonitoides arboreus, " " x 1 1/2.
Fig.14. Vitrea hammonis, " " x 1 1/2.
Fig.15. Polygyra elevata, repaired. Ohio.
Fig.16. Polygyra thyroides, showing scratches made by shrew. Cottonwood Grove.
Fig.17. Polygyra pennsylvanica, showing work of shrew.
Fig.18. Polygyra hirsuta, Brownfield Woods. xl.