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THE ECOLOGY OF THE MOLLUSCA OF THE EDWIN
S. GEORGE RESERVE, LIVINGSTON
COUNTY, MICHIGAN*

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INTRODUCTION

THIS paper is presented as a part of the co-operative efforts of a number of research workers to study the fauna of the Edwin S. George Reserve, Livingston County, Michigan. This area, which is maintained in a natural state by the Museum of Zoology of the University of Michigan, comprises about two square miles of territory.

I made collections of mollusks on the Reserve and took field notes in the fall of 1934 and again during an extended period from May to August, 1937. All specimens collected were brought in from the field for study in the laboratory. The plant-animal communities were surveyed by covering sample areas as thoroughly as possible; the transect method was mainly depended upon for ecological data.

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ECOLOGY

In studying the ecology of the molluscan fauna of the Reserve it becomes at once apparent that the various types of plant cover characterizing the plant-animal communities are of prime importance to an understanding of existing conditions. One of the purposes of this study is to describe the present conditions obtaining in the area in order to have an accurate standard for comparison for the future. In the recent past the area was cleared in various places (probably with the aid of fire) for cultivation and the planting of orchards, and there has been a certain amount of grazing pressure. In addition, the forest was lumbered, and fires again followed this activity. The intention of the present management of the Reserve is to allow it to revert to natural climax conditions; thereafter it will furnish an instructive example of the various successional phases of both the plant and the mollusk communities.

As far as the aquatic communities are concerned there is no very apparent modification by human activities. Moreover, the present restrictions on the aquatic mollusks can be traced directly to natural causes. The aquatic fauna itself is not large, and some species seem to be nearing extinction in much of the area. The aquatic mollusks invaded the area in post-glacial times when Patterson Lake, now a mile south of the Reserve, extended into it by a series of arms and bays. The old lake shores in the area have been largely obliterated, and the bogs which succeeded the lake are in process of filling. This fact explains the limited occurrence or total absence of many of the larger species that one might expect to find. Since there are practically no permanent streams on the Reserve no true fluviatile fauna is to be found. Most of the spe-

cies are members of the fauna of southern Michigan, but one, *Amnicola walkeri*, has a limited distribution, and *Gyraulus crista* is a holarctic species occurring discontinuously.

Certain of the larger species of the terrestrial fauna ordinarily expected in southern Michigan are missing. For example, there is no species belonging to the group of three-toothed polygyras, but this is probably due to the fact that their distribution stops short of Livingston County. Many of the largest species are absent simply because the original forest was mainly oak-hickory, an unsuitable cover for them. The oak-hickory community is still the most important forest type occurring here, evidently covering at least one-fifth of the area. The trees have been cut from the more level summits, the gentle slopes, and the valley bottoms. There is no evidence that this has caused the extinction of any terrestrial species, although certain species which depend on a forest cover are greatly limited. On the other hand, human intervention brought about the introduction of one slug, *Deroceras agreste*, and possibly one snail, *Vallonia costata*.

An extended classification of the plant-animal communities seems desirable. All told, twenty-seven natural and artificial communities will be considered in this paper, including three communities—pasture, pasture pool, and cultivated field communities—that no longer exist on the Reserve.

In the lists of species following, symbols are used to indicate relative abundance: a = abundant, c = common, and r = rare. When no symbol is used, it is to be inferred that the abundance is between common and rare, or is uncertain.

AQUATIC SUCCESSION
BOG-LAKE COMMUNITY

The bog lakes appear to be mere remnants of their former selves, and are certainly in the process of disappearing. They are normally full of water, but in severe summer droughts they have been known to dry up. They are bordered by various types of floating mats which are indented by open pools.

These pools have an acidity ranging from pH 5.9 to 6.0, but the open water varies from neutral to pH 8.0.

The vegetation of the bog lakes consists of *Lemna trisulca* and *Nymphaea* sp. The following mollusks occur in this community:

<i>Ammicola walkeri</i>	<i>Helisoma antrosom</i>
<i>Ferrissia</i> ?	<i>Menetus exacuouus</i> r
<i>Gyraulus crista</i> r	<i>Muscultum truncatum</i> r
<i>Gyraulus deflectus</i> c	<i>Physa elliptica</i>
<i>Gyraulus hirsutus</i> a	<i>Pisidium</i> sp. r
<i>Gyraulus parvus</i> c	<i>Planorbula armigera</i> r

TAMARACK-BOG POOL COMMUNITY

A small-sized community is found in the pools of the tamarack bogs. The pools dry up during the summer.

Mollusca:

<i>Aplexa hypnorum</i> r	<i>Lymnaea dalli</i>
<i>Gyraulus parvus</i>	<i>Pisidium</i> sp.

POLYGONUM POOL COMMUNITY

These rather large, shallow pools have gravelly bottoms. They are characterized by *Polygonum amphibium* and *Iris* sp.

Mollusca:

<i>Aplexa hypnorum</i> a	<i>Physa elliptica</i> r
<i>Lymnaea palustris</i> c	<i>Planorbula armigera</i>

MARSH POOL COMMUNITY

The pools located in open marshy ground sometimes dry up during the summer. Their waters are filled with rotting wind-carried leaves, and some algae are present.

Mollusca:

<i>Aplexa hypnorum</i> r	<i>Lymnaea palustris</i>
<i>Lymnaea dalli</i> c	

WOODS POOL COMMUNITY

During summer droughts at least, the pools located in oak-hickory woods dry up and are choked with decaying oak and hickory leaves.

Mollusca:

Lymnaea palustris
Menetus exacuus c

Musculium truncatum
Planorbula armigera

BOG SUCCESSION

FLOATING SEDGE-MAT COMMUNITY

This community occurs in the vicinity of the bog lakes and at times merges into the cat-tail marshes (*Typha latifolia*). It is characterized by the dominance of *Carex filiformis*.

Mollusca:

Succinea retusa

LEATHERLEAF COMMUNITY

This community like the preceding one occurs along the borders of bog lakes; it also has the same relative constancy of water level. It is, however, more acid in character (pH not higher than 5.0). The vegetation is *Chamaedaphne calyculata* and *Sphagnum* sp.

Mollusca:

Succinea retusa

TAMARACK BOG COMMUNITY

This is the first terrestrial community in the series. It is essentially a swamp woods type of community, having a boreal aspect. It is liable to flooding in the spring. The soil is rather acid (pH 5.0). The characteristic vegetation includes: *Larix laricina*, *Acer rubrum*, *Rhus vernix*, *Cornus stolonifera*, and *Vaccinium* sp. (high-bush blueberry).

Mollusca:

Euconulus chersinus
Striatura milium
Succinea ovalis r

Succinea retusa
Vertigo ovata c
Zonitoides arboreus r

BIRCH-MAPLE COMMUNITY

This swamp woods type is located between the tamarack swamps and the oak-hickory or sassafras woods. Soil tests show an acidity of pH 5.9 or 6.0. The community is subject to fluctuations in water level, such as flooding in the fall follow-

ing droughts. The vegetation is characterized by *Betula lutea*, *Acer rubrum*, *Vaccinium* sp., and ferns. Mollusks are not common here, and only small species occur.

Mollusca :

<i>Euconulus chersinus</i>	<i>Striatura exigua</i> r
<i>Gastrocopta pentodon</i> r	<i>Striatura milium</i>
<i>Punctum minutissimum</i>	<i>Vertigo ventricosa</i> r

MARSH SUCCESSION

SEDGE MARSH COMMUNITY

In this community the water level fluctuates; it differs in this respect from the floating sedge-mat community. It is a terrestrial community located in low valleys, and is not in any way associated with the bog lakes. The predominant vegetation is *Carex filiformis*.

Mollusca :

<i>Succinea retusa</i> c	<i>Vertigo ovata</i>
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GRASS MARSH COMMUNITY

This community is more completely terrestrial than the preceding one, and is dominated by tall grasses. It possesses a larger fauna than is to be found in the sedge marshes. Ant nests are very common here.

Mollusca :

<i>Carychium exiguum</i> c	<i>Strotilops affinis</i>
<i>Euconulus chersinus</i> r	<i>Succinea ovalis</i>
<i>Retinella electrina</i>	<i>Zonitoides arboreus</i> r

FERN MEADOW COMMUNITY

This type of community is located between the previous one and the bases of eskers and moraines. It is characterized by the sensitive, chain, and marsh ferns, thistles, and grasses. Here, for the first time in this succession, the larger species of snails are found.

Mollusca :

<i>Euconulus chersinus</i> r	<i>Polygyra hirsuta</i> c
<i>Gastrocopta contracta</i> r	<i>Retinella indentata</i>
<i>Polygyra albolabris</i>	<i>Strotilops affinis</i> r
<i>Polygyra fraterna</i> r	

WILLOW-RED OSIER-DOGWOOD COMMUNITY

This community is located on low ground often near the larger pools, and is characterized by a shrubby cover of *Salix* sp., *Cornus stolonifera*, *C. paniculata*, and *Betula glandulosa*. The topsoil is black humus.

Mollusca :

<i>Carychium exiguum</i> r	<i>Hawaiiia minuscula</i>
<i>Deroceras laeve campestre</i>	<i>Polygyra albolabris</i>
<i>Euconulus chersinus</i> r	<i>Succinea avara</i>
<i>Gastrocopta contracta</i>	<i>Vertigo ovata</i>

SAND SUCCESSION

SASSAFRAS COMMUNITY

This community, which begins a series of typically terrestrial communities, is located on predominantly sandy soils having a mixture of clays and coarser materials. The soil of the sassafras community has a pH of about 6.0. The vegetation is chiefly *Sassafras variifolium*, *Gaylussacia* sp., *Vaccinium* sp., *Vitis aestivalis*, *Pteris aquilina*, and ferns. A few *Quercus bicolor* and *Acer rubrum* are present at the lower borders of the community, which sometimes tend to shade off into a pyric succession of *Populus tremuloides*, *Rubus* sp., and *Equisetum arvense*.

Mollusca :

<i>Anguispira alternata</i> r	<i>Polygyra fraterna</i> r
<i>Euconulus chersinus</i> r	<i>Striatura milium</i>
<i>Gastrocopta contracta</i> r	<i>Zonitoides arboreus</i>

OAK-HICKORY COMMUNITY

This type of community is of wide extent and is located on moraines, eskers, and slopes too steep for satisfactory cultivation. It is the closest approach to a climax plant association in the area. The soil is somewhat calcareous, and has a pH of about 7.0. The community may be divided into three parts :

A wet zone at the bases of the slopes borders the large pools. The vegetation consists chiefly of *Ulmus americana*, *Quercus alba*, and *Cornus stolonifera*.

Mollusca:

*Succinea retusa**Zonitoides nitidus* a

The zone on the richer slopes has a vegetation made up of *Quercus alba*, *Q. borealis maxima*, *Hicoria ovata*, *H. Glabra*, *Acer saccharum*, *Prunus serotina*, *Cornus florida*, *Hamamelis virginiana*, *Podophyllum peltatum*, *Smilacina racemosa*, *Geranium maculatum*, *Viola* spp., and ferns.

Mollusca:

*Anguispira alternata**Polygyra fraterna**Carychium exiguum**Polygyra hirsuta**Euconulus chersinus**Punctum minutissimum* a*Gastrocopta contracta* r*Retinella electrina**Gastrocopta corticaria**Retinella indentata* c*Gastrocopta pentodon* c*Striatura milium* r*Hawaiiia minuscula* r*Succinea ovalis* r*Helicodiscus parallelus* c*Succinea retusa* r*Philomycus carolinensis* r*Zonitoides arboreus**Philomycus rushi**Zonitoides suppressus* r*Polygyra albolabris*

The upper zone is dry and is more affected by fires than are the other zones. The vegetation is about the same as that lower down, but the mandrake and the ferns are lacking. Many of the mollusks of the preceding zone do not appear here.

Mollusca:

Anguispira alternata r*Polygyra albolabris* r*Euconulus chersinus**Polygyra fraterna**Gastrocopta contracta* r*Punctum minutissimum* c*Gastrocopta pentodon**Retinella electrina**Helicodiscus parallelus* r*Retinella indentata**Philomycus rushi**Zonitoides arboreus*

FIRE AND CLEARING SUCCESSION

OAK-SAVANNA COMMUNITY

This community, a modification of the preceding one, has been considerably cut over and fired. The trees are very much scattered, and the ground is covered with a carpet of grass and weeds. The vegetation consists of the usual oaks and hickories, *Hamamelis virginiana*, *Vitis aestivalis*, *Galium aparine*, *Ge-*

ranium maculatum, *Smilacina racemosa*, *Fragaria virginiana*, *Poa*, and other grasses.

Mollusca :

<i>Anguispira alternata</i> c	<i>Retinella indentata</i>
<i>Polygyra albolabris</i>	<i>Zonitoides arboreus</i> c
<i>Polygyra fraterna</i>	<i>Zonitoides suppressus</i> c
<i>Retinella electrina</i>	

ASPEN-SHRUB COMMUNITY

This is the lowland equivalent of the preceding community, as far as the factors of fire and clearing are concerned. It evidently belongs to a lowland woods succession, and the vegetation consists of *Populus tremuloides*, *Ulmus americana*, *Acer rubrum*, *Cornus stolonifera*, *Viburnum alnifolium* (?), and *Vitis aestivalis*. Inasmuch as this community is of the woodland border type, the number of species is relatively large, and some of the largest-sized species here reach what is almost their maximum of abundance.

Mollusca :

<i>Anguispira alternata</i> c	<i>Polygyra fraterna</i>
<i>Deroceras laeve campestre</i>	<i>Polygyra hirsuta</i>
<i>Euconulus chersinus</i>	<i>Retinella indentata</i>
<i>Hawaia minuscula</i> r	<i>Succinea ovalis</i> c
<i>Philomycus rushi</i>	<i>Zonitoides arboreus</i>
<i>Polygyra albolabris</i> c	<i>Zonitoides suppressus</i> r

LOWLAND GRASS BANKS

This community occurs on banks along paths and the borders of pools in open clearings close to the preceding one but on slightly higher ground.

Mollusca :

<i>Anguispira alternata</i>	<i>Polygyra hirsuta</i> c
<i>Philomycus rushi</i>	<i>Retinella indentata</i>
<i>Polygyra albolabris</i> c	<i>Succinea ovalis</i>
<i>Polygyra fraterna</i> c	

ARTIFICIAL COMMUNITIES

DITCH COMMUNITY

This community occurs on ground that has been strongly altered by direct human factors. Here for the first time we

find a species introduced by man. The only example of this type of community is to be found near the Edwin S. George house. The vegetation consists of grasses, *Rubus idaeus*, and *Iris* sp. The ditch is a terrestrial habitat and is dry most of the time.

Mollusca:

<i>Cochlicopa lubrica</i> r	<i>Polygyra monodon</i> c
<i>Deroceras agreste</i>	<i>Zonitoides nitidus</i> c
<i>Discus cronkhitei anthonyi</i>	

ORCHARD COMMUNITY

Four rather old orchards are located on summit areas and are characterized by apple trees, grasses, *Rhus glabra*, brambles, and wild roses.

Mollusca:

<i>Anguispira alternata</i> r	<i>Euconulus chersinus</i>
<i>Cochlicopa lubrica</i> r	<i>Polygyra fraterna</i> r
<i>Deroceras agreste</i>	<i>Vallonia pulchella</i>
<i>Deroceras laeve campestre</i>	<i>Zonitoides arboreus</i> c

ROADSIDE COMMUNITY

This is one of the most natural of the artificial communities and is rather hard to distinguish from the open-field communities. The two types intergrade. Nevertheless, this community appears to be a special modification of the ruderal type. It is not much subject to disturbance, and moreover it seems to be a highway for the dispersal of species in the culture zone. The vegetation is chiefly made up of grasses, tall annual weeds, brambles, *Tanacetum vulgare*, *Rhus toxicodendron*, *R. glabra*, *Vitis aestivalis*, *Fragaria virginiana*, *Crataegus* sp., with a few isolated *Syringa vulgaris*, elms, wild cherries, and white oaks.

Mollusca:

<i>Anguispira alternata</i>	<i>Helicodiscus parallelus</i> r
<i>Deroceras laeve campestre</i>	<i>Philomycus rushi</i>
<i>Euconulus chersinus</i> r	<i>Polygyra albolabris</i> r
<i>Gastrocopta armifera</i> c	<i>Polygyra fraterna</i> c
<i>Gastrocopta contracta</i> r	<i>Punctum minutissimum</i> r
<i>Gastrocopta pentodon</i> c	<i>Pupoides marginatus</i> r
<i>Hawaiiia minuscula</i>	<i>Retinella indentata</i>

Succinea avara r
Succinea ovalis
Vallonia costata

Vallonia pulchella c
Zonitoides arboreus
Zonitoides suppressus

OPEN-FIELD COMMUNITIES

These communities are divisible into two general types according to their topographic situation.

Slopes and valleys. The most favorable type of open field community is to be found on the slopes and in the drier valley bottoms. The best mollusk habitats are in the relatively undisturbed fields having a sandy, calcareous soil (sometimes mixed with till). The best indicator of this optimum type of terrain is the presence of red cedars. The poorest habitat complex is to be found on east slopes which have considerable ground water; it is indicated by *Equisetum hyemale*. In general aspect these fields are characterized by open grassy areas dotted with patches of wild grape and old field growths of *Juniperus virginiana*, a few scattered hickories, elms, ash, and white oaks. Important vegetation cover includes *Ostrya virginiana*, *Juniperus depressa*, *Rubus* spp., *Arctium minus*, *Leonurus cardiaca*, *Verbascum thapsus*, grasses, and mosses. On the best types of land the mollusks occur with a frequency of about five individuals a square foot, or $\pm 217,800$ an acre.

Mollusca:

Anguispira alternata c
Deroceas laeve campestre
Euconulus chersinus
Gastrocopta armifera c
Gastrocopta contracta r
Gastrocopta pentodon
Hawaiiia minuscula
Helicodiscus parallelus
Philomyces rushi
Polygyra albolabris

Polygyra fraterna c
Punctum minutissimum r
Pupoides marginatus
Retinella electrina
Retinella indentata r
Succinea avara r
Succinea ovalis
Vallonia pulchella c
Zonitoides arboreus
Zonitoides suppressus c

Summits. The upland areas comprise open eroded uplands of sands and clays. Although cultivation and grazing have ceased on the summits and the slopes below, there is some browsing pressure exerted by deer, as indicated by the lack of any young ground hemlock (*Juniperus depressa*). Un-

doubtedly, the summits will be the last areas to revert to forest cover. The vegetation is characterized by grasses, mullein, milkweed, brambles, *Rhus typhina*, *R. glabra*, *Lespedeza*, *Tanacetum vulgare*, and a few thickets of sassafras, oak, and hickory saplings. None of the mollusks are very abundant here.

Mollusca :

<i>Deroceras laeve campestre</i>	<i>Polygyra fraterna</i> r
<i>Euconulus chersinus</i>	<i>Retinella electrina</i>
<i>Gastrocopta pentodon</i>	<i>Succinea avara</i>
<i>Hawaiia minuscula</i>	<i>Vallonia pulchella</i>
<i>Helicodiscus parallelus</i>	<i>Zonitoides arboreus</i>
<i>Polygyra albolabris</i> r	

CULTIVATED FIELD COMMUNITY

No cultivated fields occur within the grounds of the Reserve today, but a good example of this community is to be found across the road on the south side of the property. Although snails and slugs are scarce or absent on recently plowed land, they are apt to be rather common on fallow land among the weeds.

Mollusca :

<i>Deroceras laeve campestre</i> r	<i>Vallonia costata</i>
<i>Gastrocopta armifera</i> c	<i>Vallonia pulchella</i> c

PASTURE COMMUNITY

Examples of this type of community are to be found adjacent to the preceding community. Most of them are overgrazed, and the grass cover has been partly replaced by other types of weeds. Snails are apt to be scarce in such pastures except where thickets of brambles, wild grape, thistles, witch hazel, and stumps and logs furnish protection.

Mollusca :

<i>Anguispira alternata</i>	<i>Polygyra hirsuta</i>
<i>Deroceras laeve campestre</i>	<i>Succinea avara</i>
<i>Gastrocopta pentodon</i> r	<i>Succinea retusa</i>
<i>Polygyra albolabris</i> r	<i>Zonitoides arboreus</i>

PASTURE POOL COMMUNITY

The pools located in the aforementioned pastures are subject to some trampling by cattle that come for water.

Mollusca:

Aplexa hypnorum r

Lymnaea parva

Lymnaea palustris

EDIFICARIAN COMMUNITY

Although mollusks in southern Michigan seldom invade houses there are a few species that are associated with sheds and outhouses. A larger fauna is associated with the ruined foundations and cellars of old houses, and since these present xeric conditions, it is of interest to note the fauna that affect such habitats. There are very few buildings maintained in the Reserve, but under boards, stones, and bricks of a ruined farmhouse in the southwest corner of the area three species occur.

Mollusca:

Euconulus chersinus

Zonitoides arboreus c

Vallonia pulchella c

EROSION COMMUNITIES

ROCK PILES AND GULLIES

The sandy soil in Livingston County is somewhat susceptible to rapid erosion on unprotected slopes and seems to have a high ratio of Si to Fe and Al (molecular ratio higher than 2). Most of the more actively eroding gullies on the Reserve have either been blocked by piles of rocks or else are being protected by a growth of grass or willow saplings. The rock piles are often overgrown by brambles and wild grape.

Mollusca:

Anguispira alternata c

Helicodiscus parallelus

Euconulus chersinus

Polygyra fraternalis

Hawaia minuscula

Zonitoides arboreus

DISCUSSION OF ECOLOGICAL CONDITIONS

The bog lakes, with twelve species, lead all of the aquatic communities in number of species. The other communities,

in shallow pools of limited area, have less than half that number. No factors of pollution have upset the faunal balance, so it is evident that on the whole the aquatic formations are in a more natural condition than are the terrestrial ones. However, there is no evidence concerning the fate of woodland pools that may have occurred in the now deforested zone and which have probably disappeared without a trace.

The oak-hickory community, as might be expected, leads the terrestrial communities in number of species. There are twenty-two species recorded for this community. Of the communities possessing an arboreal cover the aspen-shrub woods come next, with twelve species. The roadside and open field communities each have only two less species than does the oak-hickory woods. This fact seems to imply a rather high ecological value for at least two of the communities in the culture zone (*Kulturboden*). From this it would seem that deforestation has worked no great hardship on the mollusk fauna. An examination of the faunal composition of the various communities shows that eight species, about 22 per cent of the total thirty-six species, are limited to natural woodland or marsh cover. The actual faunal composition of the culture-zone communities is somewhat different from that of the woodland cover. It is made up of a few rare species, some very adaptive mesophiles, and a number of xerophiles or facultative xerophiles. Two of the larger species, both mesophiles, are common in the open country, but for the most part the species in greatest abundance are diminutive xerophiles. One of the commoner of the small mesophiles, *Helicodiscus parallelus*, is common chiefly because of the presence of rock piles and weedy thickets. Two of the species of the open country are introductions.

In 1933 Mr. Calvin Goodrich and Dr. Henry van der Schalie, of the University of Michigan, attempted to introduce a stock of *Anguispira solitaria* (Say) into the oak-hickory woods on the south end of the Reserve. There is no trace of it there today, and it seems likely that oak-hickory cover is not suitable for that species.

In general, there is no proof that any species has become extinct on the Reserve because of human activities, but on the contrary man has been the agent for increasing the fauna. Deforestation has served to favor the small xerophiles at the expense of the general woodland fauna.

It must be confessed that inasmuch as many of the communities were studied from sample areas this summary may not be entirely complete either for all the conspicuous vegetation cover or for all the mollusks.

TAXONOMIC DISCUSSION OF SPECIES

There are sixteen aquatic species and thirty-six terrestrial species known to occur on the Edwin S. George Reserve. Certain of the species are limited to the valley areas, and these species seem to have reached the periphery of their distribution in this region. These valley-limited species evidently invaded Livingston County by way of the chain of lakes that constitute part of the headwaters of the Huron River. Examples of these invaders from the region to the south are *Polygyra hirsuta*, *P. monodon*, and *Zonitoides nitidus*. To be sure, the latter two extend into northern Michigan, but they are both limited to the shores of the Great Lakes and to large river valleys.

Polygyra thyroidus (Say) and *Planorbula crassilabris* (Walker) occur at Patterson Lake but do not reach the Reserve.

1. *Helisoma antrosom* (Conrad)

This not very common species lives on roots and decaying vegetation in the open pools of bog lakes.

2. *Planorbula armigera* (Say)

Habitats: on decaying vegetation in bog lake pools; on rotting leaves in *Polygonum* pools; and in woods pools.

3. *Gyraulus crista* (Linnaeus)

This rare snail lives in duckweed in pools along the edges of bog lakes.

4. *Gyraulus parvus* (Say)

This common species was found in duckweed of bog-lake pools; and in rotting leaves in tamarack-bog pools.

5. *Gyraulus deflectus* (Say)

This species is common in duckweed in bog-lake pools.

6. *Gyraulus hirsutus* (Gould)

This species is also common in duckweed in bog-lake pools.

7. *Menetus exacuus* (Say)

This snail is common both in duckweed in bog-lake pools; and in rotting oak and hickory leaves in woods pools.

8. *Physa elliptica* Lea

Habitats: on decaying vegetation in bog-lake pools; and on rotting leaves on the gravel bottom of *Polygonum* pools.

9. *Aplexa hypnorum* (Linnaeus)

Habitats: on rotting leaves in *Polygonum* pools; in tamarack bog pools; and in rotting leaves in marsh pools. In the spring this snail is common on the surface of the water.

10. *Ferrissia* (?)

A specimen of a species apparently belonging to this genus was found in duckweed in a bog-lake pool but was lost before it could be brought into the laboratory.

11. *Lymnaea palustris* (Müller)

Habitats: common on submerged logs in *Polygonum* pools, on rotting leaves in tamarack bog and marsh pools, and in pasture pools.

12. *Lymnaea dalli* F. C. Baker

Habitats: on rotting oak and birch leaves in marsh pools.

13. *Lymnaea parva* Lea

Habitat: on mud and decaying vegetation out of the water

along the edges of pasture pools across the road from the south end of the George Reserve.

14. *Amnicola walkeri* Pilsbry

This snail occurs in small numbers in duckweed in bog-lake pools.

15. *Musculium truncatum* (Lindley)

Habitats: in mud in bog-lake pools, and in rotting oak and hickory leaves in woods pools.

16. *Pisidium* sp.

Specimens of this small clam found on the Reserve were too young for determination. They were found in duckweed of bog-lake pools and in rotting leaves of tamarack bog pools.

17. *Helicodiscus parallelus* (Say)

Habitats: in leaf mold and under rotten logs of the oak-hickory woods; in grass, moss, in grassy gullies, rock piles, bramble thickets, wild-grape patches, in the open fields; under logs and fallen bark in the fields and on the roadsides. This snail is commonest in the open country.

18. *Anguispira alternata* (Say)

Habitats: in leaf mold, under logs, under started bark, and around boulders in the oak-hickory woods; in piles of fallen twigs, in wild-grape patches, and on boles of trees in the aspen woods; in grass and plant trash, in axils of burdocks and *Leonurus cardiaca*, and in wild-grape patches in the open fields; at the bases of elms, oaks, apple trees, and ironwood of the open fields; and often hiding under logs, around stumps, and in rock piles of the roadsides and open fields. This snail avoids the high summits. It is very active after rains, climbing as much as five feet above the ground on stumps and big logs in low fields to feed on fungi. The greater diameter of the shell only varies from 16.5 to 17.8 mm., but the height varies from 8.9 to 11.8 mm. The high-spired form occurs on

the low-lying grass banks near pools, and has a height-diameter index of about 75 per cent, whereas the low-spined individuals have an index of as low as 52 per cent.

19. *Discus cronkhitei anthonyi* (Pilsbry)

Habitats: in grass around a spring near the George house, in chinks at the base of the rock wall around the spring, in grass in the dry ditch, and at the bases of apple trees. The occurrence of this species in one locality only is puzzling. It apparently invaded the area from the old lake-chain valley and is common along the lakes to the southeast of the Reserve, as for example at Highland Lake. All the specimens collected around the spring were albinistic.

20. *Punctum minutissimum* (Lea)

Habitats: abundant in the moist zone of the leaf-mold carpet in oak-hickory woods, especially concentrated in leaf pockets; rare in grass and moss on slopes of old fields along the highway, and in wild-grape thickets on rotten boards of the roadsides.

21. *Philomyces rushi* Clapp

Habitats: in leaf mold, around stumps, under rotten logs, and under started bark on logs in the oak-hickory woods and in the aspen woods; in grass, under boards, logs, and fallen bark in open fields. It avoids summits.

22. *Philomyces carolinensis* (Bose)

Habitat: rare, under started bark on rotten logs in oak-hickory woods.

23. *Deroceras laeve campestre* (Say)

Habitats: in grass and leaves, in the willow-red osier-dogwood thickets and aspen woods; in weeds and under boards in the open fields; among stones, around boulders, and at bases of apple trees in the open fields and roadsides; and in fallow gardens.

24. *Deroceras agreste* (Linnaeus)

Habitats: at the bases of apple trees and among stones in open places. This species has been introduced into the Reserve.

25. *Euconulus chersinus* (Say)

Habitats: in tall grass in marshes; in ferns in meadows; in leaf mold and under rotten logs in oak-hickory woods, aspen woods, and willow-red osier-dogwood thickets; in grass and plant trash on open slopes; under stones, in rock piles, and under boards and shingles in the fields and orchards; and under rock slabs, cement, and boards on the site of an old house. This snail is rather characteristic on the grassy slopes of old gullies.

26. *Retinella electrina* (Gould)

Habitats: in marsh grass; in leaf mold and under logs of the oak-hickory woods; in herbaceous tall weeds, in grass, and under burdocks in the open fields; and under boards and shingles on the open slopes and summits.

27. *Retinella indentata* (Say)

Habitats: in marsh grass; in ferns in meadows; under rotten logs and in leaf-mold pockets of the oak-hickory woods; in twig piles of the aspen woods; around and under rocks in grass of the open fields; and on till among ironwood trees of the open slopes.

28. *Hawaia minuscula* (A. Binney)

Habitats: in leaf mold of the aspen woods and willow-red osier-dogwood thickets; in leaf-mold pockets of the oak-hickory woods; in grass, on till, in rock piles of the open fields; and in wild-grape thickets along the roadsides.

29. *Striatura exigua* (Stimpson)

Habitat: in leaf mold on log rafts in the birch-maple swamp woods.

30. *Striatura milium* (Morse)

Habitats: in leaf mold on log rafts in the birch-maple swamp woods; and in leaf mold in the oak-hickory and sassafras woods.

31. *Zonitoides suppressus* (Say)

Habitats: rare in leaf mold in the oak-hickory woods; in wild-grape thickets of the oak savannas; in grass, in grassy gullies, and on moss in hollows on grassy slopes of the open fields; under limbs, bark, and fragments of wood on the grassy banks of a dry brook; and in grass along roads. In general this species tends to decrease in size from the south side of the Reserve to the interior of the area.

32. *Zonitoides arboreus* (Say)

Habitats: in leaf-mold pockets, under started bark on logs and on stumps in the oak-hickory woods; in moss in the willow-red osier-dogwood thickets; in grass, under boards and logs, on stumps, under stones and bricks, and in thickets of the open fields and roadsides; and under rock slabs, cement, and boards on the site of an old house.

33. *Zonitoides nitidus* (Müller)

Habitats: on rotting leaves, stems, and limbs of the low, moist zone bordering the oak-hickory woods; in grass around a spring; and in a dry ditch.

34. *Polygyra hirsuta* (Say)

Habitats: under rotten logs and under loose bark on logs in the lower zone of the oak-hickory woods; in grass on open banks and under planks along a path; in grass, ferns, and thistles in meadows; in nettles, on stumps, and in poison ivy around pasture pools. Wherever this snail is common three specimens occur to the square foot.

35. *Polygyra monodon* (Rackett)

This species is apparently limited to a small area near the George house.

Habitats: deep in hollows in grass around the spring; at the base of the stone retaining wall around the spring; in grass in a dry ditch.

36. *Polygyra fraterna* (Say)

Habitats: in ferns in meadows; under fallen logs in the aspen woods; around stumps and rocks, under rotten logs, under fallen bark, and in leaf mold in the oak-hickory woods; in grass, plant debris, fallen leaves, in axils of burdocks and *Leonurus cardiaca*, and on till in the open fields; under boards and logs, around stumps, at the bases of oaks, elms, apple trees, and ironwood, at the bases of fence posts, in wild-grape thickets, tall annual weeds, and lilacs in the open fields and roadsides; in grass and rock piles in gullies. This snail has some tendency to climb, for it ascends as much as five inches on fence posts. It tends to be rare on summits. The species increases in size from the slopes to the valley bottoms and has a greater diameter ranging from 7.0 mm. up to 9.0 mm. It is definitely commoner in favorable ruderal country (open areas) than it ever is in woodland cover, and as many as two hundred specimens have been collected in a few hours in a limited space. Two racial tendencies are evident in this form on the Reserve—small size and albinism. The latter trait is more frequent here than in any other known locality in southeastern Michigan. Out of one batch of 134 specimens collected eleven were albinistic.

37. *Polygyra albolabris* (Say)

Habitats: in leaf mold and under logs in oak-hickory woods; under limbs, in twig piles, and in wild-grape thickets in aspen woods; under boards, under logs, and in grass in the open fields; in thickets along roadsides; and around stumps in pastures. This large snail is common in the aspen woods but is not very frequent elsewhere. The greater diameter of the shell ranges from 23.7 mm. to 26.7 mm.

38. *Cochlicopa lubrica* (Müller)

This snail is rare and has been found only at the bases of apple trees and in the grass of a dry ditch.

39. *Strobilops affinis* Pilsbry

Habitats: in tall grass in marshes; and in ferns in meadows. It is odd that this snail was not found in the woods.

40. *Vertigo ovata* (Say)

Habitats: in sedges; in grass, plant trash, and in leaves along the edges of pools in the willow-red osier-dogwood thickets; and on rotting leaves in tamarack bogs. A rather common species.

41. *Vertigo ventricosa* (Morse)

Habitat: in leaf mold on log rafts in the birch-maple swamp woods.

42. *Gastrocopta corticaria* (Say)

Habitat: common in the fecal mush of arthropods under started bark on rotten logs in the oak-hickory woods.

43. *Gastrocopta pentodon* (Say)

Habitats: in leaf mold on log rafts in the birch-maple swamp woods; in leaf mold of the oak-hickory woods; in grass and weeds, under boulders, in sumac thickets, on till slopes, and on the slopes and summits of the open fields and on roadsides. On grassy roadsides there are four of these snails to the square foot.

44. *Gastrocopta contracta* (Say)

Habitats: in deep grass in marshes; in ferns in meadows; under logs on the edge of the birch-maple swamp woods; in grass in the willow-red osier-dogwood thickets; in wild grapes and in leaf mold of the oak-hickory woods; in grass and plant trash and under leaves in the open fields; in grapevines and under rotten wood beneath the oaks and elms of the roadsides. This snail is nowhere common.

45. *Gastrocopta armifera* (Say)

Habitats: in grass, in axils of burdocks, in moss on banks, around gneiss boulders and limestone slabs, in ironwood thick-

ets, on fence posts, where it climbs as much as six inches above the ground, and several feet above the ground on large logs and on stumps in the open fields; in grass and wild grape thickets along the roadsides; in shallow grassy ravines, and gullies; and in fallow fields. This snail is very abundant in open country on slopes and in valleys but tends to avoid summit areas. It has not been found in woodland cover.

46. *Pupoides marginatus* (Say)

Habitats: in grass and on till slopes in the open fields; and in wild-grape thickets on rotten boards along the roadsides. This species apparently does not occur in woodland cover.

47. *Vallonia costata* (Müller)

Habitats: in grass and under bricks, stones, and boards along the roadsides; and in fallow fields. Whether or not *V. costata* is specifically distinct from the following species, it has a tendency to limit itself to drier habitats than does *V. pulchella*. Its limited distribution on the Reserve suggests that it has been introduced from surrounding areas. There is some evidence that it has spread into Ann Arbor, Michigan, in recent times with the advent of intensive settlement in that locality.

48. *Vallonia pulchella* (Müller)

Habitats: in grass and weeds, under bricks, stones, and boards, under dead leaves in ironwood thickets, and in wild grape thickets in open fields and along the roadsides; under cement and rock slabs on the site of an old house; and in fallow fields. This snail is rather common in open country on slopes and summits.

49. *Succinea retusa* Lea

Habitats: on duckweed and sphagnum in bog areas; it climbs as high as fifteen inches above the ground on sedges; in leaf mold in the lower edge of the oak-hickory zones; and on rotten wood and stumps around pasture pools.

50. *Succinea ovalis* Say

Habitats: in grassy marshes; in thistles and ferns in meadows; and under dead leaves in the oak-hickory woods; in grass, in the axils of burdocks, and on fence posts in the open fields and along roadsides. This snail avoids summit areas of all kinds.

51. *Succinea avara* Say

Habitats: in leaf mold in the willow-red osier-dogwood thickets; in grass, in plant trash, and around fence posts along roadsides, in pastures, and in open fields. This snail is generally distributed in open country.

52. *Carychium exiguum* (Say)

Habitats: in grass in marshes; in sedges; and in rotting debris under shrubs in the oak-hickory woods.

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