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PLEISTOCENE MOLLUSCA OF SOUTHWESTERN OHIO

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ABSTRACT

Sixty-two species of Pleistocene Mollusca are represented in this study. The mollusks were recovered from three lacustrine and one interstadial silt deposit located in southwestern Ohio. The interstadial deposit represents wn environment of the Connersville (Wisconsin) interstade. The three lacustrine deposits occur on the Miami 60 drift sheet and represent environments that were initiated after the 'Late' Wisconsin ice sheet receded northward, about 11,000 to 14,000 years ago.

The mollusks of the lacustrine deposits and the Hamilton interstadial were collected systematically in vertical increments. The mollusks of each deposit were studied quantitatively in order to determine their former environment. Species that occur most abundantly are considered indigenous, whereas the less common and rare ones represent intruders from another environment. Intrusion can be caused by natural migration of living animals or by transportation by an agent. Percentages of the total population for each species were determined. Where this was done for the increments in the section, changes are evident in the percentages of species present and the number of shells per increment. Such changes show correlation with lithologic differences in the section that reflect changes in environment.

The most common species of the Clark and upper part of the Champaign deposit consist of a typical lacustrine marl assemblage characteristic of shallow water with considerable vegetation. The muck, peat, and travertine lithologies of the Greene deposit and the contained fauna of terrestrial gastropods are not typically lacustrine. The Hamilton interstadial deposit consists largely of calcareous silts which contain mollusks and considerable plant debris.

The Clark and Champaign deposits represent former small lakes or ponds which developed in depressions shortly after ice retreat. The lakes were characterized by shallow water, a soft substrate, and abundant vegetation. Variation in percentages of indigenous freshwater species and of amphibious and terrestrial intruders reflects some changes in environment. The lithology and fauna of the Greene deposit suggest a low swampy area which experienced minor changes in environment. A low moist environment is also suggested for the Hamilton interstadial deposit.

Present in virtually all deposits were

both freshwater and terrestrial mollusks characteristic of more northerly latitudes or higher altitudes. Temperatures cooler than at present are suggested, an interpretation confirmed by vegetational studies in southeastern Indiana.

When the 'Late' Wisconsin glacier reached its maximum advance and began to retreat, the mollusks that had migrated southward into Kentucky began to repopulate the region. The hardiest forms appear to have moved into the deglaciated areas reasonably quickly. The rate of migration of these hardiest species appears to be determined largely by the rate of ice retreat. Other species, however, show delayed repopulation or slower migration. In Ohio *Lymnaea stagnalis jugularis* and *Acella haldemani* are present in Pleistocene deposits but do not live today, whereas the reverse is true in northeastern Wisconsin. These distribution patterns suggest that the northward migration of such species was in response to the gradual increase of temperature in the Ohio area. This is also true for the other species that allowed an interpretation of cooler temperatures for the region during the deposition of the sediments of this study.

Observations of fossil mollusks in northern Kentucky and in this area, as well as the modern species from Kentucky to Ontario, demonstrate the northward migration. Fossil species from Kentucky are present in the younger deposits of this area, and almost all of them live today north of central Ontario.

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ILLUSTRATIONS

INTRODUCTION

Background and Purpose of Investigation

The purpose of this investigation is to make a quantitative study of the molluscan fauna of several Late Wisconsin deposits selected from southwestern Ohio. The paleoenvironment of each deposit was to be reconstructed by relating species variation to lithologic (environmental) changes in the measured section. Such an investigation yields information concerning species repopulation after deglaciation, helps to determine rates and possible routes of species migration, and assists in establishing the significance of guide fossils for the Pleistocene.

Four deposits were selected for this investigation. Three represent lacustrine habitats and the fourth the environment of an interstadial silt.

Location of Deposits

The interstadial-silt deposit is located at Hamilton, Ohio and the three lacustrine deposits are located in the vicinity of Springfield.

More specifically, the locations are as follows: the Champaign County deposit, on the E. H. Hallman farm, four miles northwest of Urbana, in the SW¼, NW¼, Sec. 33, T 5, R 12; the Clark County deposit on the E. V. Saunders farm, just north of the village of Crystal Lake, in the NE¼, SE¼, Sec. 26, T 3 E, R 9 N; the Greene County deposit, on the Jack Groth farm, 100 feet south of Herr Road and north of Hebble Creek, in the NW¼, NE¼, SW¼, Sec. 2, T 3, R 8; the Hamilton interstadial deposit, on the north edge of the city of Hamilton, along the north bank of Twomile Creek and three-tenths of a mile west of its mouth, in the SW¼, NE¼, Sec. 29, T 4 N, R 3 E.

Method of Investigation

The lacustrine deposits were located with the aid of soils maps. The desired deposits containing molluscan shells are generally mapped as muck soils, such as the Carlisle muck, Edwards muck, and Warners loam. These soils are characterized by a rich organic layer over a calcareous clay, marl, or travertine, and they have developed in poorly drained, boggy situations on glacial outwash or kame material. The three selected were chosen on the basis of geographic location, accessibility, and a cursory inspection of the fossil content. In each a pit was dug near the edge of the deposit where a complete section was assured. Each pit measured approximately four feet by six feet, large enough for sampling and describing the section. Collections of twelve by twelve inches were made continuously from top to bottom at two-inch intervals. These samples were placed in plastic bags, labeled as to correct unit, and taken to the laboratory.

In the laboratory the samples were soaked for several days in water treated with a water-conditioner before being sieved. They were then washed through 10, 20, and 40 mesh sieves, allowed to dry, and stored for study.

The stored samples contained the molluscan shells and considerable amounts of sediment and vegetable matter that could not be washed through the sieves. Because most samples contained a very large quantity of shells, they were repeatedly halved by means of a sample splitter until the selected portion contained approximately a thousand. The shells were then picked out with a moistened brush, identified to species, and counted so that the percentage of each species of the total population could be determined for each collection. These data for the comparison of species of an individual collection as well as from collection to collection are illustrated both graphically and by tables of percentage. The approximate number of shells in each collection was determined and is shown in table form.

The Hamilton interstadial silt was collected and prepared using the same methods described above for the lacustrine deposits, except that the sample dimensions were 1 X 12 X 24 unches instead of 2 X 12 X 12 inches.

Acknowledgements

To my adviser, Professor Aurèle La Rocque, I give my sincere appreciation for his help during field work, laboratory preparation and identification, and the writing of this report. The Reverend H. B. Herrington of Westbrook, Ontario, Canada, kindly checked my identifications of pelecypods and reclassified many of them more definitely. I thank my wife Elizabeth for typing the manuscript and for her constant encouragement over the duration of this study. Thanks are also due to our children for their forbearance during this period. I acknowledge gratefully the financial assistance provided by the National Science Foundation under Science Faculty Fellowship Grant no 68127. I am also grateful to Wittenberg University for funds provided by the Office of the Dean, and to the Department of Geology, Ohio State University, for the use of a vehicle for field work.

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PLEISTOCENE GEOLOGY OF SOUTHWESTERN OHIO AND SOUTHERN INDIANA

Regional Geology

The ice advances that covered southwestern Ohio and southeastern Indiana during the Pleistocene came from the northeast and were fed by ice flowing southwestward down the major Lake Erie Lobe. A possible exception would be the advance forming the Whitewater drift of Indiana which may have had a northwestern source (Gooding, 1963, p. 675). The ice advancing southwestward encountered the dissected Mississippian and Pennsylvanian sandstones of eastern Ohio and eventually the Silurian and Devonian limestones and dolomites of western Ohio and eastern Indiana. Because of preglacial differences in topography, the ice margin formed several sub-lobes, of which the Scioto and Miami Lobes concern the area of this study.

Three major stages of glaciation, Kansan (?), Illinoian, and Wisconsin, are known to have covered the region (Fig. 1). Ice fluctuations during the major stages have resulted in the recognition of several stadials. In Indiana Gooding (1963, 1966) recognizes as many as nine separate drifts (stades), two Kansan, two Illinoian, and five Wisconsin. The principal workers in southwestern Ohio and southeastern Indiana (Gooding *et al.*, Goldthwait, Forsyth, and Durrell) have recognized the various drifts on the basis of: mineralogical and petrological characteristics reflecting regional differences in bedrock; analysis of the succession of sediment types such as tills, loesses, and gravels; detailed study and recognition of differences in soil types developed on the various drifts, as well as the depths of weathering they exhibit; analysis of fossil mollusks, pollen, and other plant materials found in certain of the sediment types; morphological differences of moraines, terraces, and other glacial features; till-fabric orientation studies; and carbon-14 dating.

The oldest deposits are considered to be Kansan and consist of lake sediments, outwash and till. Durrell (1961, p. 55) reports these from the uplands southwest of Cincinnati, both in Ohio and Kentucky. These deposits have strongly weathered Yarmouth soils with depths of leaching from twelve to thirty feet, compared to the six to twelve feet characteristic of the Illinoian to the north. In adjacent southeastern Indiana, Gooding (1966) reports deeply weathered Kansan drift under Illinoian till from three localities. The recognition of a thin organic-rich zone within the Kwnsan till of one section indicates two significant pulsations of Kansan ice. These are named the Alpine Stade at the base, the Columbia Stade at the top, and are separated by the Garrison Creek Interstadial. The presence of bright red, non-calcareous, clayey, cherty, limestone-derived soil in the basal Alpine

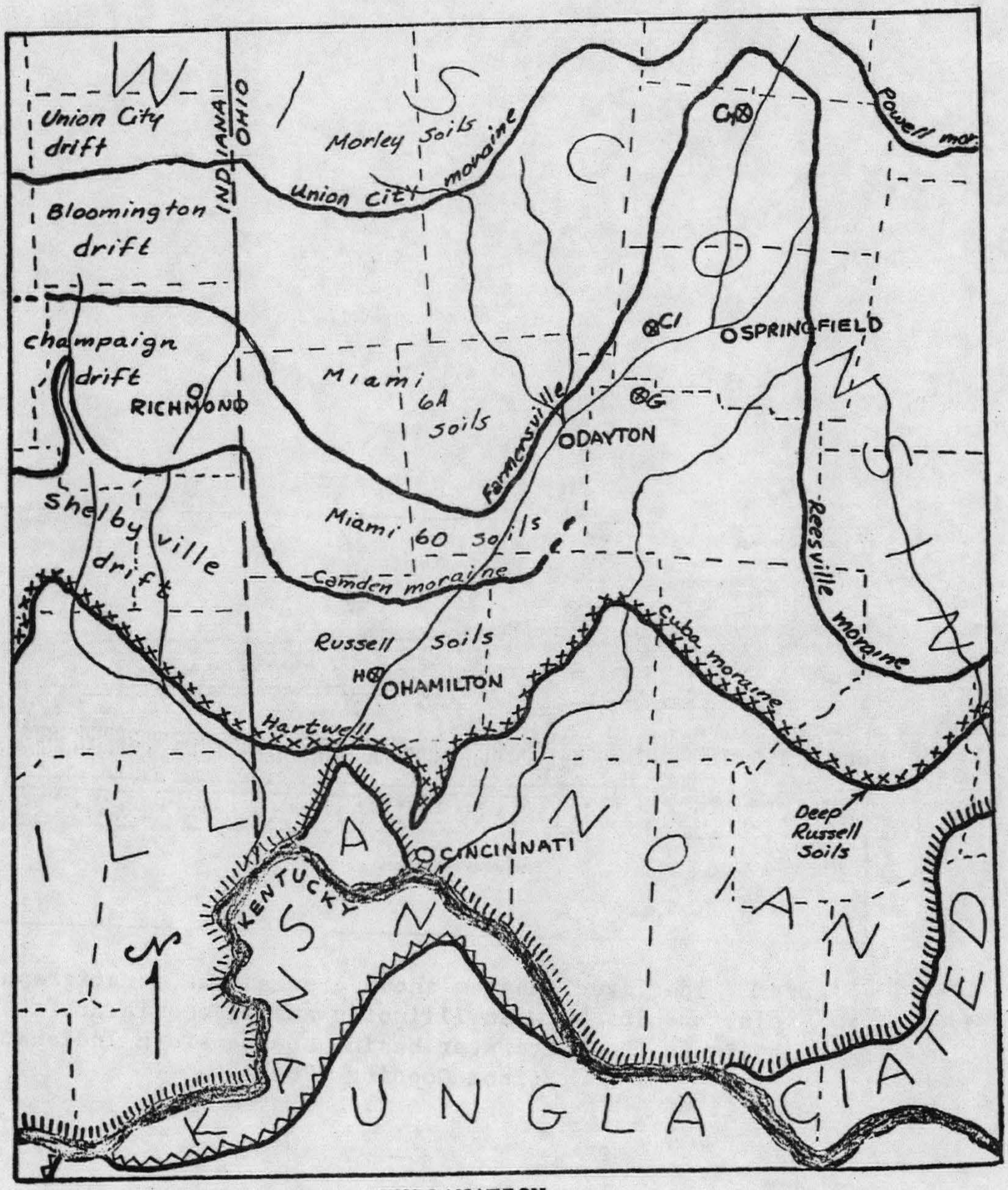
Stade, prompts Gooding to suggest that the Kansan (Alpine Stade) was the first glaciation to reach southeastern Indiana.

South of the Wisconsin drift boundary, Illinoian drift forms a continuous band across southwestern Ohio and southeastern Indiana. It consists of till and outwash covered by several feet of loess in Ohio and the southern part of the Indiana area. Sangamon soil development averages six to twelve feet, depending on the permeability of the underlying material. In Indiana Gooding (1963, p. 673) indicates that the loess cover decreases in thickness to the northwest around Richmond, where the Sangamon soil is of the humic-gley type. Humic-gley soils are developed in swamps and marshes and have organic-rich surface horizons and reduced gray and brown mottled subsoils. These soils have preserved pollen (Kapp and Gooding, 1964) that records the vegetational and climatic history of the region during the ice-free period of the Sangamon interval and the advance of the Whitewater ice. Calcareous organic silts containing mollusks and sparse coniferous pollen occur within the Illinoian drift and represent a short but significant interval of ice retreat (see Fig. 2). Gooding (1963) thus recognizes a lower Centerville Stade, an upper Richmond Stade, and an intervening Abington Interstade. Terraces related to Illinoian glaciation are known from southern Ohio (Kempton and Goldthwait, 1959; Jones, 1959) as well as for southern Indiana (Thornbury, 1950; Gooding, 1957).

A pre-classical or 'Early' Wisconsin glaciation for southwestern Ohio was suggested by Goldthwait as early as 1952. Considerable evidence exists for such a glaciation in Ohio and Indiana as well as from surrounding states and foreign localities.

In southeastern Indiana detailed work by Gooding and others (Gooding, 1957, 1961, 1963; Kapp and Gooding, 1964; and Gamble, 1958) indicates the presence of two different 'Early' Wisconsin tills lying on the Sangamon soil and buried by Shelbyville ('Late' Wisconsin) drift (Fig. 2). The western till (Whitewater drift) is characterized by red-brown till inclusions and is considered to have a northwestern source. It is older (I-477B, >41,000) and is overlain by a calcareous silt (New Paris interstadial) dated at >40,500 (L-4788) which in some sections yields mollusks. The southeastern till (Fayette drift) has no red-brown till inclusions and is known to have a northeastern source. It is stratigraphically above the New Paris silt (radiocarbon date 40,000, I-611) and is overlain by a calcareous silt (Connersville interstadial) dated at 20,000 ±500 (I-610). The latter also yields mollusks. No terraces are known to relate to these earliest Wisconsin drifts in the area.

In Ohio the 'Early' Wisconsin glaciation is represented by: outwash terraces along the Licking, Hocking, and Scioto Rivers that are intermediate in soil characteristics and elevations between those formed during the Illinoian and Wisconsin (Kempton and Goldthwait, 1959; Jones, 1959); a limited patch of till exhibiting unusually deep leaching (deep Russell soils), located along the Wisconsin drift margin in Highland County (Forsyth, 1957, 1965a; Forsyth and Bowman, 1963); and numerous paleosols buried beneath 'Late' Wisconsin drift (Forsyth, 1957). Most of these buried soils are developed on calcareous gravel under calcareous till, but in western Ohio near Sidney, the development is on a buried till (La Rocque and Forsyth, 1957; Forsyth and La Rocque, 1956). Gooding, Thorp, and Gamble (1959) and Gooding and Gamble (1960) questioned the interpretation of the soil-zones at the top of buried gravels as paleosols, as well as the interpretation of the paleosol on the lower till at Sidney, and its correlation with the gravel 'paleosols.' They argue that the gravel 'paleosols' are leached clay-enriched zones derived from the surface soil through joints in the overlying till; and that the buried soil at Sidney is truncated and if totally present would represent a soil-forming interval of greater length (and possibly older) than its proposed correlative separating the till over gravel. Goldthwait (1959) agreed with the clay-enriched hypothesis for some situations, but maintained that in others



EXPLANATION

⊗ Deposit Studied

Cn Champaign Deposit

Cl Clark Deposit

G Greene Deposit

H Hamilton Deposit

Kansan border

Illinoian border

Wisconsin border

Figure 1. Sketch map showing the area of this report and the regional Pleistocene geology.

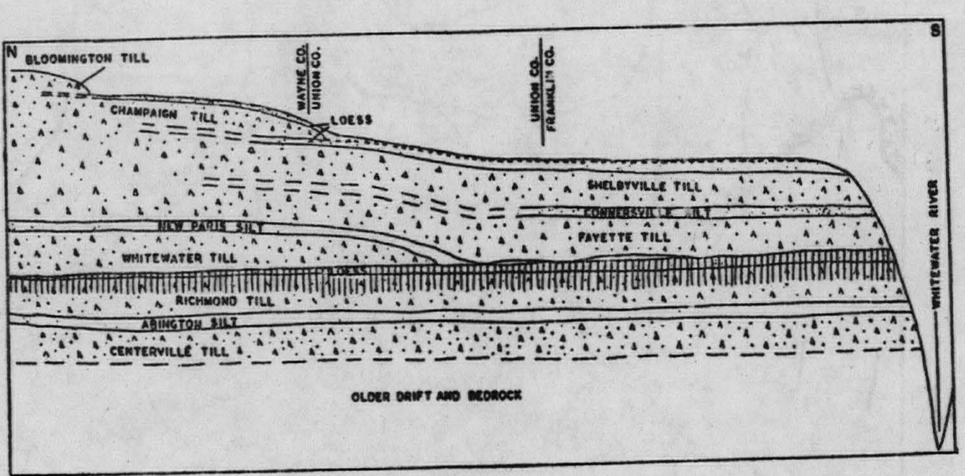


Figure 2. Idealized diagram showing areal and stratigraphic relationships between Illinoian and Wisconsin drift units in the Whitewater basin, southeastern Indiana. (from Gooding 1963)

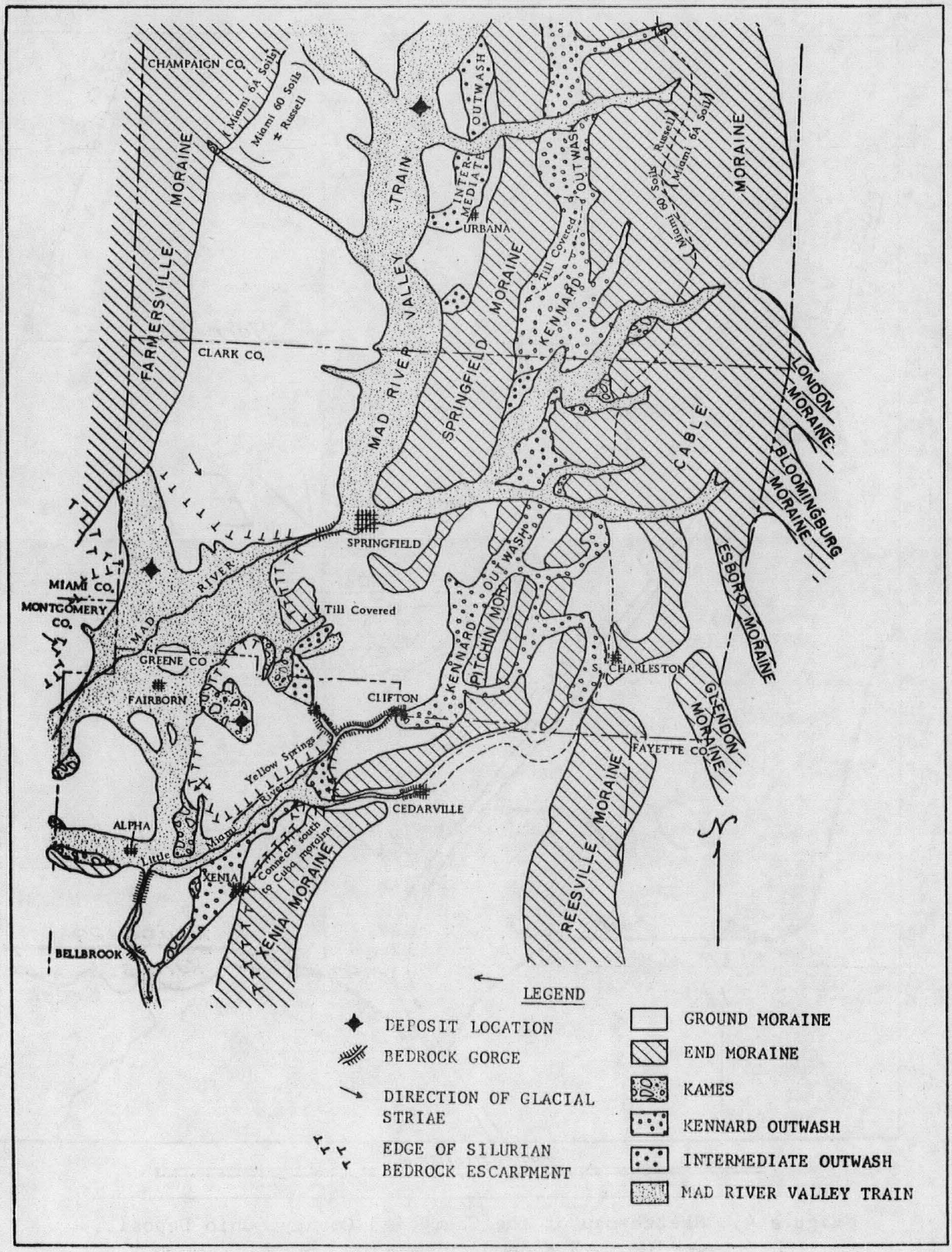


Figure 3. Map of the Pleistocene geology of the Springfield, Ohio area, and the location of deposits studied. (adapted from the Guidebook for the Thirty-fifth Annual Field Conference, Section of Geology, Ohio Academy of Science, 1960).

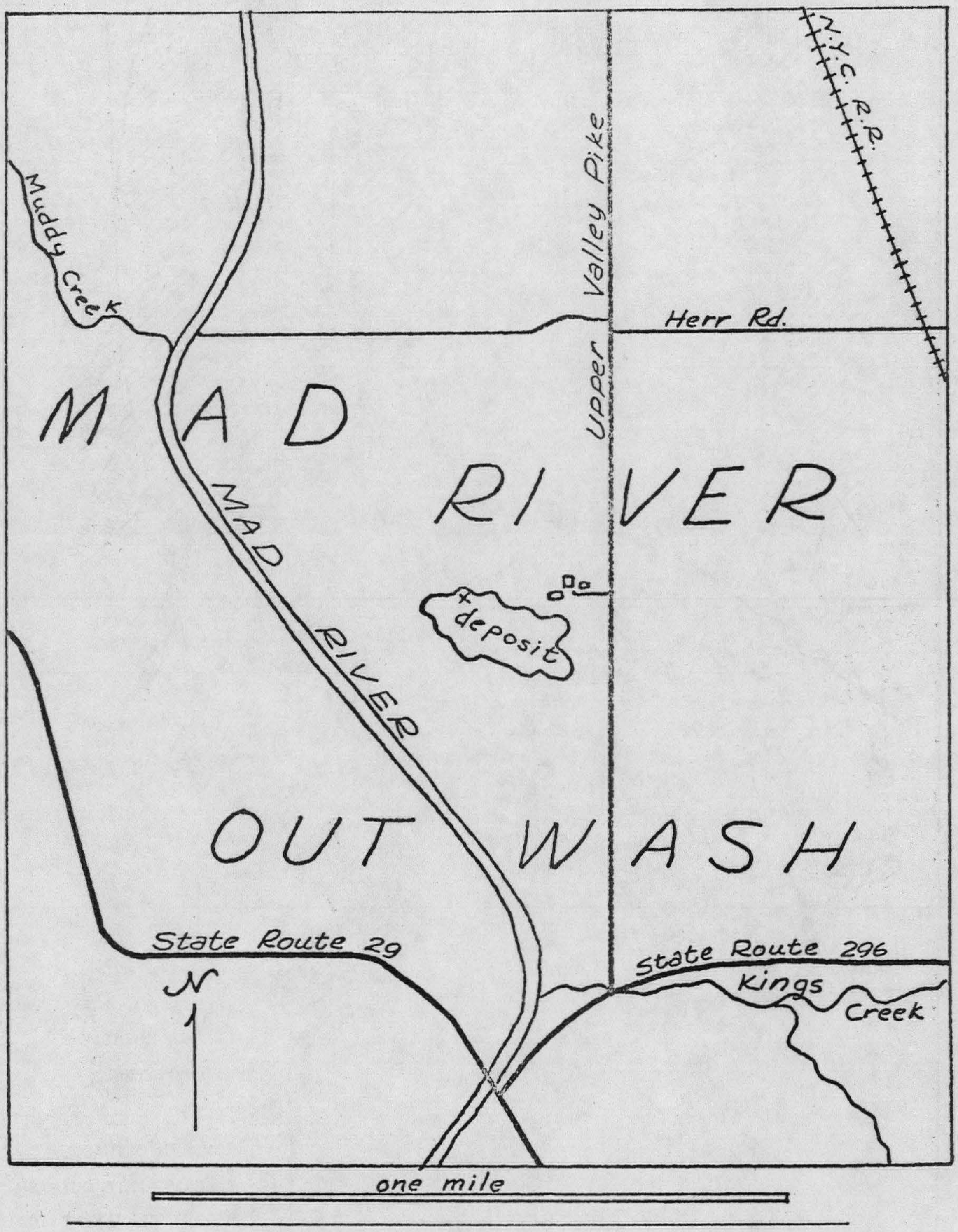


Figure 4. Sketch map of the Champaign County, Ohio Deposit.
X - Sampled section.

the overlying till is too thick, massive, and unweathered for such an interpretation. Forsyth (1956b) in a further study of buried soil at Sidney, indicates that the mineralogy and the poor development of soil horizons in the buried soil demonstrate a relatively short soil-forming interval. In addition, a small peat interval at the top of the soil yielded pollen of a non-glacial aspect and radiocarbon dates of from >37,000 (W-415) to >50,000 (GrN-4415). Considering these dates with the 22,000 ±1000 (W-414) date from the till above, Forsyth maintains that the buried soil represents a significant 'Mid' Wisconsin interstadial (Sidney Soil Interval) developed on an 'Early' Wisconsin till below. Both Forsyth (1965b, p. 595) and Goldthwait *et al*. (1965, p. 88) suggest a correlation of the 'Early' Wisconsin till of Sidney with that of Gooding's Fayette and/or Whitewater tills of Indiana.

The 'Late' Wisconsin glaciation in Ohio and Indiana is represented by the vast majority of glacial drift that covers the two states (see Fig. 1). Although there are differences in detail, the principal workers recognize three different drift sheets based primarily on differences in soils, thickness of loess cap, and constructional features such as moraines and terraces. Recognized in Ohio (Forsyth, 1965a) are from south to north: the 'shallow' Russell soils characterized by a thick loess cap and lying north of the Hartwell-Cuba moraine; the Miami 60 soils which have a thin silt cap and lie north of the Camden moraine; and the Miami 6A soils which have no silt cap and a slightly higher clay content, and lie north of the Farmersville-Reesville moraine. Traced westward into Indiana, Gooding (1963) recognizes the same drift sheets, but calls them (in the same order) Shelbyville, Champaign, and Bloomington drifts after Leverett and Taylor (1915). In Ohio a fourth, more northerly drift is recognized behind the Union City-Powell moraine. The soils here (the Morley and St. Clair) are more clay-rich, being derived by incorporating lake sediments from the north during a short recession and readvance of the ice. Gooding recognizes this same soil association on Union City drift westward into Indiana (Gooding oral communication).

Though similar Wisconsin drift sheets are recognized between Ohio and Indiana, the detailed geology and interpretations are different. In Ohio, except for the most northerly clay-rich till (Morley-St. Clair soils), no stratigraphic superposition of the three tills has been found. Based on the lack of superposed tills and radiocarbon dates Goldthwait (1958) and Forsyth (1961) depict the Wisconsin ice as entering Ohio more than 25,000 years ago, reaching its maximum extent 18,000 years ago, and receding to northwestern Ohio about 14,000 years ago. In Indiana, however, evidence for oscillations of the Wisconsin ice has been observed (Gooding, 1963) (Fig. 2). The southernmost Shelbyville drift, which is covered by a loess (Shelbyville loess), has been observed beneath the Champaign till a short distance back from its maximum extent. In two of these sections, sparse mollusks have been collected. The Champaign loess which covers the Champaign till, and may also be represented at the top of the Shelbyville loess where it covers the exposed Shelbyville drift, was not observed beneath the Bloomington till to the north. However, the greater clay content of the Bloomington till suggests a minor retreat and readvance, incorporating lacustrine material a short distance to the north.

Lacustrine deposits

General Statement

The location of the three Springfield area lacustrine deposits is shown on Fig. 3. This figure also provides a more detailed picture of the relation of the deposits to the local geology.

Champaign Deposit

The Champaign deposit (Figs. 3 and 4) represents one of several extinct lakes that developed in the sand and gravels of the Mad River valley train. The lake probably formed in a large kettle on what appears to be a pitted outwash plain. The present area of the extinct lake is barely noticeable, topographically, having been tiled and used today for both pasture and cropland. The deposit was located as an area of Carlisle muck and Warners loam, with the aid of Soil Conservation Service maps. The deposit is characterized by a black, mucky surface soil over peat, which grades downward into marl and sand at the base. The depth of the deposit is unknown, as it was deeper than the maximum length of the auger (15 feet). An excavation site was chosen near the north end of the deposit where a complete section could be measured.

Stratigraphic Section

Unit	Coll.	Description	Thickness (inches)
0	--	Muck, black, abundant plant matter, unfossiliferous, disturbed.	10
1	1	Peat and muck, reddish brown with limonite staining, visible plant fragments, unfossiliferous(?); collected the basal 3 in.	6
2	1-10	Marl, gray, fossiliferous, run through with plant-root channels; interface with unit below quite irregular, covering interval between collections 2-10 to 3-3 . . .	20
3	1-13	Sand, fine grained, clayey, intermixed with gray porous travertine; unit fossiliferous, with oxidized root channels.	26
Base		Outwash, water.	---
		Total	62

Clark Deposit

The Clark deposit is located (Figs. 3 and 5) on one of the tributaries of the Mad River valley train. Goldthwait (in Norris, 1952) maps the area (Fig. 3) as outwash, a designation for higher gravels and terraces. This higher terrace apparently represents a drainage-way to the Mad River when the ice stood over the later channel just to the west. Several other prominent boggy depressions occur in the area, but the one chosen has the only existing lake (Crystal Lake). The excavation was made at the north end of the Carlisle muck deposit, in order to get a complete section.

Stratigraphic Section

Unit	Coll.	Description	Thickness (inches)
1	-	Muck, disturbed, black, unfossiliferous.	10
2	-	Muck, grading downward into brown, mucky peat, unfossiliferous.	16
3	1-17	Marl, gray, fossiliferous; 3-1 transitional between units 2 and 3; 3-17 marly gravel. . . .	34
Base		Outwash, water.	---
		Total	60

Greene Deposit

Whereas both the Champaign and Clark deposits were formed (Figs. 3 and 6) on the Mad River valley train, the Greene deposit developed in a depression on kame and kame-moraine. Although all three must have originated in kettles, the Greene deposit may represent a longer accumulation than the other two. Its association with the scattered deposits of the problematical Camden to Springfield moraine would suggest that it was initiated before the ice receded westward to form the Mad River valley train. The deposit is considerably different from the other two in that it contains little marl and a thick section of mostly peat and some travertine.

Stratigraphic Section

Unit	Coll.	Description	Thickness (inches)
1	1-3	Muck, black, slightly disturbed at surface, fossiliferous; 1 -2t means transitional between units 1 and 2.	7
2	1-15	Muck, black, peaty, fossiliferous; irregular thin zones of travertine occur in interval 9-22 in. from top of unit (Coll. 2-5 to 2-11), zones at 9 in and 22 in. most pronounced.	30
3	1-5	Silt, highly calcareous (travertine?) and fossiliferous, clayey, peaty; calcareous content decreases toward interface with lower unit.	10
4	-	Clay, light gray, to medium gray with abundant root channels, unfossiliferous.	31
Base		Gravel. Total	78

The Hamilton Interstadial Deposit

The Hamilton section is one of several in southwestern Ohio that appears to have a succession of Illinoian and Wisconsin drift very similar to that which occurs in eastern Franklin and southern Fayette Counties of southeastern Indiana. Radiocarbon dates for the interstadial silt and the base of the overlying till of the Hamilton section are 18,750 ± 300 (W-738) and 19,000 ± 500 (W-738) for the Connersville Interstade in Indiana. The similarity in the sections and the radiocarbon dates demonstrate a reasonably good correlation between the two areas (Gooding, 1963, p. 678; Durrell, 1961, p 89; Forsyth, 1961, p. 590).

The stratigraphic section given below is limited to the interstadial silt unit that was collected systematically for its mollusk content. For a description of the entire Hamilton section, the reader is referred to that published by Durrell (1961, p. 89 and 90).

Unit	Coll.	Description	Thickness (inches)
1	1-4	Silt, with some pebbles, highly organic, containing mollusks, with a zone of wood fragments and moss remains at the top.	4
2	5-6	Silt, very sandy and iron stained, organic, contains mollusks.	2
3	7-12	Silt, very gravelly and sandy, organic, contains mollusks.	6
		Total	12

SYSTEMATIC PALEONTOLOGY

General Statement

This chapter summarizes data for each species identified in the three lacustrine and one interstadial deposits studied from the area of this investigation. The data include an abbreviated synonymy and diagnosis of shell morphology, as well as information on ecology, general distribution, and geologic distribution.

The information for this section was summarized largely from La Rocque (1963-1964, 1966, 1967, 1968, and in press) and from data collected by previous workers in Pleistocene non-marine Mollusca in the Department of Geology at Ohio State University. Other valuable references used include: Baker (1928), Pilsbry (1946, 1948), and Herrington (1962).

PHYLUM MOLLUSCA

CLASS PELECYPODA

Order Teleodesmacea

Family Sphaeriidae

Sphaerium lacustre (Müller) 1774

Tellina lacustris Müller 1774, Verm. Terr. et Fluv., p. 204.
Sphaerium lacustre La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 295.

TYPE LOCALITY. Europe, probably Denmark.

DIAGNOSIS. Shell small to medium size, walls thin, anterior end not so high as posterior; beaks somewhat anterior; striae moderately fine to fine, uneven; dorsal margin long and curved, ventral margin curved to slightly flattened; anterior end rounded, posterior end almost straight; lateral teeth slim but distinct, cardinal teeth weak. (Condensed from Herrington, 1962, p. 19, 20).

ECOLOGY. Most plentiful in small lakes and ponds, but also found in large lakes, rivers, and creeks. It appears to prefer a muddy bottom. (Herrington, 1962, p. 20).

DISTRIBUTION. General: Northwest Territories east to Nova Scotia, and south to California, Colorado, Iowa, Louisiana, Alabama, Georgia, and Florida. This study: Champaign and Clark deposits.

GEOLOGIC RANGE. Early Pliocene to present. Taylor and Hibbard (1955, p. 12) recorded this species from deposits of probably Illinoian age in Oklahoma. It is also a common species among late Pleistocene and living assemblages in Ohio. The form *ryckholti* was reported by Herrington (1962, p. 21) from fossil assemblages in Early and Middle Pliocene deposits of Kansas and Oklahoma.

Sphaerium rhomboideum (Say) 1822

Cyclas rhomboidea Say 1822, Acad. Nat. Sci. Philadelphia, Jour., v. 2, p. 380.
Sphaerium rhomboideum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 300.

TYPE LOCALITY. Lake Champlain.

DIAGNOSIS. Shell moderately large and inflated walls thin; beaks central and low; striae fine and regular; shell more or less rectangular in outline.

ECOLOGY. Herrington (1962) reports this species from eddies in creeks and rivers, ponds, and sheltered places in small lakes. It has a preference for muddy bottom with weeds and algae.

DISTRIBUTION. General: Ontario as far north as James Bay; northern United States including: Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, Michigan, Minnesota, Iowa, Montana, and Idaho (Herrington, 1962, p. 25). This study: Clark deposit.

GEOLOGIC RANGE. Pleistocene: Sangamon to present. La Rocque (1967, p. 302, 303) quotes various workers who report this species from marl of Sangamon and Wisconsin age, as well as living forms from Hemlock (Mackay) Lake, Ottawa, Ontario.

Sphaerium securis (Prime) 1851

Cyclas securis Prime 1851, Boston Soc. Nat. History Proc., v. 4, p. 160.
Sphaerium securis La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 290.

TYPE LOCALITY. Fresh Pond and Cambridge Meadows, Cambridge, Massachusetts.

DIAGNOSIS. Shell small, inflated, higher at posterior than at anterior end, walls light; beaks subcentral, of moderate height and somewhat swollen; striae fairly coarse to moderately fine, distinct, evenly spaced; dorsal margin nearly straight to slightly curved, ventral margin longer and curved up at anterior end, yielding a greater disparity between the height of

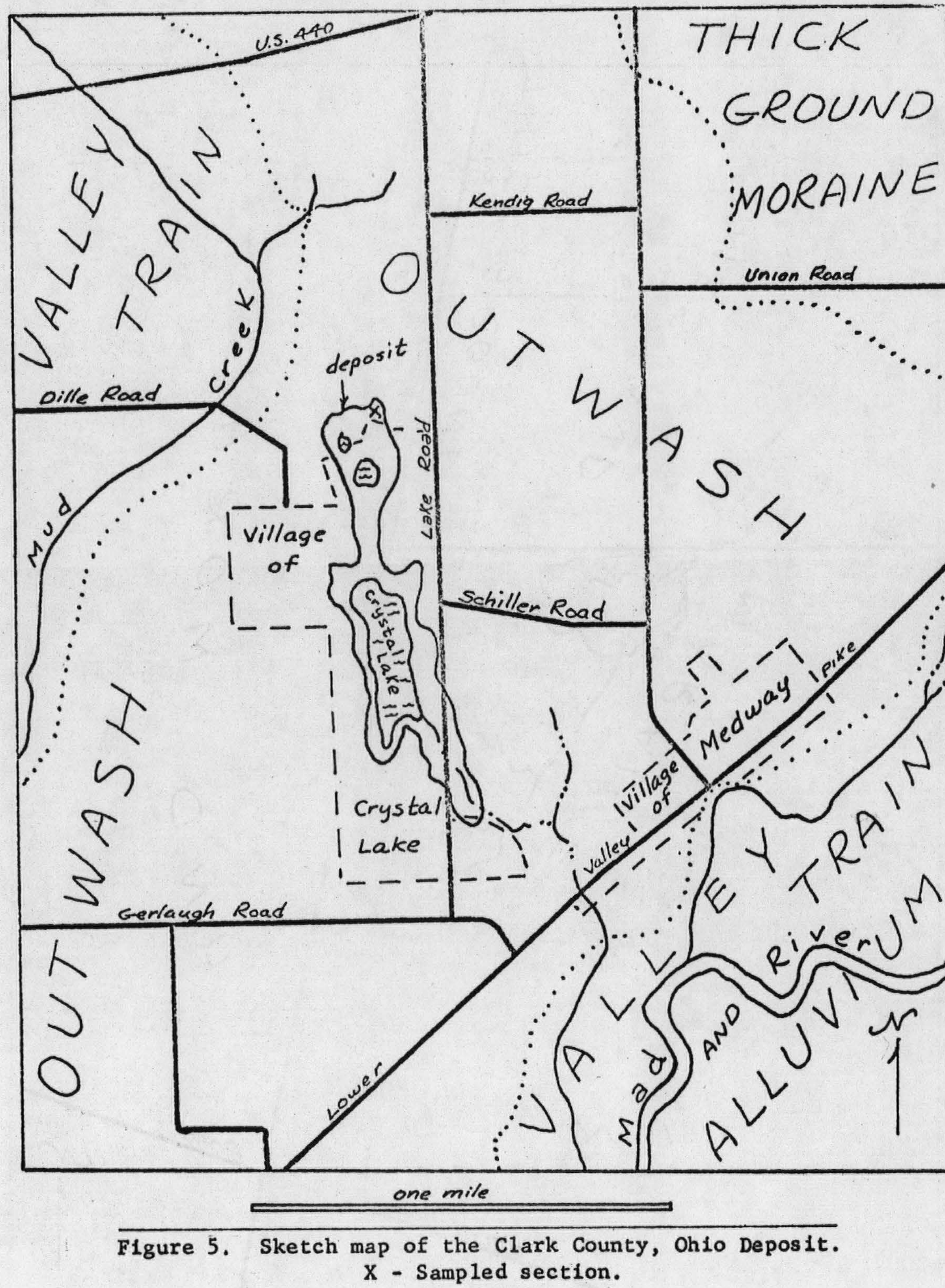


Figure 5. Sketch map of the Clark County, Ohio Deposit.
X - Sampled section.

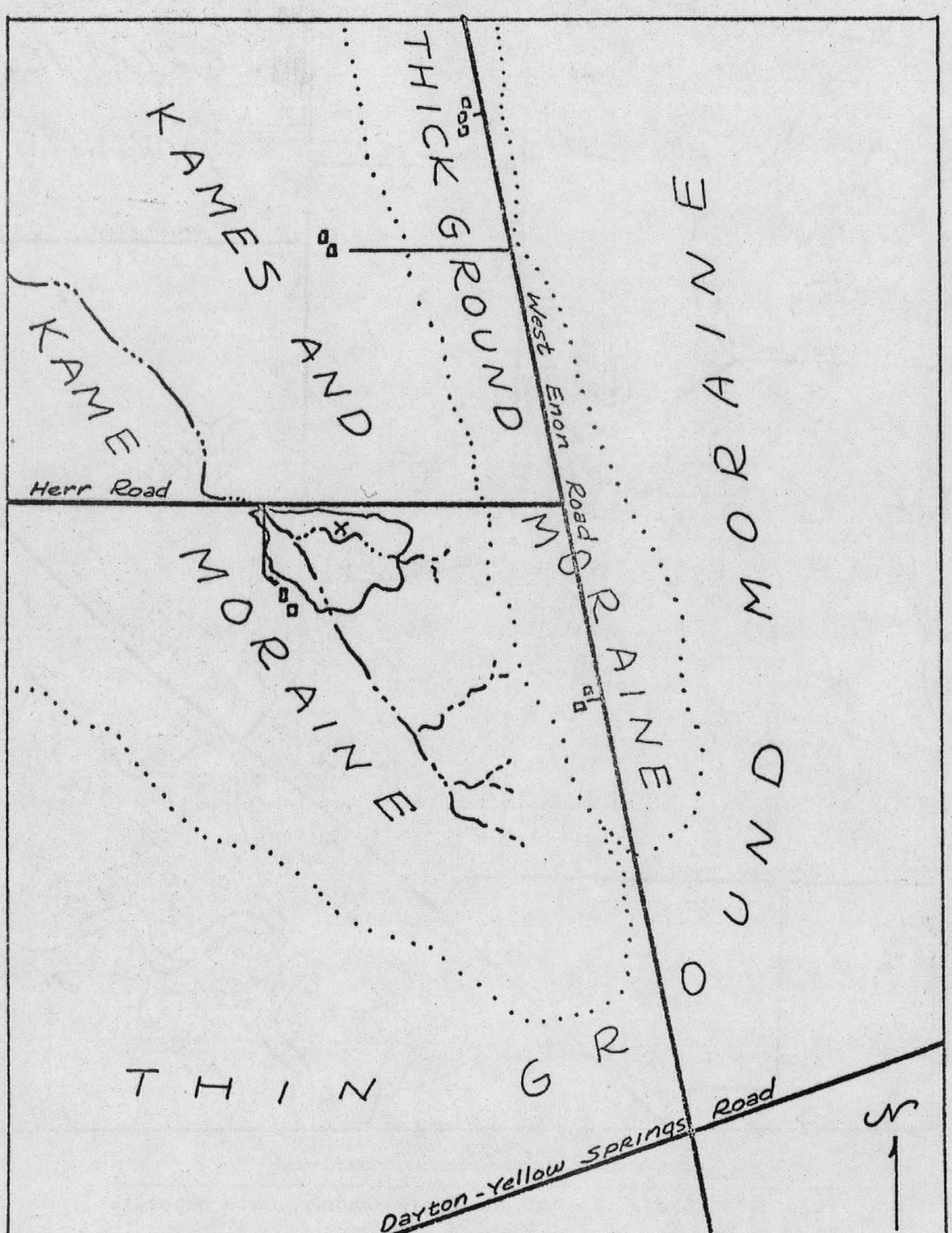


Figure 6. Sketch map of the Greene County, Ohio Deposit.
X - Sampled section.

the anterior and posterior ends than in any other species of *Sphaerium* (Herrington, 1962, p. 26).

ECOLOGY. Herrington (1962, p. 26) summarizes the ecology as 'Ponds, lakes, and rivers. Frequently found in fine sand.'

DISTRIBUTION. General: La Rocque (1967, p. 291) reports Newfoundland, Nova Scotia, New Brunswick, Quebec, Ontario (southern part only, north and east of Toronto), British Columbia, Maine, New York, Pennsylvania, Ohio, Michigan, Wisconsin, Minnesota, Iowa, Montana, and Washington, south to Florida, Alabama, Mississippi, Louisiana, and Texas. This study: Clark deposit.

GEOLOGIC RANGE. Pleistocene: Late Wisconsin to present. Herrington (1962, p. 26) gives no fossil record for this species, but La Rocque (1967, p. 291) notes several references to this species from both Canadian and U. S. localities. 'All of these records should probably be referred to the late Wisconsin.'

Sphaerium sulcatum (Lamarck) 1818

Cyclas sulcata Lamarck 1818, Animaux sans Vert., v. 5, p. 560.
Sphaerium sulcatum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 303.

TYPE LOCALITY. Lake George, New York.

DIAGNOSIS. Shell large, heavy, transversely oval, inflated, almost equipartite, rather solid; striae unevenly spaced; hinge long, lateral teeth short to medium in length, cardinal teeth nearer anterior end (Herrington, 1962, p. 29).

ECOLOGY. 'Small lakes, also eddies in rivers and creeks. It has a preference for soft sand with vegetation; never found in swamps or ponds.' (Herrington, 1962, p. 29).

DISTRIBUTION. General: Alberta east to the Gaspé Peninsula; south to Wyoming, Iowa, South Dakota, Minnesota, Illinois, Indiana, Ohio, Pennsylvania, and Virginia. It probably does not extend south of the area covered by glaciers (Herrington, 1962, p. 29). This study: Champaign and Clark deposits.

GEOLOGIC RANGE. Pliocene(?); Pleistocene: Nebraskan, Illinoian (?), Sangamon, Wisconsin. La Rocque (1967, p. 303) compiled numerous reports for this species from Nebraskan through Wisconsin deposits. A preglacial report was indicated by one author, but whether he meant Pliocene by 'preglacial' is not certain.

REMARKS. The specimens of *S. sulcatum* of this study were referred to *S. simile* by H. B. Herrington. Herrington (1962, p. 29) used the name *S. sulcatum*, but readopted *S. simile* (1965, p. 44) because of the confusion involving the interpretation of measurements in Say's original description. Say's type cannot be found. La Rocque (1967, p. 303) rejects *S. simile*, but gives an account of it for the record. *S. sulcatum* is used in this report.

Pisidium adamsi Prime 1851

Pisidium adamsi (Prime) Stimpson 1851, Moll. New England, p. 16.
Pisidium adamsi La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 316.

TYPE LOCALITY. Norway, Maine; Holly, Oakland County, Michigan.

DIAGNOSIS. Shell large and inflated; beaks broad and full; striae heavy and uniformly spaced; dorsal margin long and gently curved; anterior end steep with slightly curved slope, posterior end truncate and vertical; ventral margin long and gently curved; hinge long, curved and heavy; lateral teeth heavy, with heavy cusps; cardinal teeth central or on the anterior side of center. (Condensed from Herrington, 1962, p. 31).

ECOLOGY. 'Small lakes, ponds, rivers, and (rarely) creeks. It has a preference for muck and decaying vegetable matter.' (Herrington, 1962, p. 31).

DISTRIBUTION. General: New Brunswick, Quebec, Ontario, Saskatchewan; Eastern United States - New York south to Florida and west to Iowa and Missouri. This study: Champaign deposit.

GEOLOGIC RANGE. Pleistocene: late Wisconsin. Early workers found this species as fossils in Maine, Illinois, Michigan, and Ohio. In recent years other occurrences in marl deposits have been noted in Ohio (La Rocque, 1967, p. 316).

Pisidium casertanum (Poli) 1791

Cardium casertanum Poli 1791, Test. utr. Sicil., p. 65, pl. 16, fig. 1.
Pisidium casertanum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 342.

TYPE LOCALITY. Sicily.

DIAGNOSIS. Average shell rather long in outline and of moderate weight; beaks subcentral and not high; striae fine; dorsal and ventral margins parallel and gently curved; anterior end moderately long and rounded, posterior end truncate; hinge-plate moderately long and broad; lateral teeth distinct, not long, with rather sharp cusps; cardinal teeth near anterior cusps. (Condensed from Herrington, 1962, p. 35).

ECOLOGY. This species, the most common *Pisidium*, is adapted to a wide range of habitat. It is found in bog ponds, ponds, swamps that dry up for several months of the year, swamp-creeks, creeks with considerable current, rivers, and lakes, including the Great Lakes (Herrington, 1962, p. 34).

DISTRIBUTION. General: This species is known throughout Canada from Newfoundland to British Columbia, and over the United States, except for Hawaii, Kentucky, and North Dakota. This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Pliocene to present. Numerous records are known from the Wisconsin in the United States and Canada. Sangamon, Illinoian(?), Nebraskan, and Pliocene occurrences are also reported (La Rocque, 1967, p. 343).

Pisidium compressum Prime 1851

Pisidium compressum Prime 1851, Boston Soc. Nat. Hist. Proc., v. 4, p. 164.
Pisidium compressum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 329.

TYPE LOCALITY. Fresh Pond, near Cambridge, Massachusetts.

DIAGNOSIS. Shell of medium size, heavy, varying from short and high to moderately long; beaks prominent, quite far back, narrow and usually with ridges; striae medium to fine; dorsal margin short and round, ventral margin long (three times that of the dorsal); anterior and posterior ends rounded and sloping at different angles; hinge long, heavy, and curved; lateral teeth short and incorporated into the hinge-plate; cardinal teeth central. (Condensed from Herrington, 1962, p. 35).

ECOLOGY. Next to *P. casertanum*, this species is the most abundant in North America where it is found in creeks, rivers, and lakes. It has a preference for sandy bottoms with vegetation, and shallow water, but it has been collected from depths to twenty meters (Herrington, 1962, p. 35).

DISTRIBUTION. General: In North America from Northwest Territories, British Columbia, to Quebec and Prince Edward Island, southward to California, Nevada, Texas, Georgia, and Mexico. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Middle Pliocene to present. Several workers in the central Great Plains report this species from the Middle Pliocene to Wisconsin. Previous workers in Ohio have reported it from Wisconsin deposits (La Rocque, 1967, p. 331, 332).

Pisidium ferrugineum Prime 1851

Pisidium ferrugineum Prime 1851, Boston Soc. Nat. Hist. Proc., v. 4. p. 162.
Pisidium ferrugineum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 340.

TYPE LOCALITY. Cambridge, Massachusetts.

DIAGNOSIS. Shell small, inflated, walls thin; beaks subcentral, tubercular, plain, or even low and broad, usually not blending into shell readily; striae coarse to faint; dorsal margin rounded and of variable length, ventral margin rounded much as dorsal; anterior and posterior ends rounded with variable slope depending on length of the dorsal margin; hinge-plate narrow; lateral teeth short with pointed cusps; cardinal teeth straight or slightly curved and very small near anterior cusps. (Condensed from Herrington, 1962, p. 39).

ECOLOGY. '*P. ferrugineum* has a preference for cool climates. When found on sandy bottom the striae are prominent and the beaks more or less tubercular. Those specimens obtained from lakes that are filling up with marl or developing a mucky bottom are smoother, have a greater diameter, and the beaks do not have the tubercular appearance. The varieties are much more common than the typical form with its strange tubercular beaks. Found in lakes, creeks, and rivers.' (Herrington, 1962, p. 40).

DISTRIBUTION. General: Northwest Territories and British Columbia to Newfoundland and New Brunswick, south to California, Utah, Illinois, Indiana, Ohio, New York, and New Jersey. This study: Clark and Champaign deposits, Hamilton interstadial (?).

GEOLOGICAL RANGE. Pleistocene: Wisconsin to present (La Rocque, 1967, p. 340).

Pisidium milium Held 1836

Pisidium milium Held 1836, Isis, v. 29, p. ?
Pisidium milium La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 324.

TYPE LOCALITY. Unknown.

DIAGNOSIS. Shell small, long, walls thin, much inflated; beaks rather far back, swollen, and prominent; striae widely spaced and low; dorsal and ventral margins parallel, dorsal short and curved, ventral long and almost straight; posterior end truncate or rounded, anterior end long and steep-sloped; hinge-plate narrow and short; lateral teeth short with rather sharp cusps on top; cardinal teeth varying from subcentral to very near anterior cusps. (Condensed from Herrington, 1962, p. 44).

ECOLOGY. Mud or ooze bottom in creeks and rivers, but mostly in ponds and small lakes. Herrington (1962, p. 45) indicates it is a rather scarce species, occurring only in small numbers in a habitat.

DISTRIBUTION. General: Ontario, Manitoba Saskatchewan, and British Columbia; Maine, New York, Michigan, Minnesota, Montana, Oregon, Utah, Colorado, and the Aleutian Islands. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene: Wisconsin to present.

Pisidium nitidum Jenyns 1832

Pisidium nitidum Jenyns 1832, Cambridge Philos. Soc. Trans., v. 4, p. 304, pl. 20, figs. 7-8.
Pisidium nitidum La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 333.

TYPE LOCALITY. Great Britain.

DIAGNOSIS. Shell small, walls thin, rhomboid, of small diameter; beaks subcentral, broad, and not prominent; striae fine, uniform, distinct; dorsal margin long and evenly curved, ventral margin more gently curved; anterior end rounded, posterior end vertical or undercut; hinge long, moderately wide, somewhat curved; lateral teeth moderately long, distally straight or flaring, cusps prominent; cardinal teeth subcentral. (Condensed from Herrington, 1962, p. 45).

ECOLOGY. *P. nitidum* may be found in large ponds, bog ponds, lakes, creeks, and rivers. It is a fairly common clam and seems to prefer shallow water (Herrington, 1962, p. 46).

DISTRIBUTION. General: North America from Mexico to Hudson Bay, except for southeastern United States. Also Eurasia and North Africa. (La Rocque, 1967, p. 334). This study: Clark, Champaign, and Greene deposits, Hamilton interstadial (?).

GEOLOGIC RANGE. Early Pliocene to present. It has been recorded from Early Pliocene deposits as well as Nebraskan, Aftonian, Illinoian (?), Sangamon, and Wisconsin from the central Great Plains. Numerous Ohio workers have recorded it from Wisconsin deposits (La Rocque, 1967, p. 334).

REMARKS. Herrington (1962, p. 45) notes that two ecological forms are recognized in addition to the typical species. They are: *nitidum* form *pauperculum* and *P. nitidum* form *contortum*. Both of these forms are represented in this study and were identified by Herrington.

Pisidium variabile Prime 1851

Pisidium variabile Prime 1851, Boston Soc. Nat. Hist. Proc., v. 4, p. 163.
Pisidium variabile La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 338.

TYPE LOCALITY. Fresh Pond, near Cambridge, Massachusetts.

DIAGNOSIS. Shell heavy, varying from short and high to long; beaks prominent, quite far back, and broad; striae coarse to fine; dorsal margin short and round, anterior margin long (sometimes three times that of the dorsal); anterior end descends with steep straight slope, posterior end broadly rounded, vertical, or slightly undercut; hinge long, heavy, and steeply curved; lateral teeth short and incorporated into the hinge-plate; cardinal teeth central. (Condensed from Herrington, 1962, p. 50).

ECOLOGY. This species is found in creeks rivers, and lakes, usually in still water where soft sediments accumulate. (Herrington, 1962, p. 50).

DISTRIBUTION. GENERAL: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, Maine, and Prince Edward Island, south to California, Utah, Colorado, Illinois, Indiana, Ohio, and Virginia (Herrington, 1962, p. 50). This study: Clark, Champaign, and Greene deposits.

GEOLOGIC RANGE. Pleistocene to present. This species has been recorded from Yarmouth, Sangamon, and Wisconsin deposits (La Rocque, 1967, p. 339).

Pisidium ventricosum Prime 1851

Pisidium ventricosum Prime 1851, Boston Soc. Nat. Hist. Proc., v. 4, p. 68.
Pisidium obtusale form *ventricosum* Herrington 1962, Revis. Sphaeriidae N. America, p. 46.
Pisidium ventricosum Herrington 1965, Nautilus v. 79 (2), p. 44.

TYPE LOCALITY. Fresh Pond, Cambridge, Massachusetts.

FORMS. Herrington (1962, p. 46) recognized two forms of the European species *Pisidium obtusale: P. obtusale* form *ventricosum* and *P. obtusale* form *rotundatum*. Herrington (1965, p. 44) revised his nomenclature to *P. ventricosum* and *P. ventricosum* form *rotundatum*. Both forms are represented in this study and were identified by Herrington.

DIAGNOSIS. The following description is adapted from Herrington (1962, p. 46) for form *P. obtusale rotundatum*. Shell very small, walls thin, more or less oval in outline, inflated; striae moderate to fine, evenly spaced; beaks prominent and quite posterior; dorsal margin short and well rounded, ventral margin long and more openly rounded; posterior end well rounded and vertical, anterior end descending rather low, round; hinge short, far back but almost parallel with ventral margin; lateral teeth short with short high cusps; cardinal teeth close to anterior cusps. *P. obtusale ventricosum* is described as being similar to *P. o. rotundatum* with a heavier hinge-plate, and with the ventral margin pushed forward, making the posterior end undercut and not vertical.

ECOLOGY. The form *rotundatum* is found in sheltered spots in lakes, creeks, and rivers, but occurs most commonly in ponds and lagoons, sheltered among leaf litter. The form *ventricosum* is found mostly in lakes and large rivers (Herrington, 1962, p. 47).

DISTRIBUTION. General: For *P. obtusale ventricosum* La Rocque (1967, p. 349) gives: Northwest Territories, Manitoba, Colorado, Michigan, Ohio, New York, Maine, New Hampshire, and Massachusetts. For *P. obtusale rotundatum*, the following: Alaska, Yukon, Northwest Territories, east to Manitoba, Ontario, Quebec, and Maine, south to Colorado, Minnesota, Wisconsin, Indiana, Ohio, and New Jersey. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene to present. Numerous workers report this species from late Wisconsin deposits.

Pisidium walkeri Sterki 1895

Pisidium walkeri Sterki 1895, Nautilus, v. 9, p. 75.
Pisidium walkeri La Rocque 1967, Pleist. Moll. Ohio, pt. 2, p. 343.

TYPE LOCALITY. Kent County, Michigan.

DIAGNOSIS. Shell of medium size, long, moderate diameter, thin walls; beaks far back, prominent, narrow; striae medium to somewhat heavy, uniformly spaced; dorsal margin tilted back, short, curved, ventral margin long and little curved; anterior end a long slightly curved slope, posterior end vertical; hinge short, far back, tilted; lateral teeth long with moderately sharp cusps; cardinal teeth subcentral. The form *mainense* is smaller with finer striae, the anterior slope more rounded and beginning closer to the beaks. The shell is shorter and appears higher in outline. (Condensed from Herrington, 1962, p. 51).

ECOLOGY. This species is found in creeks, rivers, and small lakes, where it is usually not abundant in any one place. *P. walkeri* form *mainense* is found in bodies of water having a soft bottom (Herrington, 1962, p. 51).

DISTRIBUTION. General: Northwest Territories to Ontario, southward to New York, eastward to Arizona, Montana, South Dakota, Missouri Iowa, Michigan, Pennsylvania, and West Virginia. The form *mainense* is reported from Alberta, Saskatchewan, and the southern parts of Ontario; Maine, Massachusetts Rhode Island, New York, Ohio, Michigan, and Illinois (Herrington, 1962, p. 51). This study: Clark deposit.

GEOLOGIC RANGE. Pleistocene to present. Illinoian, Sangamon, and Wisconsin occurrences have been reported (La Rocque, 1967, p. 345).

REMARKS. One specimen of the form *mainense* was identified by Herrington from the shells of this study.

CLASS GASTROPODA

Order Ctenobranchiata

Family Valvatidae

Valvata sincera Say 1824

Valvata sincera Say 1824, Rept. Long's Exped., v. 2, p. 264, pl. 15, fig. 11.
Valvata sincera La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 363.

TYPE LOCALITY. 'Northwest Territory.' (Say).

DIAGNOSIS. Shell subglobose-conic, rather solid; whorls 4, evenly rounded and increasing in diameter; striae fine and regular; sutures well impressed; aperture circular; umbilicus round, deep, exhibiting the volutions almost to the apex. (Condensed from Baker, 1928, p. 23).

ECOLOGY. Generally regarded as a lake species, it has been found in deep water in Lake Michigan and Lake Superior (Baker, 1928, p. 23).

DISTRIBUTION. General: This species has been found in Newfoundland, Quebec, Maine, west to western Ontario and Manitoba; south to Wisconsin, Michigan, and northern New York. This study: Clark and Champaign deposits, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Wisconsin to present. This species has been found in many late Pleistocene deposits.

Valvata tricarinata (Say) 1817

Cyclostoma tricarinata Say 1817, Jour. Acad. Nat. Sci. Phila., v. 1, p. 13.
Valvata tricarinata La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 367.

TYPE LOCALITY. Delaware River.

DIAGNOSIS. Shell turbinate, thin, translucent, shining; whorls about 4, rapidly enlarging, flattened between the carinae, sloping upward from the carina to the suture on the upper surface; spire elevated but depressed at the apex; coarse growth lines more or less equally spaced; sutures distinct and well impressed; body whorl large with three sharp carinae, one each on the shoulder, periphery, and the base, which encircles the round, deep, funnel-shaped umbilicus; aperture circular, modified somewhat by the carinae. (Condensed from Baker, 1928, p. 11-12).

ECOLOGY. Baker (1928, p. 14) reports that this species has been found on mud, clay, sand, gravel, and bare-rock bottom, with or without vegetation in both streams and lakes. Water depth from shallow-water to more than 9 meters.

DISTRIBUTION. General: Great Slave Lake and the Mackenzie River south and east to New England and Virginia. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene: Nebraskan to present. Taylor (1960, p. 32) reports this species from deposits of Nebraskan and Wisconsin age. It is a common fossil in Wisconsin deposits of Ohio and the rest of the Midwest, as well as very abundant in living assemblages.

Family Amnicolidae

Amnicola limosa (Say) 1817

Paludina limosa Say 1817, Jour. Acad. Nat. Sci. Phila., v. 1, p. 125.
Amnicola limosa La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 384.

TYPE LOCALITY. Delaware and Schuylkill Rivers, Pennsylvania.

DIAGNOSIS. Broadly conic in shape, approximately 4.5 mm. high, 3 mm. wide, 4½ whorls; apex blunt; later whorls round and somewhat shouldered, increasing gradually in size; body whorl round; aperture subround, mostly basal; umbilicus deeply perforate. (Condensed from Berry, 1943, p. 23).

ECOLOGY. Widely distributed, occurring in creeks, rivers, and fresh- and brackish-water lakes. It is generally found in thick beds of *Chara*, *Potamogeton*, *Vallisneria*, and *Elodea*. These plants are not used for food, but they harbor rich colonies of diatoms on which the snail feeds. (Berry, 1943, p. 26).

DISTRIBUTION. General: New England and New Jersey west to Utah, Manitoba, south to Texas. This study: Clark deposit, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (La Rocque, 1968, p. 384).

Amnicola lustrica Pilsbry 1890

Amnicola lustrica Pilsbry 1890, Nautilus, v. 4, p. 53.
Amnicola lustrica La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 388.

TYPE LOCALITY. Not specifically given. Pilsbry gave New York to Illinois and Minnesota as its distribution.

DIAGNOSIS. Shell small, conic, about 4 mm. high, 5 whorls increasing gradually in size; apex elevated, acute, sutures deeply impressed, whorls shouldered and rounded; aperture ovate, umbilicus narrow and perforate. (Condensed from Berry, 1943, p. 30).

ECOLOGY. It is often associated with *A. limosa* and generally inhabits the same type of environment. It occurs on stones in rivers and lakes and often on growths of *Vallisneria*, *Potamogeton*, and *Chara* (Berry, 1943, p. 32).

DISTRIBUTION. General: New York to Minnesota and southern Ontario. Authentically reported from Indiana, Illinois, New York, Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, and southern Ontario. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Late Pleistocene to present (La Rocque, 1968, p. 388).

ORDER PULMONATA

Family Lymnaeidae

Lymnaea stagnalis jugularis Say 1817

Lymnaea jugularis Say 1817, Art. Conchology, Nich. Encycl., v. 1, no pagination.
Lymnaea stagnalis jugularis La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 435.

TYPE LOCALITY. Not stated specifically by Say. Synonyms for the species designated as 'Lake Superior' and 'fresh waters of America.' (Baker, 1928 p. 198).

DIAGNOSIS. Shell large, elongate and fragile; growth lines rather coarse, crossed by distinct spiral lines; nuclear whorls 1¼, smooth and shining; whorls 7, early ones not rapidly increasing whereas body whorl is more rapidly expanding; spire whorls flat-sided and body whorl more rounded; spire long, acutely pointed, usually more than one-half the shell length, sutures distinct; aperture ovate; outer lip thin and acute, parietal wall with a thin callus wholly or partially covering the umbilicus. (Condensed from Baker, 1928, p. 198, 199).

ECOLOGY. Usually found in more or less stagnant parts of ponds or lakes and rivers around vegetation. (Baker 1928, p. 202).

DISTRIBUTION. General: a circumboreal species, it is distributed in North America from the 37th (Colorado) and 41st (Illinois) parallels of north latitude to the Arctic Ocean. This study: Champaign and Clark deposits.

GEOLOGIC RANGE. Pleistocene: Kansan(?), Illinoian to present (La Rocque, 1968, p. 435).

Acella haldemani ('Deshayes' Binney) 1867

Lymnaea gracilis Jay 1839 (non Ziethen, 1830), Cat., Ed. 3, p. 112, pl. i, figs. 10, 11; Binney, 1865, *Op. cit.*, p. 69, fig. 114.
Acella haldemani La Rocque, 1968, Pleist. Moll, Ohio, pt. 3, p. 455.

TYPE LOCALITY. Lake Champlain.

DIAGNOSIS. Shell very slender, thin and fragile; growth lines fine, no spiral sculpture; whorls 5½, very oblique and flat-sided; spire very slender, acute, and much longer than the aperture; sutures much impressed; aperture long, narrow, and twisted to the left at its junction with the body whorl; inner lip raised; axis gyrate. (Condensed from Baker, 1928, p. 267).

ECOLOGY. '*Haldemani* is an inhabitant of larger lakes, in more or less sheltered bays, always a protected habitat, in water from 0.3 to over 1 m. deep.' (Baker, 1928, p. 270).

DISTRIBUTION. General: Vermont and eastern Ontario, west to northern Minnesota, south to northern Illinois and Ohio. This study: Champaign and Clark deposits.

GEOLOGIC RANGE. Pleistocene: late Wisconsin to present (La Rocque, 1968, p. 456).

Fossaria obrussa decampi (Streng) 1906

Limnaea desidiosa var. *decampi* Streng 1906, Nautilus v. 9, p. 123.
Fossaria obrussa decampi La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 476.

TYPE LOCALITY. Brook's Lake, Newaygo County, Michigan.

DIAGNOSIS. Shell small, oblong, somewhat inflated, subconic, rather solid; whorls 5, spire whorls convex, distinctly shouldered near the suture, body whorl much flattened in the middle; spire short, broadly conic, turreted, about as long as the aperture, sutures deeply impressed; aperture long and narrow, somewhat elliptical, forming a prominent shoulder above and rounded below. (Condensed from Baker, 1928, p. 300).

ECOLOGY. Baker (1928, p. 300) states that the ecology of *F. obrussa decampi* is probably the same as *F. obrussa* which lives on the margins of small bodies of wwter on a substrate of mud flats and debris.

DISTRIBUTION. General: Maine west to Wisconsin; northern Michigan south to northern Illinois. This study: Clark, Champaign, and Greene deposits.

GEOLOGIC RANGE. Pleistocene: Wisconsin to present. This species has been recorded from deposits of Wisconsin age in the U.S. and Canada and from living assemblages in Manitoba, Minnesota, and Wisconsin.

REMARKS. The species of *Fossaria* in the four lacustrine deposits exhibit considerable variation in shell morphology. Close examination of the specimens showed definite gradations toward other species. The specimens of the Champaign deposit displayed tendencies toward *F. obrussa*, *F. parva*, and *F. galbana*, whereas those of the Clark deposit approached *F. galbana* and *F. obrussa* in some of the specimens. The Greene deposit showed large quantities of stunted forms which resembled *F. parva*. Because the majority of the specimens fitted the characteristics of *F. obrussa decampi*, it was decided to place them all in this group.

Fossaria parva (Lea) 1841

Lymnaea parva Lea 1841, Proc. Amer. Phil. Soc., v. 2, p. 33.
Fossaria parva La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 477.

TYPE LOCALITY. Cincinnati, Ohio.

DIAGNOSIS. Shell small, solid, turreted; growth lines close set and well marked, spiral lines very fine or absent; whorls 5 - 5½, very convex and regularly increasing in size; spire elevated into an acute pyramid generally longer than the aperture; sutures deeply impressed; aperture roundly elliptical with outer lip thin and inner lip broadly reflected over the umbilicus; parietal callus well marked and thick; umbilical chink well marked, open, and with a straight axis (Baker, 1928, p. 285).

ECOLOGY. This species inhabits wet, marshy places, generally out of water, on sticks, stones, or muddy flats. *Parva* is more prone to leave the water than any other species of the family (Baker, 1928, p. 287).

DISTRIBUTION. General: Connecticut west to Idaho, James Bay and Montana south to Maryland, Kentucky, Oklahoma, southern New Mexico and Arizona. This study: Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Wisconsin to present. (La Rocque, 1968, p. 478).

REMARKS. A few of these specimens possessed limited *F. obrussa decampi* characteristics similar to those of the Greene deposit. Because the majority of the specimens were *F. parva* it was decided to group them all in that species.

Family Planorbidae

Gyraulus parvus (Say) 1817

Planorbis parvus, Say 1817, Nicholson's Encycl., ed. 1, v. 2, pl. 1, fig. 5.
Gyraulus parvus La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 491.

TYPE LOCALITY. Delaware River, near Philadelphia, Pennsylvania.

DIAGNOSIS. Shell ultra-dextral, depressed, with rounded periphery; growth lines oblique and fine; whorls 3½, rapidly enlarging, rounded below the periphery and somewhat flattened above on the body whorl and all the spire whorls; spire flat, the first two whorls sunken below the body whorl; sutures deeply impressed; base slightly concave, umbilical region wide and shallow; aperture long-ovate, nearly in the same plane as the body whorl. (Condensed from Baker, 1928, p. 375).

ECOLOGY. Usually in quiet bodies of water, often of small size, on mud, sandy mud, sand, gravel, or boulder bottoms; on logs and vegetation in shallow water about a foot to four feet in depth. It appears to be most partial to a habitat of rather thick vegetation (Baker, 1928, p. 376, 378).

DISTRIBUTION. General: Eastern North America east of the Rocky Mountains from Florida northward to Alaska and northern Canada. This study: Clark, Champaign, and Greene deposits, Hamilton interstadial.

GEOLOGIC RANGE. Middle Pliocene to present. It is a common species in Pleistocene deposits and has been recorded for the Nebraskan, Aftonian, Sangamon, and Wisconsin. (Hibbard and Taylor, 1960, p. 100).

REMARKS. Roy (1964, p. 28) noted that some shells of this species in northeastern Wisconsin had an angulated body whorl similar to that of *G. altissimus*. It was demonstrated that a complete gradation existed between *parvus* and *altissimus* characteristics, and that these represented only a genetic variation within one species, *G. parvus*. A similar situation was noted for the specimens of *G. parvus* in this investigation and a similar conclusion was reached.

Gyraulus deflectus (Say) 1824

Planorbis deflectus Say 1824, Long's Exped., v. 2, p. 261, pl. xv, fig. 8.
Gyraulus deflectus La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 485.

TYPE LOCALITY. Northwest Territory.

DIAGNOSIS. Shell dextral, depressed, orbicular, with a more or less distinct keel at the periphery; growth lines fine, crossed by more or less distinct spiral lines; whorls 4½, rapidly enlarging; spire flat with all whorls but the apical in the same plane; sutures impressed; base slightly concave, flattened, and showing all volutions; aperture suboval and more or less deflected downward. (Condensed from Baker, 1928, p. 370).

ECOLOGY. A species of quiet bodies of water. Taken from reasonably shallow water (up to approximately 18 feet) from substrates of sand and mud (Baker, 1928, p. 370, 371).

DISTRIBUTION. General: Massachusetts west to Nebraksa, northward to Great Slave Lake, southward to Maryland. This study: Champaign and Clark deposits.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present. Baker (1920, p. 387) records this species for Yarmouth, Sangamon, and 'Wabash' (Wisconsin) deposits. A number of recent workers report it from the Wisconsin of Ohio.

REMARKS. This species is present in only very small numbers in the Clark and Champaign deposits. Those present are generally immature and difficult to distinguish from *G. parvus*. It was possible to separate them, however, because of their greater thickness and spiral sculpture.

Armiger crista (Linnaeus) 1758

Nautilus crista Linnaeus 1758, Syst. Nat., ed. 10, p. 709.
Armiger crista La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 496.

TYPE LOCALITY. Europe.

DIAGNOSIS. Shell very small, ultradextral, depressed, fragile; growth lines rather coarse and crossed by very fine spiral striae; whorls 2½, rapidly increasing in diameter, flatly rounded below, costate on the periphery where the costae project conspicuously; costae reduced to low ridges on the upper and lower surfaces; spire flat; umbilicus open to apex; aperture ovate. (Condensed from Baker, 1928, p. 285).

ECOLOGY. This species inhabits small lakes with shallow, quiet water, on muddy or silty bottoms with abundant vegetation.

DISTRIBUTION. General: Europe; Asia; North America, from Maine west to Alberta, south to California, central Utah, Illinois, Indiana, and Ohio. As a Pleistocene fossil it is known as far south as Texas. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Middle Pleistocene to present (La Rocque, 1968, p. 498).

Helisoma anceps striatum
(F. C. Baker) 1902

Planorbis bicarinatus striatus Baker 1902, Nautilus, v. 15, p. 120.
Helisoma anceps striatum La Rocque, 1968, Pleist. Moll. Ohio, pt. 3, p. 500.

TYPE LOCALITY. Coldspring Park, Milwaukee Wisconsin; Pleistocene.

DIAGNOSIS. Shell small, 3½ whorls, dorsal and ventral carinae distinct, cordlike, elevated; dorsal carina on center of upper side of body whorl; body whorl round; umbilicus small, deepl heavy spiral striae which become ridge-like in some specimens; aperture higher than wide. (Condensed from Baker, 1928, p. 328).

DISTRIBUTION. General: Pleistocene deposits from Wisconsin, Illinois and Indiana northeast to Quebec. Living today in small deep lakes in Wisconsin and Michigan. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present. This variety is known from numerous late Wisconsin deposits in Ohio. Baker (1920, p. 387) gives Yarmouth and 'Wabash' (Wisconsin).

Helisoma campanulatum (Say) 1821

Planorbis campanulatus Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 166.
Helisoma campanulatum La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 504.

TYPE LOCALITY. Cayuga Lake, New York.

DIAGNOSIS. Shell ultra-sinistral, discoidal, more or less rounded; whorls 4½, rounded below and subcarinate above; spire flat; sutures deeply impressed; base of shell shows 2½ volutions within a deep umbilicus; aperture lunate. (Condensed from Baker, 1928, p. 346).

ECOLOGY. Characteristic of lakes, in shallow water, on a rock, sand, or mud bottom with or without vegetation. It is also found in quiet parts of rivers and streams.

DISTRIBUTION. General: Vermont west to North Dakota, south to Ohio and Illinois, and north to the Mackenzie drainage. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene: Late Wisconsin to present. This species has been recorded frequently from late Wisconsin deposits in Ohio and also for Indiana and Illinois.

Promenetus exacuous (Say) 1821

Planorbis exacuous Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 168.
Promenetus exacuous La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 510.

TYPE LOCALITY. Lake Champlain, New York, Vermont, and Quebec.

DIAGNOSIS. Shell ultra-dextral, very much depressed, with an acute periphery; whorls 4, increasing rapidly in diameter; spire flat; sutures impressed; umbilicus narrow and deep; aperture ovate. (Condensed from Baker, 1928, p. 361).

ECOLOGY. In quiet, shallow water with more or less marshy places; soft mud bottom.

DISTRIBUTION. General: Northern U. S. east of the Rocky Mountains; Canada south to New Mexico. This study: Clark and Champaign deposits.

GEOLOGIC RANGE. Pleistocene: Sangamon to present. It is common in deposits of Wisconsin age (Hibbard and Taylor, 1960, p. 107).

Family Ancylidae

Ferrissia parallela (Haldeman) 1821

Ancylus parallelus Haldeman 1841, Monogr. pt. 2, p. 3.
Ferrissia parallela La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 521.

TYPE LOCALITY. New England.

DIAGNOSIS. Shell narrow and elongate, side margins nearly straight, widening more or less anteriorly, ends rounded; anterior slope long and convex, posterior shorter and straight or concave; apex sub-acute, slightly anterior of the shell. (Condensed from Baker, 1928, p. 396).

ECOLOGY. It inhabits quiet water one to six feet deep, usually ponds or lakes. It is found on plants, such as *Vallisneria* and *Potamogeton*.

DISTRIBUTION. General: Nova Scotia and New England west to Minnesota, Manitoba south to Rhode Island, central New York, northern Ohio, and Indiana. This study: Greene deposit.

GEOLOGIC RANGE. Pliocene to present. It

is commonly found in deposits of Wisconsin age (Taylor, 1960, p. 61).

Family Physidae

Physa gyrina Say 1821

Physa gyrina Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 171.
Physa gyrina La Rocque 1968, Pleist. Moll. Ohio, pt. 3, p. 541.

TYPE LOCALITY. Bowyer Creek, near Council Bluffs, Iowa.

DIAGNOSIS. Shell large, elongate or subcylindrical, fairly thick; growth lines coarse; whorls 5-6, the last rather large, compressed or slightly inflated; spire somewhat long, acute, whorls well rounded; aperture 5/10 to 7/10 the length of the shell. (Condensed from Baker, 1928, p. 450).

ECOLOGY. This species is characteristic of shallow, slow-moving and stagnant bodies of water.

DISTRIBUTION. General: United States east of the Mississippi River; Eastern Canada (Ontario and Quebec), northward to the Arctic regions. This study: Clark and Greene deposits.

GEOLOGIC RANGE. Pleistocene: Nebraskan to present (Taylor, 1960, p. 32, 39). It is a common species of late Pleistocene as well as living assemblages.

Family Carychiidae

Carychium exiguum (Say) 1822

Pupa exigua Swy 1822, Jour. Acad. Nat. Sci. Phila., v. 2, p. 375.
Carychium exiguum La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. 'Harrigate, Philadelphia.' (Pilsbry, 1948, p. 1052).

DIAGNOSIS. Shell rimate, oblong, whitish, somewhat pellucid; spire convexly conic, summit obtuse; whorls 4½, convex, last whorls weakly striate; aperture over one third total length, ovate; outer lip expanded and thickened in its lower two thirds, upper part narrower and strongly arcuate; two teeth may be present, one a low columellar and the other a short basal. (Modified from Pilsbry, 1948, p. 1052).

ECOLOGY. *C. exiguum* lives in crevices of rotten logs or on dead leaves in moist places and is sometimes found in very wet places (Pilsbry, 1948, p. 1054).

DISTRIBUTION. General: Newfoundland to Colorado, south to Mobile Bay, Alabama, and near Deming, southwestern New Mexico. This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Pleistocene: Aftonian to present. Baker (1920, p. 388) recorded this species from the Aftonian, Yarmouth, Sangamon, and 'Wabash' (Wisconsin) beds. It is a common species of late Wisconsin deposits of Ohio.

Family Polygyridae

Stenotrema leaii (Binney) 1842

Helix leaii 'Ward, Ms.' A. Binney 1842, Boston Jour. Nat. Hist., v. 3, p 362.
Stenotrema leaii La Rocque, in press, Pleist. Moll. Ohio, pt. 4,

TYPE LOCALITY. Alpena County, Michigan.

DIAGNOSIS. Shell depressed, low spire of narrow, closely coiled whorls; whorls rounded to subangular at periphery; sculpture of faint growth-lines and short, delicate hairs arising from small acute bases, which alone remain on most adult shells; aperture oblique, ovate-lunate, thickened within, and well reflected on its outer and basal margins; parietal tooth short, white, straight, standing obliquely on the thin parietal callus. (Modified from Pilsbry, 1940, p. 677).

ECOLOGY. This species is found in wooded areas in the leaf litter or under logs and bark. It is also known from wetter locations, in stream drift, very damp locations along shorelines in piles of reeds tossed up after storms, and other moist and shady places along river banks (La Rocque, in press).

DISTRIBUTION. General: New York west to Minnesota (including southern but not northern Ontario) and South Dakota, south to Kansas, Missouri, Illinois, Indiana, Ohio, Pennsylvania, and Maryland. This study: Greene deposit.

GEOLOGIC RANGE. Pleistocene: Aftonian to present (La Rocque, in press) He also notes that this species was recorded in older reports from 'The Old Forest Bed of the Ohio River' and the 'Middletown preglacial deposits.' The age of these is uncertain.

Mesodon clausus (Say) 1821

Helix clausa Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 154.
Mesodon clausus La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Illinois.

DIAGNOSIS. Shell narrowly umbilicate with umbilicus half or nearly covered; depressed-globose with conoidal spire; striae close and fine, spiral lines microscopic; last whorl descends very little in front and has a furrow behind lip; peristome narrow and reflected; parietal callus thin and transparent. (Condensed from Pilsbry, 1940, p. 712).

ECOLOGY. In Tennessee, this species is found in the foothills of the Cumberland Mountains, in red and black oak forest (La Rocque, in press).

DISTRIBUTION. General: Michigan and Minnesota, south to Alabama and Georgia. This study: Greene deposit.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (Baker, 1920, p. 389).

Family Zonitidae

Euconulus fulvus (Müller) 1774

Helix fulva Müller 1774 (part), Verm. Terr. et Fluv., v. 2, p. 56.
Euconulus fulvus La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Fridrichsdal, Denmark.

DIAGNOSIS. Shell thin, minutely perforate or closed; spire conic with slightly convex outlines and obtuse apex; periphery rounded, sometimes somewhat angular, base convex; aperture lunate. (Condensed from Pilsbry, 1946, p. 236).

ECOLOGY. This species is common in drift debris of creeks and rivers, and lives among damp leaves in well-shaded places.

DISTRIBUTION. General: 'Almost throughout the Holarctic realm, but wanting in the Gulf and South Atlantic States from Texas to North Carolina.' (Pilsbry, 1946, p. 236). This study: Champaign and Greene deposits, Hamilton interstadial.

GEOLOGIC RANGE. Middle Pliocene to present for Europe (Pilsbry, 1946, p. 236). In North America it is limited to the Pleistocene, possibly Yarmouth to the present. (La Rocque, in press).

Nesovitrea binneyana (Morse) 1864

Hyalina binneyana Morse 1864, Jour. Portland Soc. Nat. Hist., v. 1, p. 13, 61, figs. 25, 26, pl. 2, fig. 9, pl. 6, fig. 27.

Retinella binneyana Pilsbry 1946, Land Moll. N. Amer., v. 2, pt. 1, p. 259, fig. 127a.
Nesovitrea binneyana La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Cumberland. Kennebec, Penobscot, and Piscataquis Counties, Maine.

DIAGNOSIS. 'Shell thin, pellucid nearly colorless, composed of nearly four whorls gradually enlarging; spire slightly elevated; aperture well rounded, umbilicus showing all the volutions.' (Morse, 1864, from Pilsbry, 1946, p. 261).

ECOLOGY. This species is an inhabitant of damp woodlands, especially those of deciduous trees; occasionally found in *Sphagnum* bogs (Oughton, 1948, p. 94).

DISTRIBUTION. General: Quebec west to western Ontario; south to Wisconsin, Ohio, Michigan, Pennsylvania, New York, and Maine. This study: Champaign and Greene deposits, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Late Wisconsin to present. It has been recognized in several late Wisconsin deposits in Ohio.

Glyphyalinia indentata (Say) 1823

Helix indentata Say 1823, Jour. Acad. Nat. Sci. Phila., v. 2, p. 372.
Glyphyalinia indentata Ahlstrom 1930, Nautilus, v. 44, p. 45.
Retinella (Glyphyalinia) indentata H. B. Baker 1930, Proc. Acad. Nat. Sci. Phila., v. 82, p. 209.
Retinella indentata Goodrich and van der Schalie 1944, Rev. Moll. Indiana, p. 271.
Glyphyalinia indentata Bickel 1968, Sterkiana, no. 31, p. 28.

TYPE LOCALITY. Probably northern Philadelphia and New Jersey.

DIAGNOSIS. Shell depressed, pellucid, highly polished; whorls 4, with regular, distant and subequidistant impressed lines crossing and extending to the base; sutures not deeply indented; aperture rather large with simple lips; umbilicus none, but the umbilical region is deeply indented. (Modified from a description by Say in Pilsbry, 1946, p. 289).

ECOLOGY. It is known from damp woodlands, especially deciduous areas, on outcrops of quartzite, in leaf mold on loose shale, and under pieces of wood and sandstone in fields (La Rocque, in press).

DISTRIBUTION. General: Southern Ontario north to Ottawa; U. S.: New England, New York, the Virginias, west to Kansas, south to Tennessee and northern Alabama. This study: Greene deposit.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (Baker, 1920, p. 389). It has been identified as a species in several late Wisconsin deposits in Ohio.

Hawaiia minuscula (Binney) 1840

Helix minuscula Binney 1840, Boston Jour. Nat. Hist., v. 3, p. 435 (1841?), pl. 22, fig. 4.
Hawaiia minuscula La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Ohio.

DIAGNOSIS. Shell minute, umbilicus about one third the diameter of the shell; depressed, spire low and convex; whorls 4, strongly convex and slowly widening; unevenly striate above, smooth below; spiral lines distinct or wanting; aperture rotund, height and width about equal. (Condensed from Pilsbry, 1946, p. 421).

ECOLOGY. This species is found in wet areas such as flood plains of creeks and rivers, a preference which may influence its widespread occurrence. In Ontario it is confined to Paleozoic terrains (mostly limestones). (Oughton, 1948, p. 94).

DISTRIBUTION. General: Fairly widespread in North America and the Pacific area. In the U.S. it is generally spread over every eastern and midwestern state south to Florida, rather local in the Rocky Mountain states, generally absent from the Pacific Northwest, and in southern California where it may be due to accidental importation. This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Late Miocene to present (Hibbard and Taylor, 1960. p. 148). It is widely distributed as a Pleistocene fossil in Iowa, Nebraska, Oklahoma, Texas, Indiana, and Ohio.

Zonitoides arboreus (Say) 1816

Helix arboreus Say 1816, (Nicholson's) Amer. Edit. British Encycl., v. 2, art. Conchology, species no. 2, pl. 4, fig. 4.
Zonitoides arboreus La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Probably Philadelphia, Pennsylvania.

DIAGNOSIS. Shell umbilicate, umbilicus contained about 4½ to 5 times in the diameter; translucent; whorls about 4½ moderately convex, regularly increasing; growth wrinkles weak, spiral striae faint, base smoother; aperture lunate, wider than high, peristome thin. (Pilsbry, 1946, p. 481).

ECOLOGY. This is a common snail in both damp and drier open deciduous woodlands, but it is by no means restricted to this. It lives on and under leaf litter, logs and bark, rocks, and in leaf mold (La Rocque in press).

DISTRIBUTION. General: This species has a wide distribution over North America. Pilsbry (1946, p. 481) reports that it is found in all the states of the U.S. except Alaska. This study: Greene deposit.

Family Limacidae

Deroceras sp.

Deroceras Rafinesque 1820, Annals of Nature, v. 1, p. 10.
Deroceras La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

DIAGNOSIS. Shell internal, oval, very shallow cap-like, concentrically striate; nucleus off center and to the left of the middle posterior margin.

ECOLOGY. Living species inhabit many environments from deciduous forests to house basements; everywhere there is moisture.

DISTRIBUTION. General. Living species occupy the entire Palearctic region and both Americas. Specimens identifiable as *Deroceras* sp. have been found in many Pleistocene deposits of Ohio. This study: Greene deposit, Hamilton interstadial.

GEOLOGIC RANGE. Upper Pliocene to present (Hibbard and Taylor, 1960, p. 20).

REMARKS. *Deroceras* is a genus of slugs which have an internal shell. Identification based on shell alone is very difficult. *Deroceras laeve* and *D. reticulatum* are the two species known to live in Ohio at the present time. *D. aenigma*, an extinct form described by Leonard (1950, p. 38) from the Pleistocene of Kansas, is doubtfully known from Ohio.

Family Endodontidae

Discus cronkhitei (Newcomb) 1865

Helix cronkhitei Newcomb 1865, Proc. Cal. Acad. Sci., v. 3, p. 180 (Klamath Valley, Ore.). --- Gabb, 1868, Amer. Jour. Conch., v. 4, p. 228, footnote.
Discus cronkhitei La Rocque, in press, Pleist. Moll. Ohio, pt, 4.

TYPE LOCALITY. Klamath Valley, Oregon.

DIAGNOSIS. Shell depressed, thin, with a low conoid spire and open umbilicus showing all whorls; whorls convex with rounded periphery; sculpture of retractive riblets separated by wider intervals and extending to the base; aperture rounded, peristome thin. (Condensed from Pilsbry, 1948, p. 601).

ECOLOGY. This is a woodland species that lives in leaf litter and under logs and bark. It also lives in and under numerous types of debris in damp spots in non-woodland areas (La Rocque, in press).

DISTRIBUTION. General: Canada, Alaska, Newfoundland; in the United States reaching south to California and Florida (Oughton, 1948, p. 36). This study: Champaign deposit, Hamilton interstadial.

GEOLOGIC RANGE. Middle Pliocene to present. The Tertiary date is based on a single occurrence in Wyoming. It is known from Kansan, Illinoian, and Wisconsin deposits of the southern Great Plains and from the Wisconsin of the Midwest (La Rocque, in press).

Helicodiscus parallelus (Say) 1821

Planorbis arallelus Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 164; corrected to *parallelus* in the Index, p. 407.
Helicodiscus parallelus La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Council Bluffs, Iowa.

DIAGNOSIS. Shell small, disk-shaped, the upper surface flat or very slightly convex, umbilicus broad; whorls 4 to 4½, convex, very narrow, and slowly increasing; spiral striations distinct; aperture narrow, lunate with a pair of small conical teeth. (Condensed from Pilsbry, 1946, p. 625).

ECOLOGY. Numerous authors report this species associated with a variety of habitats It is a common species of woodland areas living in or on a considerable variety of debris, usually in moist situations.

DISTRIBUTION. General: Manitoba east to Newfoundland, Prince Edward Island, New Brunswick, and Maine, south to Oklahoma, Arkansas, Alabama, and Georgia. This study: Greene deposit.

GEOLOGIC RANGE. Pleistocene: Nebraskan to present (Hibbard and Taylor, 1960, p. 144).

Punctum minutissimum (Lea) 1841

Helix minutissima Lea 1841, Trans. Amer. Philos. Soc., v. 9, p. 17.
Punctum minutissimum La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. In the vicinity of Cincinnati, Ohio.

DIAGNOSIS. Shell very minute, depressed conoid, umbilicate; sculpture of very fine growth lines and spiral striae; whorls 3¾, convex, the last whorl descending to about the periphery of preceding whorl; aperture rounded-lunate, lip simple and acute. (Condensed from Pilsbry, 1948, p. 644).

ECOLOGY. This species lives on damp leaves, around decaying logs, and tends to prefer especially dense hardwood areas where it is found on the rotten bark of beech trees and in large forms of fungi (Pilsbry, 1948, p. 645).

DISTRIBUTION. General: Entire United States. New Mexico to Manitoba, New England to California. (Oughton, 1948, p. 39). This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Pleistocene: Sangamon to present (Taylor and Hibbard, 1955, p. 12).

Family Succineidae

Oxyloma retusa (Lea) 1834

Succinea retusa Lea 1834, Trans Amer. Philos. Soc., v. 5, p. 117, pl. 19, fig. 86.

Oxyloma retusa La Rocque, in press, Pleist. Moll. Ohio. pt. 4.

TYPE LOCALITY. Near Cincinnati, Ohio.

DIAGNOSIS. Shell ovately oblong, very thin, pellucid; spire short; whorls 3; aperture below dilate and drawn back. (Modified from Pilsbry, 1948, p. 786).

ECOLOGY. *Oxyloma retusa* is a species that lives among plants and debris at the margins of ponds, streams, and other wet places (La Rocque, in press).

DISTRIBUTION. General: Ohio, Illinois, Iowa, Minnesota, North Dakota, Montana; Yukon and British Columbia (?) east to Labrador and Maine. This study: Greene deposit.

GEOLOGIC RANGE. Early Pleistocene to present (Hibbard and Taylor, 1960, p. 141).

Succinea avara Say 1824

Succinea avara Say 1824, Appendix to Long's Second Exped., v. 2, p. 260, pl. 15, fig. 6.
Succinea avara La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Northwest Territory.

DIAGNOSIS. Shell slender, fragile; litle more than 3 whorls, very strongly convex; sutures deep; aperture ovate, two thirds the length of the shell or less. (Condensed from Pilsbry, 1948, p. 837).

ECOLOGY. Usually found on vegetable debris thrown up on muddy shores, or on the muddy banks of ditches, often exposed to the sun; also in meadows and swampy places. It is an upland species as well, found under stones with Pupillidae, or occasionally after rains crawling up the trunks of trees (Pilsbry, 1948, p. 839).

DISTRIBUTION. General: Mackenzie District south to British Columbia, California, and Mexico; east to Quebec, New Brunswick, and Newfoundland, south to Florida. This study: Champaign deposit.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present. Numerous occurrences are recorded for the Wisconsin in Ohio (La Rocque, in press).

REMARKS. The specimens of *Succinea* in the Champaign deposit were identified as *Succinea avara*. The specimens of this deposit showed gradation toward the higher spire and more deeply impressed whorls characteristic of *S. grosvenori gelida*. Nevertheless, the great majority possessed the characteristics of *S. avara*.

Succinea grosvenori gelida Baker 1927

Succinea grosvenori gelida Baker 1927, Nautilus, v. 40, p. 118.
Succinea grosvenori gelida La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Boone County, Illinois, one-half mile north of depot at Irene, in Peorian loess.

DIAGNOSIS. Shell small, elongate, narrow; whorls 3½, convex, separated by deep sutures, last whorl comparatively small, flat-sided or slightly convex; spire long, acute; aperture rounded, about one half as long as the shell; slight callus spread over the parietal wall; sculpture of fine striae. (Condensed from Pilsbry, 1948, p. 823).

ECOLOGY. Since it is an extinct species, it is assumed to be close to that of the typical form. Pilsbry (1948, p. 821) states about *Succinea grosvenori*, '... as now understood, (this species) tolerates an astonishingly wide range in practically all external conditions. It occurs from the warm humid Gulf coast to semi-arid areas in the great plains and mountain states, and in British America it extends north within the border of Northwest Territory.'

DISTRIBUTION. General: Extinct. Reported from the Pleistocene of Illinois, Indiana, Ohio, New York, and Kentucky. The distribution of this form may be greater as it may be confused with other species of *Succinea*. This study: Greene deposit, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Yarmouth, Sangamon, and late Wisconsin (La Rocque, in press).

REMARKS. See the Remarks section under *Succinea avara*.

Family Strobilopsidae

Strobilops labyrinthica (Say) 1817

Helix labyrinthica Say 1817, Jour. Acad. Nat. Sci. Phila., v. 1, p. 124.
Strobilops labyrinthica La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Philadelphia, Pennsylvania.

DIAGNOSIS. Shell dome-shaped, periphery obtusely subangular, narrowly umbilicate; whorls 5½, convex, very slowly expanding; sculptured with narrow, obliquely radial ribs; aperture semilunar. (Condensed from Pilsbry, 1948, p. 854).

ECOLOGY. Under loose bark of logs, in half decayed wood, among dead leaves and in sod at the bases of trees. (Pilsbry, 1948, p. 854).

DISTRIBUTION. General: Manitoba, east to New Brunswick and Maine; south to Georgia and Alabama. This study: Greene deposit.

GEOLOGIC RANGE. Late Pliocene to present (Hibbard and Taylor, 1960, p. 121). Pleistocene records include Aftonian, Yarmouth, Illinoian (?), Sangamon, and Wisconsin.

Family Pupillidae

Gastrocopta armifera (Say) 1821

Pupa armifera Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 162.
Gastrocopta armifera La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Germantown, Philadelphia, Pennsylvania.

DIAGNOSIS. Shell large perforate, rimate, oblong, obtusely conic; thin, parafine white, weakly striate; whorls 6½, moderately convex, the last compressed around axis; aperture rounded, peristome thin and expanded with a callus forming a raised edge across parietal wall; angular and parietal lamellae joined; columellar lamella subvertical; basal lamella low and often inconspicuous; palatal folds stand on white callus, lower short and entering, upper shorter, small suprapalatal tubercle above palatal folds. (Modified from Pilsbry, 1948, p. 875).

ECOLOGY. This species may be found readily in river drift. It seems to have a preference for rocky situations and may prefer limestone districts. (Oughton, 1948, p. 50). La Rocque (in press) notes that, 'In central Ohio it is very abundant in disused quarries and in crevices formed by bedding planes of limestones along roadsides, river banks and hillside gullies, in some cases in exposed situations without protective cover. It is the commonest pupillid in stream-drift collections in Ohio.'

DISTRIBUTION. General: Alberta, Manitoba, Ontario, Quebec, and southward to New Mexico, Texas, and Florida. This study: Greene deposit, Hamilton interstadial.

GEOLOGIC RANGE. Early Pliocene to present (Hibbard and Taylor, 1960, p. 124).

Gastrocopta contracta Say 1822

Pupa contracta Say 1822, Jour. Acad. Nat. Sci. Phila., v. 2, p. 374.
Gastrocopta contracta La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Occoquan, Virginia.

DIAGNOSIS. Shell ovate-conic, rimate, bluish-milky color, translucent; growth lines fine; about 5½ whorls, last half of body whorl straightened, pinched at base, and a low rounded ridge behind peristome; aperture rounded-triangular, expanded; angulopariental lamella S-shaped; columellar lamella large, deeply placed with callus in front; two palatal folds connected by a low callus, the lower obtuse, and larger than theupper; peristome thin and well expanded. (Modified from Pilsbry, 1948, p. 881).

ECOLOGY. This species lives in a variety of habitats including stream flood plains and slopes, in logs and debris on the floors of hardwood forests, and limestone bluffs wherever there is sufficient moisture.

DISTRIBUTION. General: Eastern Canada and the United States: Maine, Ontario, and Manitoba, south to Florida and Mexico. This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Early Pliocene to present (Hibbard and Taylor, 1960, p. 126).

Gastrocopta pentodon (Say) 1821

Vertigo pentodon Say 1821, Jour. Acad. Nat. Sci. Phila., v. 2, p. 376.
Gastrocopta pentodon La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Pennsylvania.

DIAGNOSIS. Shell rimate, oblong-conic with obtuse summit, clear or whitish; whorls 5, convex, the last with a rounded ridge close behind the lip; teeth typically five, the anguloparietal lamella simple, columellar lamella thin and horizontal; palatal folds stand upon the callus ridge the lower compressed and entering more deeply than the upper; accessory denticles usually present in subcolumellar, basal, and interpalatal positions; peristome thin, narrowly expanded, with a thin parietal callus developed. (Modified from Pilsbry, 1948, p. 888).

ECOLOGY. *G. pentodon* lives on wooded hillsides or in well-drained groves, among leaves in the underbrush; also common among moss and grass in forest and on open slopes. (Pilsbry, 1948, p. 888).

DISTRIBUTION. GENERAL: Eastern United States and Canada: Prince Edward Island to Alberta, south to central Florida and Texas, west into Arizona and eastern Mexico. This study: Champaign deposit.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (Baker, 1920, p. 388).

Gastrocopta tappaniana (C.B. Adams) 1842

Pupa tappaniana 'Ward' C. B. Adams 1842, in Thompson's History of Vermont, p. 158.
Gastrocopta tappaniana La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Vermont.

DIAGNOSIS. Shell larger than *G. pentodon*, obtusely conic; only one tooth on the parietal wall, usually 6 on the columellar, basal and outer margins, those on the latter standing on a strong rib; lower palatal fold usually not as long and entering as in *G. pentodon*. (Modified from Pilsbry, 1948, p. 889).

ECOLOGY. This species is found 'in low, moist places, under wood, often with *Vertigo ovata*, while *G. pentodon* lives in drier situations.' (Pilsbry, 1948, p. 889, 890).

DISTRIBUTION. General: Ontario and Maine to Virginia and Alabama, west to South Dakota and Kansas, southwest to Arizona, but not known from the southeastern Atlantic States from Virginia to Florida. This study: Greene deposit, Hamilton interstadial.

GEOLOGIC RANGE. Late Pliocene to present (Hibbard and Taylor, 1960, p. 127). Aftonian, Yarmouth, Illinoian (?), and Wisconsin records have been reported for the Pleistocene.

Pupoides albilabris (C.B. Adams) 1841

Pupa albilabris 'Ward's letter' C. B. Adams 1841, Amer. Jour. Sci., v. 40, p. 271.
Pupoides albilabris La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Upper Missouri.

DIAGNOSIS. Shell minutely perforate, rimate, slowly tapering to an obtuse summit, cinnamon or darker; growth lines lightly marked; whorls strongly convex, the last half-whorl compressed laterally; aperture oval, peristome expanded and reflected, strongly thickened within, outer lip more strongly arched near upper insertion. (Modified from Pilsbry, 1948, p. 921).

ECOLOGY. A common snail which prefers limestone soils but lives elsewhere. It may be found under stones or at roots of grass in well-drained but often sunny places. Following rains it is sometimes found on trees a few feet from the ground. (Pilsbry, 1948, p. 923).

DISTRIBUTION. General: Eastern North America from Ontario and Maine to the Gulf of Mexico, west to the Dakotas, Colorado, and western Arizona, south to northern Mexico. This study: Greene deposit.

GEOLOGIC RANGE. Early Pliocene to present (Hibbard and Taylor, 1960, p. 128).

Pupilla muscorum (Linnaeus) 1758

Turbo muscorum Linnaeus 1758, Syst. Nat., v. 10, p. 767.
Pupilla muscorum La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Sweden.

DIAGNOSIS. Shell shortly rimate, cylindric, auburn or brown, moderately solid, summit rounded and obtuse; whorls with fine, uneven striations, moderately convex; last half of last whorl tapering downward, compressed, rising to aperture, having a strong crest near and parallel to the outer and basal lip; aperture somewhat oblique and typically without teeth; peristome narrowly reflected outwardly with a pale callus within. (Modified from Pilsbry, 1948, p. 933).

ECOLOGY. *P. muscorum* is especially abundant in bedrock areas, on escarpments, under slabs, and in joints and fissures. Oughton (1948, p. 95) indicated doubt about its occupying flood plains. La Rocque (in press) notes its abundance in his stream drift records. If not native to the flood plain, it must be washed in from high banks.

DISTRIBUTION. General: British Columbia east to Newfoundland and Maine; Alaska south and east to New Mexico, Arizona, Vermont, New Hampshire, Maine, and New Jersey. Also Europe, north Africa, northern and central Asia. This study: Champaign deposit, Hamilton interstadial.

GEOLOGIC RANGE. Late Pliocene to present (Hibbard and Taylor, 1960, p. 132). These authors note an earlier record of Middle Pliocene.

Vertigo elatior Sterki 1894

Vertigo ventricosa var. *elatior* Sterki 1894, Land and Fresh Water Moll. of New Philadelphia ..., p. 5.
Vertigo elatior La Rocque, Pleist. Moll. Ohio, pt. 4, in press.

TYPE LOCALITY. New Philadelphia, Ohio.

DIAGNOSIS. Shell larger and more elevated than that of *V. ventricosa*, with a rather acute apex; palatal callus strong, basal fold well developed; external impression over the lower palatal fold is distinct and deeper than in *V. pygmaea;* suprapalatal fold commonly developed; angular lamella rarely present. (Modified from Pilsbry, 1948, p. 956).

ECOLOGY. A hardy species rather typical of more rigorous climate zones but able to exist in mountainous areas to the south.

DISTRIBUTION. General: Newfoundland west to British Columbia, south to New Mexico. This study: Champaign deposit, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Aftonian to Wisconsin.

Vertigo gouldii (Binney) 1843

Pupa gouldii Binney 1843, Proc. Boston Soc. Nat. Hist., v. 1, p. 105.
Vertigo gouldii La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Brookline, Massachusetts.

DIAGNOSIS. Shell oval to cylindric-oblong, brown, closely and sharply striate; last whorl with crest close behind lip; aperture has outer lip flattened or little inflexed; teeth white, angular lamella strong and long, columellar lamella strong, a subcolumellar basal fold below it, two palatal folds strong and near together with the lower a little farther inward. (Modified from Pilsbry, 1948, p. 972).

ECOLOGY. This species lives in leaf mold, under plant debris, logs, bark, among leaves, moss, or grass in moist situations not far from water. It is also reported from woodland areas (La Rocque, in press). Franzen and Leonard (1947, p. 359), noting its presence in the Pleistocene of Kansas, state, 'This species at the present time is limited in its distribution to regions where cooler and more humid climatic conditions obtain.'

DISTRIBUTION. General: Newfoundland, Prince Edward Island, Quebec, Ontario, New Brunswick, and Maine, south to Kentucky, Tennessee, and northern Alabama. The distribution into Kentucky, Tennessee, and Alabama is local and appears to follow the mountains southward (Pilsbry, 1948, p. 972). This study: Champaign and Greene deposits, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (Leonard, 1950, p. 27). La Rocque (in press) indicates no specific record from the Pleistocene deposits of Ohio. As a result of this study it can now be reported. *Vertigo gouldii* occurs in the Champaign County and Hamilton deposits. One specimen that compares with *V. gouldii* was recognized from the deposit in Greene County. It is also known from the Pleistocene of Indiana and Kentucky.

Vertigo gouldii hannai Pilsbry 1919

Vertigo hannai Pilsbry 1919, Man. Conch., v. 25 p. 114, pl. 12, fig. 12.
Vertigo gouldii hannai La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Long Island, Phillips Co., Kansas (Franzen and Leonard 1947, p. 363).

DIAGNOSIS. Shell brown, ovate, lines of growth faint, whorls 4½, well rounded with well impressed sutures; apex smooth and obtusely pointed; peristome thin and sharp, slightly expanded, with virtually no indentation in upper palatal wall; aperture semicircular, with six teeth, two parietal lamellae with the angular the smaller, one centrally located columellar which is bifid, one small basal tooth, and two palatal lamellae of which the lower is larger. (Modified from Pilsbry, 1948, p. 976).

ECOLOGY. None specified. Possibly the same as for the typical form.

DISTRIBUTION. General: Not specifically known. Pleistocene records are known from Kansas, Indiana, and Ohio (this report). This study: Champaign deposit, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Kansan to present. Wayne (1959, p. 13) reports the oldest occurrence for this species in a section considered by him to be Kansan.

The Kansas report gave only Pleistocene. Pilsbry (1948, p. 976) reports the paratype to be from Yarmouth loess at Carlinville, Illinois. The records in this study appear to be all late Wisconsin.

Vertigo modesta (Say) 1824

Pupa modesta Say 1824, Long's Second Exped., Appendix, p. 259, pl. 15, fig. 5.
Vertigo modesta La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Pilsbry (1948, p. 983) gives the type locality as 'somewhere near or west of the western end of Lake Superior.'

DIAGNOSIS. Shell cylindric-oblong, cinnamon, weakly striate; last whorl with weak crest behind obtuse outer lip which expands very little; teeth four, the parietal and columellar lamellae and lower-palatal fold subequal and short, the upper-palatal fold smaller; whorls 5½. (Modified from Pilsbry, 1948, p. 982).

ECOLOGY. In Ontario this species is found in wet locations, such as margins of ponds, streams, and marshes (Oughton, 1948, p. 94).

DISTRIBUTION. General: 'This is the most abundant and widely distributed species in the north country.' Labrador westward to British Columbia; locally in Maine, Vermont, Connecticut; from Pleistocene deposits of the Midwest (Pilsbry, 1948, p. 982, 983). This study: Champaign deposit, Hamilton interstadial (the first reported fossil occurrences in Ohio.

GEOLOGIC RANGE. Pleistocene: Yarmouth to present (Leonard, 1950, p. 27).

Vertigo milium (Gould) 1840

Pupa milium Gould 1840, Boston Jour. Nat. Hist., v. 3, p. 402; v. 4, p. 359.
Vertigo milium La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Oak Island, Chelsea, near Boston, Massachusetts.

DIAGNOSIS. Shell shortly oval and cinnamon, weakly striate; last whorl has an external impression over the lower palatal fold and a swelling in front of it, below a deeper impression which runs to the lip over the palatal fold; angular lamella high, short, and situated inward; parietal lamella high and long, entering deeply; strong columellar lamella enters horizontally then turns downward; upper palatal fold long and high whereas the lower is a little immersed, high, thin, and curves downward; basal fold somewhat immersed, short and high; small tubercular suprapalatal fold sometimes present; outer lip somewhat expanded and strongly biarcuate; parietal callus rather thick. (Modified from Pilsbry, 1948, p. 944, 945).

ECOLOGY. *V. milium* lives in moist situations among leaf mold, plant debris, grass, and moss; under logs, bark, and rocks in woodlands and flood plains of rivers. It seems to have a preference for limestone terrains (La Rocque in press).

DISTRIBUTION. General: Maine and Quebec to the Florida Keys, west to South Dakota, Colorado, and southeastern Arizona. Mexico, Jamaica, and Santo Domingo. This study: Greene deposit.

GEOLOGIC RANGE. Late Pliocene to present (Hibbard and Taylor, 1960, p. 135).

Vertigo morsei Sterki 1894

Vertigo morsei Sterki 1894, Nautilus, v. 8 p. 89.
Vertigo morsei La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Joliet, Illinois.

DIAGNOSIS. Shell large (largest *Vertigo*), cylindric-ovate, brown, a few weak striae; whorls about 6, slowly increasing, having a moderate crest behind the lip. a wide depression over the palatal folds, and a distinct crease from the crest to the lip point; aperture relatively small, outer margin angularly inbent near the middle; teeth typically nine, 3 on the parietal wall, a strong columellar lamella, a smaller basal fold in a subcolumellar position, upper and lower palatal folds high and long, small tubercular suprapalatal and infrapalatal folds; infraparietal and infrapalatal tubercles sometimes wanting; peristome a little expanded. (Modified from Pilsbry, 1948, p. 952).

ECOLOGY. Oughton (1948, p. 94) records this species somewhat doubtfully for flood plains of creeks and rivers.

DISTRIBUTION. General: New York and New Jersey west to Michigan, Indiana, and Illinois. This study: Champaign and Greene deposits.

GEOLOGIC RANGE. Pleistocene: late Wisconsin to present.

Vertigo ovata Say 1822

Vertigo ovata Say 1822, Jour. Acad. Nat. Sci. Phila., v. 2, p. 375.
Vertigo ovata La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Philadelphia, Pennsylvania.

DIAGNOSIS. Shell brown, convexly conic, summit obtuse; whorls 5, increasing rapidly with the last much the largest; strong crest and double furrows behind lip, with a deep furrow running from crest to lip point; aperture thin and expanded with a distinct sinulus and inbent outer lip; parietal lamella strong and long, angular lamella small, a minute infraparietal tubercle usually present, columellar lamella strong, basal fold small and in subcolumellar position, usually a minute infrapalatal fold in basal margin, upper and lower palatal folds strong, standing on callus ridge with a minute suprapalatal tubercle usually above them. (Modified from Pilsbry, 1948, p. 953).

ECOLOGY. Oughton (1948, p. 94) notes that this species is found in wet locations, such as flood plains of creeks, margins of ponds, streams and marshes.

DISTRIBUTION. General: 'The most widely distributed *Vertigo*.' Labrador west to British Columbia, north to Alaska; south to Florida, Mexico, and the West Indies (Pilsbry, 1948, p. 953). This study: Greene deposit.

GEOLOGIC RANGE. Early Pliocene to present (Hibbard and Taylor, 1960, p. 135).

Vertigo ventricosa (Morse) 1865

Isthmia ventricosa Morse 1865, Ann. Lyc. Nat. Hist. N. Y., v. 8, p. 207.
Vertigo ventricosa La Rocque, in press, Pleist. Moll. Ohio pt. 4.

TYPE LOCALITY. Not specified.

DIAGNOSIS. Shell umbilicate, ovate, conic, smooth, polished; apex obtuse; suture deep; whorls four, convex; aperture semicircular with five teeth, one prominent on the parietal margin, two smaller on the columellar margin, and two prominent within; peristome widely reflected. (Modified from Pilsbry, 1948, p. 957).

ECOLOGY. This species is found living in and under debris in wet locations in such areas as flood plains of creeks and rivers, margins of ponds, streams, marshes, and woodlands (La Rocque, in press).

DISTRIBUTION. General: Prince Edward Island and Quebec south to New England and New York, west to Ontario, Ohio, Illinois, and Missouri. This study: Champaign deposit.

GEOLOGIC RANGE. Pleistocene. Pilsbry (1948) does not record it as a fossil. Goodrich and van der Schalie (1944, p. 276) record it for the loess of Posey County, Indiana. It is present in the marl of the Champaign deposit of this report.

Columella alticola (Ingersoll) 1875

Pupilla alticola Ingersoll 1875, Bull, U. S. Geol. and Geogr. Surv. Terr., v. 1, p. 128; 8th Ann. Rep. Hayden Survey, p. 391, fig.
Columella alticola La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Cunningham Gulch, Colorado.

DIAGNOSIS. Shell perforate, straight, two and one half times as long as broad, densely striate, brown, apex obtuse; whorls 6 or 7, convex, the middle three equal, yielding parallel sides, the last noticeably greater and expanding toward the aperture; sutures deeply impressed; aperture small, oblique, subtriangular, margins connected by a thin deposit without internal processes; peristome simple and somewhat reflected over umbilicus. (Modified from Pilsbry, 1948, p. 1003, 1004).

ECOLOGY. Most ecological information reported for this species indicates a preference for very moist situations in the cooler climates of higher latitudes or altitudes.

DISTRIBUTION. General: British Columbia and Alberta south to New Mexico and Arizona, east to far northern Ontario, Wyoming and Colorado. As a fossil it ranges much farther east. This study: Champaign deposit, Hamilton interstadial.

GEOLOGIC RANGE. Pleistocene: Aftonian to present (Baker, 1920 p. 389). Subsequent authors give only Wisconsin ages.

Family Valloniidae

Vallonia gracilicosta Reinhardt 1883

Vallonia gracilicosta Reinhardt 1883, Sitzungs-Ber. Ges. Naturforsch. Freunde Berlin, p. 42.
Vallonia gracilicosta La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Little Missouri River, North Dakota.

DIAGNOSIS. Shell flat with little projecting apex, widely umbilicate, whitish-gray; whorls 3½, convex, deeply sutured, distinctly striated with crowded ribs, last whorl expanding and slightly descending toward the aperture; aperture transversely oval with a strongly expanded and white-lipped peristome. (Condensed from Pilsbry, 1948, p. 1029).

ECOLOGY. Most records indicate that this species lives in or near woodlands in many types of debris. However, it is known from a rockslide above timberline at an altitude of approximately 11,000 feet (La Rocque, in press).

DISTRIBUTION. General: Alberta, Manitoba, and Ontario, south to Texas and Arizona. This study: Champaign and Greene deposits, Hamilton interstadial.

GEOLOGIC RANGE. Late Pliocene to present (Hibbard and Taylor, 1960, p. 137). Earlier workers limited it to the Pleistocene.

Vallonia pulchella (Müller) 1774

Helix pulchella Müller 1774, Verm. Terr. et Fluv., v. 2, p. 30.
Vallonia pulchella La Rocque, in press, Pleist. Moll. Ohio, pt. 4.

TYPE LOCALITY. Denmark.

DIAGNOSIS. Shell depressed, widely umbilicate, milky; sculpture of minute striae; whorls 3½, convex, sutures deep, last whorl well rounded, not descending noticeably; aperture oblique, peristome expanding greatly, much thickened within. (Modified from Pilsbry, 1948, p. 1023).

ECOLOGY. Oughton (1948, p. 94) reports this species from drier more open woods as well as from wetter locations. In Ontario it is confined to Paleozoic limestone terrains. Reports indicate it can survive very well during extended periods of dryness.

DISTRIBUTION. General: Manitoba east to Prince Edward Island, New Brunswick, Newfoundland, and Nova Scotia, south to Missouri and Kentucky. This study: Greene deposit.

GEOLOGIC RANGE. Pleistocene: Nebraskan to present. Taylor (1960, p. 76) reported the oldest record of Nebraskan for the Sand Draw local fauna. Previous workers had given a Yarmouth record as the oldest.

PALEOECOLOGY

General Statement

One of the most important parts of this study is the interpretation of the former environment. Such interpretation is based upon the traditional geological assumption that the mollusks, other fossil materials including vegetation, and the enclosing sediment represent what has been preserved of the environment in which the mollusks lived. As with geologically older faunas, the species preserved are identified on the basis of shell morphology. However, because the vast majority of the species concerned are still living, it is possible with Pleistocene assemblages to refer to living species for information concerning their environmental preferences. Environments such as are represented by these Pleistocene studies are predominantly thanatocoenoses, that is, a mixture of native species with those that lived nearby and were brought into the environment after death. In the interpretation of such environments, it can be assumed that those species occurring in greatest abundance are the most productive and indigenous species. The fact that some genera such as *Ferrissia, Promenetus*, and *Armiger* occur in small quantities even in favorable habitats must nevertheless be kept in mind. Any relationship between the variation in species and the changes in lithology is important in the interpretation of environment. In addition, other factors, not directly preservable, such as water depth and temperature, are involved and must be taken into account.

In order to attempt the environmental interpretations mentioned above, it is necessary to analyze the composition of the fauna from quantitative data gathered for the assemblage studied. These data are derived from the study of the species collected, using the methods described earlier. The data are here presented in a series of tables and plates. The tables show the vertical distribution of species as percentages of the total population sample of lithologic unit; whereas the plates of figures depict graphically the vertical variation of the most significant species in each of the deposits or groups of interstadials. The unit-collection numbers used in the tables and plates are the same as those shown in the descriptions of the stratigraphic sections for each deposit.

That diversity is represented in the environments of this study is attested to by the general composition of the fauna. Sixty-two species are represented, of which thirteen are sphaeriid clams (plus three forms of species) sixteen freshwater gastropods (four gill-breathers and twelve lung-breathers), and thirty-three terrestrial gastropods (see Tables 1 and 2). On the following pages an attempt is made to reconstruct the paleoecology of each of the deposits. For each a brief analysis of the composition of the fauna is made, followed by the paleoecological interpretation it might suggest. Attention is called to the tables and plates of figures showing the distribution of species for each deposit.

Champaign Deposit

Composition of the fauna

Forty species are represented in the Champaign deposit. Of these, three are gill-breathing freshwater gastropods, nine are lung-breathing freshwater gastropods, eighteen are terrestrial gastropods, and ten (plus two forms of one species) are sphaeriid clams. Of these forty species, only five occur abundantly, and an additional six are common. The remaining species occur in relatively minor amounts in different parts of the section (see Table 4 and Plates I to III). The diversity of species present suggests diversity in environment, an observation fortified by an inspection of Tables 3 and 4, and the measured section for this deposit (p. 8). Good correlations are shown here between lithology, number of shells per collection unit, and two broad faunal zones that can be recognized by the general presence or absence of terrestrial gastropods. Whereas the first break in lithology is recognized at the change from Unit 3 to Unit 2, the obvious break based on number and type of mollusks appears to be slightly above at collections 2-9 and 2-10. The irregular interface between these units mentioned in the measured section helps to explain this slight discrepancy. The next major change occurs at the contact between Unit 2 and Unit 1. Here the break shown by the numbers of shells is obvious, and the change in terrestrial versus freshwater forms is noticeable.

Fossaria obrussa decampi, *Gyraulus parvus*, *Valvata sincera*, *Pisidium nitidum* form *pauperculum*, and *Succinea avara* are the most abundant species. *F. o. decampi* and *S. avara* are most abundant in the lower part of Unit 3 and generally decrease upward, the latter becoming very rare in Unit 2. *G. parvus*, *V. sincera*, and *P. nitidum* form *pauperculum* occur in very small numbers in the lower part of Unit 3 and increase upward to their maximum abundance in Unit 2. *Pisidium casertanum*, *P. compressum*, *P. ferrugineum*, *P. nitidum*, *Gastrocopta pentodon*, and *Vertigo morsei*, though not abundant, are common and occur in largest quantities in Unit 3. All other species occur in lesser percentages, but some are nevertheless important in the interpretation of the environment.

Interpretation

The fine-grained sand of Unit 3 and the species contained in it suggest a very near-shore environment for the area of the study site in the early history of the lake. *F. obrussa decampi*, which makes up 55 percent of the species in the basal collection (3-13), is characteristic of shallow water at the margins of small bodies of water on a substrate of mud flats or debris. *P. casertanum* (7 per cent) and *P. compressum* (3 per cent) are clams that prefer shallow water, and the latter is characteristic of sandy substrates. The land snail *S. avara* (9 per cent) lives on debris near water or sometimes farther away on upland slopes. It is a common associate of pupillid gastropods and occurs here with *Vertigo elatior* (7 per cent).

The early developed near-shore environment continued throughout the sedimentation of Unit 3, but a general deepening of the water is indicated by the general decrease in the abundance of *F. obrussa decampi* (55 to 19 per cent) and the increases shown by *G. parvus* (0.8 to 27 per cent), *V. sincera* (0.8 to 15 per cent), and the various species of *Pisidium*. *G. parvus* is best adapted to water one to four feet deep with abundant vegetation. *V. sincera* is a lake species that prefers cooler and deeper water; and most species of *Pisidium* live in shallow water on a relatively soft substrate. Terrestrial gastropods appear to become well established in the area adjacent to the lake and increase in numbers and diversity during the deposition of Unit 3. Besides *S. avara*, most of these species form only a very minor proportion of each collection, but collectively they are quite important. The majority prefer wet and moist places such as the flood plains of rivers; but some, such as *Discus*

TABLE 1. FRESHWATER SPECIES REPRESENTED IN THIS STUDY.

Species	Champaign	Clark	Greene	Hamilton
<u>Gastropods</u>				
Acella haldemani	X	X	0	0
Amnicola limosa	0	X	0	X
Amnicola lustrica	X	X	0	0
Armiger crista	X	X	0	0
Ferrissia parallela	0	0	X	0
Fossaria obrussa decampi	X	X	X	0
Fossaria parva	0	0	0	X
Gyraulus deflectus	X	X	0	0
Gyraulus parvus	X	X	X	X
Helisoma anceps striatum	X	X	0	0
Helisoma campanulatum	X	X	0	0
Lymnaea stagnalis jugularis	X	X	0	0
Physa gyrina	0	X	X	0
Promenetus exacuous	X	X	0	0
Valvata sincera	X	X	0	X
Valvata tricarinata	X	X	0	0
<u>Pelecypods</u>				
Pisidium adamsi	X	0	0	0
Pisidium casertanum	X	0	X	0
Pisidium compressum	X	X	0	0
Pisidium ferrugineum	X	X	0	X
Pisidium milium	X	X	0	0
Pisidium nitidum	X	X	X	X
P. n. form contortum	X	X	0	0
P. n. form pauperculum	X	X	0	0
Pisidium variabile	X	X	X	0
Pisidium ventricosum	X	X	0	0
Pisidium walkeri form mainense	0	X	0	0
Sphaerium lacustre	X	X	0	0
Sphaerium rhomboideum	0	X	0	0
Sphaerium securis	0	X	0	0
Sphaerium sulcatum	X	X	0	0
Total species and forms	24	27	7	6

X - Species present; 0 - Species absent

TABLE 2. TERRESTRIAL SPECIES REPRESENTED IN THIS STUDY

Species	Champaign	Clark	Greene	Hamilton
Carychium exiguum	X	O	X	O
Columella alticola	X	O	O	X
Deroceras sp.	O	O	X	X
Discus cronkhitei	X	O	O	X
Euconulus fulvus	X	O	X	X
Gastrocopta armifera	O	O	X	X
Gastrocopta contracta	X	O	X	O
Gastrocopta pentodon	X	O	O	O
Gastrocopta tappaniana	O	O	X	X
Glyphyalinia indentata	O	O	X	O
Hawaiia minuscula	X	O	X	O
Helicodiscus parallelus	O	O	X	X
Mesodon clausus	O	O	X	O
Nesovitrea binneyana	X	O	X	X
Oxyloma retusa	O	O	X	X
Punctum minutissimum	X	O	X	O
Pupilla muscorum	X	O	O	X
Pupoides albilabris	O	O	X	O
Stenotrema leaii	O	O	X	O
Strobilops labyrinthica	O	O	X	O
Succinea avara	X	O	O	O
Succinea grosvenori gelida	O	O	X	X
Vallonia gracilicosta	X	O	X	X
Vallonia pulchella	O	O	X	O
Vertigo elatior	X	O	O	X
Vertigo gouldii	X	O	X	X
Vertigo gouldii hannai	X	O	O	X
Vertigo milium	O	O	X	O
Vertigo modesta	X	O	O	X
Vertigo morsei	X	O	X	O
Vertigo ovata	O	O	X	O
Vertigo ventricosa	X	O	O	O
Zonitoides arboreus	O	O	X	O
Total species	18	0	24	14

X - Species present; O - Species absent

cronkhitei, *Gastrocopta pentodon*, *Punctum minutissimum*, *Nesovitrea binneyana*, and *Vallonia gracilicosta* are more characteristic of woodlands. Occasional flooding was postulated above as a means of helping to wash in such a diversity of non-indigenous species. All of the terrestrial types reach a maximum near the middle of the unit and then decrease to virtual elimination at the top.

The deepening of the water and the shifting of the shoreline which started in Unit 3, persisted through the deposition of Unit 2. Supporting this is the continuation of the trends mentioned in the previous unit; namely, the decrease of *F. obrussa decampi*; the increase in *G. parvus*, *V. sincera*, and some of the species of *Pisidium*; as well as the virtual elimination of terrestrial species. The most evident indication of the deepening of the water is the lithology itself--marl.

The peat of Unit 1 suggests that in time the water began to recede and vegetation encroached upon the lake as it eventually became extinct. Based upon the ecology of the mollusks, however, the picture is not quite as evident. A general increase upward of *F. obrussa decampi* toward Unit 1, the disappearance of some of the minor freshwater forms, and the reappearance of some of the land snails, certainly support the interpretation of the lithology. The fact that the collection of Unit 1-1 came from the basal three inches, coupled with the realization that the upper part of the section is probably disturbed more (this is cropland) than was originally thought, would help explain the high percentages of freshwater forms.

As described above, the type of lithology and the species present suggest that the Champaign deposit was w small shallow lake. The section studied was located near the margin and shows that extremely shallow water existed very early in the area, followed by a steady rising of the lake level. The shoreline of the lake shifted away (probably northward) and gradually returned again as the lake was filled in and became extinct. The lake was more than likely quiet and protected, as *Acella haldemani* and *Lymnaea stagnalis jugularis* are fairly fragile and sensitive to such an environment. Bottom conditions were soft, water vegetation fairly abundant and cool temperatures prevailed. Cool temperatures are indicated by numerous species, both freshwater and terrestrial. Freshwater species include *Helisoma anceps striatum*, *Valvata sincera*, and *Pisidium ferrugineum*. Terrestrial species include *Vertigo modesta*, *Vertigo gouldii*, *V. g. hannai*, *V. elatior*, and *Columella alticola*. All of these forms occur today in the latitude of Canada or northern United States. A few species are known farther south, but only in the higher altitudes.

Clark Deposit

Composition of the fauna

The fauna of the Clark deposit consists of an assemblage of freshwater mollusks made up of fourteen gastropod species, eleven pelecypod species, and two forms of one species of pelecypod. Four gill-breathing and ten lung-breathing gastropods are represented. A comparison of Table 3, Table 5, and the measured section (p. 8) shows that the fauna represents only the marl unit of the section. The peat unit appeared to be unfossiliferous and was not collected. The number of shells per collection unit shows a gradual increase from the lower to the upper part of the unit, except for collection 3-1 which was in part transitional with the peat unit above. *Amnicola lustrica*, *Gyraulus parvus*, and *Pisidium nitidum* are the most abundant species. These three are followed closely in numbers by *Fossaria obrussa decampi*, *Valvata sincera*, *V. tricarinata*, and *Pisidium ferrugineum*. *Helisoma anceps striatum*, *Pisidium nitidum* form *pauperculum*, and *Pisidium ventricosum* occur in small quantities, but are persistent throughout the deposit (see Table 5, Plates IV and V).

Interpretation

The above-mentioned species represent a typical lacustrine marl assemblage. At the collection site, the early history of the lake was one of reasonably shallow water with a soft substrate of marl with considerable vegetation. Four of the species are considered to be abundant enough to be indigenous: *G. parvus* (24 per cent), *P. nitidum* (24 per cent), *P. ferrugineum* (12 per cent), and *V. tricarinata* (10 per cent). All of these species prefer shallow water, *Pisidium* a soft substrate, and *G. parvus* abundant vegetation. The amphibious snail *F. obrussa decampi* (8 per cent) would indicate that very shallow mud flats and the shoreline were not far away. *V. sincera* (16 per cent) is common enough to be considered a native to the environment. However, this species is found today in the deep water of Lakes Michigan and Superior, an ecology which does not fit totally with that previously suggested. On the other hand, if its present preference for deep water is dictated by temperature, it could be considered native. That the water was cool at this time is supported also by such a preference for the species *P. ferrugineum* and *Helisoma anceps striatum*.

The remaining history of the lake appears to be a general decrease in depth and shifting of the shoreline toward the position of the collection site. Such an interpretation is suggested by the trends of reduction in *V. sincera, P. nitidum,* and *V. tricarinata,* as well as the increase in *F. obrussa decampi*. Postulating shallower water might seem anomalous, however, by the progressive decrease shown in *G. parvus*, a species which prefers such a habitat. On the other hand, considering this decrease along with the marked increase in *Amnicola lustrica* helps to explain the apparent anomaly. *A. lustrica* is a species that is also particularly abundant in shallow water, living among thick beds of vegetation. It would seem likely, then, that the reduction shown by *G. parvus* is due to its competition with *A. lustrica* in the habitat. Water temperature remained cool during the later stages of lake history as attested to by the persistence of *P. ferrugineum* and *H. anceps striatum*. Quiet, protected, and even swampy situations nearby are indicated by *Acella haldemani, Lymnaea stagnalis jugularis, Physa gyrina,* and *Promenetus exacuous*. That the shoreline of the lake eventually migrated southward over the collection site to its present position in the village of Crystal Lake is demonstrated by the peat and muck layers at the top of the marl.

Greene Deposit

Composition of the fauna

The Greene deposit differs greatly in both lithology and fauna from the other two lacustrine deposits studied (see Table 3, Table 6, and the measured section on p. 9). The section lacks the typical lacustrine marl accumulation so characteristic of the other two deposits. In the Greene deposit the modern, mucky surface soil is underlain by units of black peaty muck with irregular zones of travertine; calcareous, clayey, and peaty silt; and gray clay. The correlation between the units of the measured section and the number of shells per collection unit is not immediately clear without some explanation. The break between Units 2 and 3 is marked by the sharp increase in shells as the peaty muck passes into the calcareous, peaty, and clayey silt. The contact between Unit 2 and Unit 1 can hardly be confirmed by the data based on the number of shells. This contact was in fact a rather arbitrary one made in the field and based only upon apparent fossil content and what appeared to be the upper disturbed zone. The most pronounced, apparent anomaly occurs at collections 2-5 and 2-11. This striking jump in shell content however corresponds well with the observed interbedded travertine units mentioned in the measured section. The two most discernible travertine layers occurred at approximately nine and twenty-two inches from the top of the unit. These correspond approximately with collections 2-5 and 2-11.

TABLE 3. NUMBER OF SHELLS PER COLLECTION UNIT[a]

Champaign Co., O. Unit	#	Clark Co., O. Unit	#	Greene Co., O. Unit	#	Hamilton, O.[b] Unit	#
1-1	57	3-1	51264	1-1	4076		
2-1	34816	3-2	80000	1-2	1772	1	397
2-2	34016	3-3	63552	1-3	4670	2	923
2-3	22624	3-4	50304	1-2t	3080	3	1359
2-4	37856	3-5	57280	2-1	5070	4	1495
2-5	36192	3-6	64576	2-2	8418	5	802
2-6	30464	3-7	55296	2-3	9608	6	224
2-7	17424	3-8	64000	2-4	5028	7	112
2-8	14128	3-9	54016	2-5	17136	8	107
2-9	4320	3-10	47040	2-6	22980	9	181
2-10	2952	3-11	40992	2-7	13560	10	99
3-1	3156	3-12	39616	2-8	13210	11	160
3-2	3544	3-13	30592	2-9	19200	12	134
3-3	2800	3-14	28800	2-10	18768		
3-4	4152	3-15	29184	2-11	14096		
3-5	4312	3-16[c]	14784	2-12	3732		
3-6	2976	3-17[d]	65728	2-13	4160		
3-7	1444			2-14	6456		
3-8	989			2-15	5936		
3-9	1052			3-1	16592		
3-10	1458			3-2	20592		
3-11	1824			3-3	37824		
3-12	1824			3-4[e]	174		
3-13	1572			3-5	3018		

a. Each collection of 2"x12"x12" equals approximately 4700cc of shells and debris.

b. Hamilton unit collections were 1"x12"x24".

c. Collection less than 2" thick.

d. Collection approximately 3" thick.

e. Low number of shells due to sampling error.

TABLE 4. VERTICAL DISTRIBUTION OF SPECIES IN THE CHAMPAIGN COUNTY, OHIO DEPOSIT.

Unit	Acella haldemani	Amnicola lustrica	Fossaria obrussa decampi	Armiger crista	Gyraulus deflectus	Gyraulus parvus	Helisoma anceps striatum	Helisoma campanulatum	Lymnaea stagnalis jugularis	Promenetus exacuous	Valvata sincera	Valvata tricarinata	Pisidium adamsi	Pisidium casertanum	Pisidium compressum	Pisidium ferrugineum	Pisidium milium	Pisidium nitidum	Pisidium nitidum f. contortum	Pisidium nitidum f. pauperculum	Pisidium variabile	Pisidium ventricosum	Sphaerium lacustre	Sphaerium sulcatum	Carychium exiguum	Columella alticola	Discus cronkhitei	Euconulus fulvus	Gastrocopta contracta	Gastrocopta pentodon	Hawaiia minuscula	Punctum minutissimum	Pupilla muscorum	Nesovitrea binneyana	Succinea avara	Vallonia gracilicosta	Vertigo elatior	Vertigo gouldii	Vertigo gouldii hannai	Vertigo modesta	Vertigo morsei	Vertigo ventricosa	Vertigo sp. immatures	Total specimens
1-1	-	-	12.1	-	-	37.9	-	-	-	-	13.8	1.7	-	-	-	-	-	-	-	5.2	6.9	-	-	-	-	-	-	-	1.7	13.8	-	-	1.7	-	5.2	-	-	-	-	-	-	-	-	58
2-1	-	0.5	23.7	0.1	-	39.9	0.1	0.1	-	0.1	8.9	1.8	-	-	0.8	0.1	-	1.2	-	21.2	1.0	0.3	-	-	-	-	-	-	-	0.2	-	-	-	-	0.1	-	-	-	-	-	-	-	-	1093
2-2	-	0.3	22.0	0.1	-	37.6	0.2	0.2	0.2	-	10.0	2.3	-	0.1	0.1	-	-	1.1	-	25.7	-	-	0.1	0.1	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	0.1	1060
2-3	0.1	0.2	21.2	0.1	0.1	32.0	0.9	-	-	-	17.2	3.3	-	-	6.7	-	-	0.9	-	13.6	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	995
2-4	-	-	19.7	0.2	0.1	36.0	0.2	-	-	0.1	11.5	3.4	-	-	1.0	-	-	0.1	-	25.5	2.0	0.3	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1191
2-5	0.1	-	19.0	-	0.1	37.3	0.7	-	-	0.1	9.9	3.2	-	0.1	2.7	0.1	-	0.3	-	24.8	1.3	0.1	-	0.1	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	1131
2-6	0.1	-	15.8	-	0.1	34.0	0.4	0.1	-	-	15.8	3.2	-	0.1	3.4	-	-	-	-	23.7	3.0	0.1	-	0.1	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	1046
2-7	-	-	11.5	0.1	-	29.7	0.1	-	-	-	20.1	1.4	-	-	2.0	-	-	-	-	32.7	1.8	0.4	-	0.1	-	-	-	-	-	0.1	-	-	-	-	0.2	-	-	-	-	-	-	-	-	1142
2-8	-	-	11.2	0.3	-	37.0	0.5	-	-	0.1	18.1	1.3	-	0.2	2.8	0.1	-	-	-	24.5	3.5	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	0.1	-	1020
2-9	-	-	14.0	0.1	-	34.6	0.7	-	-	-	23.3	0.8	-	0.8	3.3	0.2	-	1.6	0.2	17.0	2.5	0.5	-	-	-	-	-	0.1	-	0.1	-	-	-	-	0.6	-	-	-	-	-	-	-	-	1071
2-10	-	-	16.6	0.3	-	33.5	0.2	-	-	-	15.1	-	-	6.5	2.6	0.8	-	-	-	13.8	2.3	2.5	0.2	-	0.1	0.1	0.5	0.1	-	0.8	-	-	0.1	-	2.2	0.2	0.9	0.2	-	0.3	0.3	-	-	964
3-1	0.2	-	19.2	-	-	27.0	0.2	-	-	-	10.2	0.1	-	16.2	2.7	0.7	-	9.5	0.2	5.0	0.9	0.6	-	-	0.1	0.4	-	0.2	-	0.8	0.2	-	-	0.1	3.9	0.3	0.7	-	-	0.3	0.3	-	0.4	1098
3-2	-	-	20.7	0.2	-	31.1	0.1	-	-	-	7.2	-	-	12.8	0.7	0.9	-	10.7	-	8.3	0.7	0.2	-	-	-	-	0.4	0.1	-	0.2	0.1	-	-	-	2.8	0.1	0.8	-	-	0.2	1.2	-	0.7	902
3-3	-	-	27.6	0.1	-	25.3	-	-	-	-	6.5	-	0.1	17.6	0.8	0.4	0.1	5.7	-	5.5	0.4	1.3	-	-	0.1	-	-	-	-	1.5	0.2	-	0.1	0.3	3.3	0.1	1.1	0.1	-	0.6	1.1	-	0.5	1051
3-4	-	-	24.2	0.1	-	23.3	-	-	-	0.1	4.7	-	-	10.4	1.2	9.2	0.1	16.4	-	1.4	0.1	1.0	-	-	0.4	-	-	0.4	-	1.4	0.1	-	-	0.1	2.9	0.7	0.4	0.1	-	0.1	1.4	-	0.3	1413
3-5	-	-	36.9	-	-	22.2	-	-	-	-	4.2	-	-	16.7	1.3	0.4	-	3.4	0.1	0.6	0.1	0.8	-	-	0.1	-	-	0.4	-	2.5	0.2	-	0.2	-	5.5	0.5	1.0	-	-	0.2	1.6	-	1.5	1151
3-6	-	-	39.0	-	-	11.7	-	-	-	-	1.5	-	-	9.5	1.2	0.1	0.3	1.2	-	1.0	-	0.1	-	-	-	0.1	0.1	0.6	0.1	7.1	-	-	-	1.8	13.6	2.1	3.1	0.1	0.1	1.0	2.2	-	2.8	1049
3-7	-	-	40.0	0.1	-	3.5	-	-	-	-	0.4	-	-	4.7	0.9	-	-	0.4	-	0.7	0.1	-	-	-	0.3	0.6	0.6	1.0	-	8.3	-	-	0.1	2.2	19.3	3.3	3.0	0.6	0.4	0.9	3.5	0.2	5.1	1073
3-8	-	-	30.2	-	-	2.3	-	-	-	-	0.9	0.1	-	5.4	0.5	-	-	-	-	0.5	-	-	-	-	0.3	0.2	0.5	1.0	0.1	7.0	-	0.4	0.4	1.6	22.6	3.3	5.5	0.1	0.3	1.6	9.7	0.8	5.0	1028
3-9	-	-	50.8	-	-	2.0	-	-	-	-	0.5	-	-	-	1.0	-	-	-	-	0.1	-	-	-	-	0.1	-	0.6	0.6	-	3.1	-	-	0.2	2.3	23.4	3.1	3.1	0.2	0.5	0.6	3.1	0.5	4.3	821
3-10	-	-	34.6	-	-	1.8	-	-	-	-	1.1	-	-	4.0	0.7	0.4	-	9.6	-	0.8	-	-	-	-	0.2	0.3	0.4	0.7	-	5.1	-	-	0.8	1.7	18.6	3.9	5.9	-	0.4	2.1	2.4	0.1	4.2	987
3-11	-	-	42.2	-	-	1.8	-	-	-	-	0.9	-	-	4.8	3.0	0.1	-	0.3	-	1.5	-	-	-	-	-	0.5	1.4	0.6	-	2.4	-	-	1.0	0.7	20.4	2.8	7.4	-	0.6	2.4	1.6	0.3	4.1	1043
3-12	-	-	43.7	-	-	1.5	-	-	-	-	1.2	-	-	0.1	8.2	-	-	-	-	1.1	-	-	-	-	-	0.5	1.2	-	-	1.3	-	-	0.8	0.8	17.5	6.3	7.7	-	-	1.9	1.1	0.2	5.1	974
3-13	-	-	55.8	-	-	0.8	-	-	-	-	0.8	-	-	7.3	2.8	-	-	0.3	-	0.3	-	-	-	-	-	-	0.6	0.6	-	2.4	-	-	0.5	1.6	9.3	2.9	7.1	-	-	1.4	2.9	0.2	2.5	646

The fauna in this deposit is also quite different. Of the thirty-two species represented, only seven are freshwater forms. These consist of three pelecypods and four lung-breathing gastropods. All of the twenty-seven remaining species are terrestrial forms which are persistent throughout the deposit. Some occur in very small numbers, others are common but not abundant, and still others are abundant. *Gastrocopta tappaniana, G. contracta, Oxyloma retusa, Strobilops labyrinthica,* and *Succinea grosvenori gelida* are most abundant. Only one freshwater gastropod approaches the quantities of the terrestrial species – the amphibious *Fossaria obrussa decampi*. (Plates VI, VII, and VIIIL.

Interpretation

Earlier reference to the Greene deposit as lacustrine is for the most part a misnomer. The fauna, the majority of the lithologies in the section, and the geologic situation seem to militate against a lacustrine interpretation. The deposit is located in a bottom-land area of Hebble Creek, not topographically enclosed at present. Closed depressions however, are not uncommon in kame or kame-moraine areas such as this. The only lithologic evidence suggesting a depression is the light gray clay found in Unit 4. If there was a depression sufficient for a lake, it was small and became filled with clay early in its history. The latter part of the history of the Greene deposit is that represented by Units 3 through 1 and their enclosed mollusks. The history suggested is one of a low, poorly drained, wet, swampy area with abundant vegetation. The lung-breathing snail *Fossaria obrussa decampi* and the clam *Pisidium casertanum* are the only freshwater forms that occur in any abundance in the peaty-muck sequence. Both forms are well adapted to such an environment There appears to be some correlation of their peak abundances with the times of accumulation of travertine in the section. These times probably represent episodes of running water. *Physa gyrina* and *Gyraulus parvus* are also lung-breathing snails that are present, but not abundant. The former has a preference for a swampy environment, and the latter can exist in it.

Most of the land snails present could probably exist in the environment postulated. However, *G. contracta, G. tappaniana, O, retusa, S. labyrinthica,* and *S. grosvenori gelida* are the most abundant, and probably represent the major indigenous species. Although in lesser numbers, *Hawaiia minuscula* and *Vertigo milium* appear also to be compatible. *Helicodiscus parallelus, Carychium exiguum,* and the other land snails that occur more rarely, are those that have been washed in from the meadows and woodlands that surrounded the deposit.

Hamilton Deposit

Composition of the fauna

The fauna of the Hamilton interstadial silt consists largely of an assemblage of terrestrial species with minor freshwater forms. More specifically, fourteen terrestrial gastropods, two lung-breathing gastropods, two gill-breathing gastropods, and two freshwater pelecypods are represented. *Succinea grosvenori gelida, Vertigo elatior, Vallonia gracilicosta, Pupilla muscorum,* and *Vertigo modesta* are the most abundant and persistent species (See Table 7 and Plate IX).

Interpretation

A comparison of the measured section (p. 9) and the number of shells per unit (Table 3) suggests that the species seem to be most abundant in the upper silt unit. However, there is a fairly gradual increase upward rather than a marked one where the lithology changes. This would suggest that time, rather than any marked change in lithology or environment, was the major factor. From the standpoint of environment, all three lithologies seem to have been environmentally similar for the mollusks once they became established.

TABLE 5. VERTICAL DISTRIBUTION OF SPECIES IN THE CLARK COUNTY, OHIO DEPOSIT.

Unit	Acella haldemani	Amnicola limosa	Amnicola lustrica	Fossaria obrussa decampi	Armiger crista	Gyraulus deflectus	Gyraulus parvus	Helisoma anceps striatum	Helisoma campanulatum	Lymnaea stagnalis jugularis	Physa gyrina	Promenetus exacuous	Valvata sincera	Valvata tricarinata	Pisidium compressum	Pisidium ferrugineum	Pisidium milium	Pisidium nitidum	Pisidium nitidum f. contortum	Pisidium nitidum f. pauperculum	Pisidium variabile	Pisidium ventricosum	Pisidium walkeri f. mainense	Sphaerium lacustre	Sphaerium rhomboideum	Sphaerium securis	Sphaerium sulcatum	Total specimens
3-1	-	2.1	35.4	17.8	-	-	16.6	0.4	-	-	0.1	-	0.5	9.1	0.7	3.2	-	9.4	1.8	2.2	-	0.8	-	-	-	-	-	984
3-2	-	0.8	29.9	15.9	0.2	-	12.9	0.2	-	0.1	0.2	-	0.3	11.6	0.2	7.2	-	15.8	2.9	-	-	1.9	-	0.1	-	-	-	1364
3-3	-	-	35.5	8.1	-	-	14.6	0.1	-	-	-	-	0.9	12.9	-	8.0	-	15.2	4.4	-	-	0.3	-	-	-	-	-	992
3-4	-	0.6	36.8	7.1	0.1	0.1	11.9	0.5	0.1	-	0.1	-	0.7	6.9	-	10.1	-	17.1	5.2	-	0.1	1.8	-	1.0	0.1	-	-	1076
3-5	-	-	32.9	9.2	-	0.1	16.3	0.3	0.6	-	0.5	0.1	1.6	7.7	-	6.5	-	16.8	6.0	0.3	0.2	1.0	-	0.1	-	-	-	1015
3-6	-	-	26.5	8.8	0.1	0.1	16.6	0.1	0.3	-	0.6	-	2.4	8.3	0.2	10.4	-	19.9	3.6	-	0.3	1.6	-	0.1	-	-	-	901
3-7	-	-	23.8	12.5	-	0.4	17.5	0.2	1.3	-	0.5	-	4.0	9.3	-	22.2	-	1.4	5.0	-	-	1.5	-	0.4	-	-	0.1	857
3-8	-	1.2	15.0	6.5	-	0.2	15.5	1.0	1.7	-	0.3	-	4.0	9.5	0.1	19.8	-	19.0	3.9	-	0.2	1.9	-	0.2	-	0.1	0.1	1008
3-9	-	-	15.7	4.5	-	0.9	14.7	0.7	0.8	-	0.3	-	4.6	10.0	-	18.4	0.2	22.6	5.1	-	-	0.8	-	0.6	-	0.1	0.1	1007
3-10	-	0.8	9.7	6.7	-	0.4	15.5	1.1	0.5	-	0.2	-	5.5	11.1	-	15.5	0.1	30.1	1.9	-	-	0.9	-	-	-	-	0.1	1015
3-11	-	0.5	9.7	5.1	-	0.4	16.9	0.6	0.2	0.1	0.1	-	6.1	11.3	-	19.2	-	26.4	2.8	-	-	0.7	0.1	-	-	-	0.1	1302
3-12	-	0.3	7.6	6.3	0.1	0.3	18.1	0.6	0.3	-	0.1	-	7.7	10.3	0.2	17.1	-	28.7	1.6	-	-	0.4	-	0.3	-	-	-	1242
3-13	-	1.2	10.0	5.1	-	0.3	16.8	0.9	0.7	-	0.7	-	5.7	10.9	-	20.1	-	24.5	1.7	-	-	1.3	-	-	-	-	0.2	1033
3-14	0.2	0.9	7.4	6.4	-	0.3	19.6	0.7	0.3	-	-	0.1	7.0	12.5	-	15.8	-	26.3	1.5	0.1	0.1	0.4	-	0.4	-	-	0.1	1021
3-15	-	-	5.1	5.6	0.1	0.2	23.3	0.3	0.1	-	-	-	11.9	12.0		16.7	-	23.6	0.3	0.1	-	0.6	-	0.2	-	-	-	1025
3-16	-	0.3	1.7	6.1	0.2	0.2	25.4	0.3	-	-	-	-	13.3	8.1	0.2	16.3	-	26.5	0.6	-	-	0.6	-	0.1	-	-	-	999
3-17	-	-	0.8	8.3	0.1	0.2	24.2	0.2	-	-	-	-	16.6	10.1	0.2	12.2	-	24.2	1.0	0.4	0.2	1.5	-	-	-	-	-	1025

TABLE 6. VERTICAL DISTRIBUTION OF SPECIES IN THE GREENE COUNTY, OHIO DEPOSIT.

Unit	Ferrissia parallela	Fossaria obrussa decampi	Gyraulus parvus	Physa gyrina	Deroceras sp.	Carychium exiguum	Euconulus fulvus	Gastrocopta armifera	Gastrocopta contracta	Gastrocopta tappaniana	G. contracta & G. tappiana immatures	Hawaiia minuscula	Helicodiscus parallelus	Mesodon clausus	Oxyloma retusa	Punctum minutissimum	Pupoides albilabris	Nesovitrea binneyana	Glyphyalinia indentata	Stenotrema leaii	Strobilops labyrinthica	Succinea grosvenori gelida	Vallonia gracilicosta	Vallonia pulchella	Vertigo cf. gouldii	Vertigo milium	Vertigo morsei	Vertigo ovata	Zonitoides arboreus	Pisidium casertanum	Pisidium nitidum	Pisidium variabile	Total specimens
1-1	-	10.1	1.3	0.1	1.3	0.1	-	0.3	6.1	31.3	19.4	-	2.4	-	7.3	0.1	0.5	-	-	0.4	7.1	5.2	-	0.3	-	3.9	0.3	1.9	-	1.0	-	-	1009
1-2	-	11.3	0.3	0.1	-	-	-	0.1	6.7	27.6	14.7	-	3.6	-	12.7	-	1.8	-	1.1	0.5	7.6	2.6	-	1.0	-	2.8	0.5	3.3	0.1	0.8	-	-	879
1-3	0.1	13.9	0.6	0.1	0.1	-	0.3	0.2	9.0	23.7	18.6	-	2.5	-	8.2	-	1.8	0.5	1.1	0.8	5.8	5.7	0.2	-	0.1	1.0	0.5	3.1	0.4	1.1	-	-	924
1-2t	-	8.8	0.4	-	-	17.5	-	-	4.2	16.8	22.1	-	2.7	-	7.1	-	0.8	0.3	0.7	-	6.2	7.0	-	-	-	2.3	-	1.8	0.1	1.2	-	-	770
2-1	-	6.6	0.1	-	0.1	0.3	-	-	3.5	29.1	12.8	-	4.6	-	11.3	-	-	-	-	-	12.3	16.5	-	-	-	2.3	-	0.2	-	-	-	-	819
2-2	-	5.9	-	0.2	0.6	3.2	-	0.1	4.8	28.4	8.6	11.0	3.2	-	7.1	-	-	0.1	0.5	0.7	10.6	10.3	-	-	-	2.9	-	-	0.1	1.6	-	-	1403
2-3	-	2.8	0.2	-	2.3	2.5	0.1	0.3	7.8	24.3	13.5	10.1	4.8	0.1	7.2	-	-	0.3	1.5	-	8.7	7.9	-	-	-	5.4	-	-	0.1	0.3	-	-	1201
2-4	-	1.4	0.2	0.3	0.3	0.3	-	1.3	6.2	25.1	11.2	7.1	11.4	-	10.2	0.1	-	0.2	3.3	0.2	6.5	11.3	-	-	-	2.9	0.1	-	0.1	0.2	-	-	938
2-5	-	6.9	0.2	1.2	1.0	0.5	-	0.5	4.4	24.8	14.4	5.8	5.1	-	12.8	-	-	0.4	0.7	0.2	7.2	10.8	-	-	-	1.9	0.6	-	0.2	0.6	-	-	1071
2-6	-	3.0	0.1	0.3	0.9	2.4	-	0.2	4.1	31.7	15.5	3.6	1.8	0.1	9.8	-	-	1.0	1.0	0.4	9.3	10.2	-	-	-	3.9	0.4	-	0.1	0.4	-	-	1149
2-7	-	3.3	0.1	-	4.1	0.5	-	0.2	9.3	22.4	20.1	6.1	3.8	-	8.4	-	0.1	0.6	2.0	0.2	8.3	5.7	-	-	-	4.1	0.2	-	0.2	0.6	-	-	1356
2-8	-	1.2	0.2	0.2	2.7	1.4	-	0.1	8.1	30.5	19.7	6.7	3.0	-	7.2	-	-	0.1	1.1	0.3	4.6	8.7	-	-	-	3.3	0.2	-	0.2	0.8	-	-	1321
2-9	-	3.6	0.4	0.7	0.8	2.3	-	-	6.7	26.8	23.7	2.2	2.2	-	8.1	-	-	0.2	0.6	0.4	7.0	7.4	-	-	-	5.0	0.3	0.2	0.6	0.9	-	-	1200
2-10	-	11.3	1.5	2.5	0.4	-	-	-	2.8	23.1	11.5	0.2	0.7	-	18.0	-	-	-	0.3	0.1	4.1	6.0	-	-	-	4.0	2.3	-	1.7	9.5	-	-	1173
2-11	-	11.2	3.0	1.3	1.3	0.6	-	-	0.9	26.0	13.8	0.7	0.5	-	19.4	-	-	0.1	0.1	0.2	2.5	4.5	-	-	-	0.6	1.4	-	-	12.0	-	-	881
2-12	-	13.5	1.3	2.7	0.1	4.3	-	-	2.1	29.7	13.4	0.3	0.5	-	17.0	-	0.1	0.2	0.3	0.4	3.8	2.0	-	-	-	0.3	0.9	-	-	7.0	-	0.1	933
2-13	-	6.6	3.1	0.3	-	7.7	-	0.1	2.8	38.5	9.1	0.4	0.6	-	7.4	-	-	0.7	1.0	0.7	11.9	1.4	-	-	-	1.5	0.2	-	-	6.2	-	-	1040
2-14	-	7.3	1.7	0.1	2.9	3.0	-	5.3	13.1	10.4	14.9	9.5	3.7	-	8.9	-	-	1.2	2.9	1.1	5.8	0.6	-	-	-	4.0	0.3	-	-	3.2	-	-	807
2-15	-	4.2	3.5	0.4	0.9	0.9	-	7.5	13.7	17.8	17.1	9.3	6.4	0.1	9.7	0.1	-	0.1	4.2	-	1.8	-	-	-	-	1.2	0.5	-	-	0.7	-	-	1113
3-1	-	10.5	7.9	1.7	0.5	-	-	4.1	4.1	27.8	12.2	2.4	4.9	0.1	12.8	-	-	-	2.9	0.1	3.7	0.7	-	-	-	0.7	1.0	-	0.2	1.7	-	-	1037
3-2	-	5.8	2.4	0.2	0.2	0.5	-	0.2	0.4	46.3	24.1	0.2	2.6	0.1	8.5	-	-	-	0.8	0.3	3.8	0.6	-	-	-	1.9	0.6	-	0.2	0.2	0.2	-	1287
3-3	-	4.7	0.7	0.2	0.9	9.4	0.3	0.2	0.3	45.5	23.1	0.5	0.7	-	6.4	-	-	0.8	0.8	0.3	3.0	0.4	-	-	-	1.5	0.3	-	0.1	0.2	-	-	1182
3-4	-	4.6	4.6	-	-	9.2	-	3.5	1.2	19.6	21.9	-	6.9	-	17.3	-	-	-	3.5	-	5.8	-	-	-	-	2.3	-	-	-	-	-	-	87
3-5	-	7.0	3.1	0.4	-	0.7	0.1	1.5	2.1	39.3	27.0	1.3	2.3	0.1	6.2	-	-	1.3	0.9	0.4	2.4	0.6	-	-	-	1.7	0.6	-	0.1	1.1	-	-	1509

TABLE 7. VERTICAL DISTRIBUTION OF SPECIES IN THE HAMILTON, OHIO INTERSTADIAL DEPOSIT.

Unit	Euconulus fulvus	Nesovitrea binneyana	Discus cronkhitei	Vallonia gracilicosta	Gastrocopta armifera	Gastrocopta tappaniana	Columella alticola	Pupilla muscorum	Vertigo modesta	Vertigo elatior	Vertigo gouldii	Vertigo gouldii hannai	Succinea grosvenori gelida	Deroceras sp.	Fossaria parva	Gyraulus parvus	Valvata sincera	Amnicola limosa	Pisidium cf. ferrugineum	Pisidium cf. nitidum	Total specimens
1	0.3	-	-	17.2	0.3	-	16.7	5.6	4.8	27.8	3.0	0.5	23.7	-	0.3	-	-	-	-	-	396
2	-	0.1	-	14.3	0.1	0.1	4.9	2.1	3.3	26.9	2.6	0.2	44.3	0.3	0.4	0.1	-	-	-	0.2	921
3	-	-	0.1	15.6	-	0.1	3.9	2.2	4.6	29.2	2.0	0.4	40.4	-	1.1	0.3	-	-	-	0.1	763
4	-	0.2	-	15.0	-	0.1	5.4	3.3	5.4	28.1	1.1	1.2	39.5	-	0.7	-	-	-	-	-	987
5	0.2	0.2	-	13.7	0.2	-	9.2	1.5	3.2	15.8	0.3	1.6	54.0	-	-	-	-	0.2	-	-	620
6	-	-	-	6.2	-	-	5.8	2.2	11.1	17.8	0.9	1.8	53.3	-	-	-	-	-	-	0.9	225
7	-	-	-	8.0	-	-	-	-	4.4	14.3	7.1	2.7	61.6	-	1.8	-	-	-	-	-	112
8	-	-	-	13.1	-	-	-	4.7	10.3	21.5	4.7	2.8	40.2	-	-	0.9	0.9	-	0.9	-	107
9	-	-	-	16.0	-	-	2.2	3.9	5.5	23.2	-	-	48.1	-	0.5	-	-	0.5	-	-	181
10	-	-	-	23.2	-	-	-	28.3	3.0	-	-	-	44.4	-	-	-	-	-	1.0	-	99
11	-	-	-	21.9	-	-	-	25.0	1.3	-	-	0.6	50.0	-	-	-	-	-	1.3	-	160
12	-	-	-	15.7	-	-	-	23.9	1.5	0.8	0.8	0.8	56.7	-	-	-	-	-	-	-	134

Table 7 suggests that the time of establishment occurred at about collection 8 to 9. The habitat suggested by the mollusks is one of a low, very moist area with considerable vegetation. The presence of sand and gravel in the lower part probably means that the area was a drainage way for glacial meltwater during a short ice-recession. Traces of freshwater species and terrestrial forms such as *Euconulus fulvus, Nesovitrea binneyana* and *Discus cronkhitei* suggest that lacustrine, higher grassy, and possibly woodland environments were not too far away.

The percentages of individual species appear to suggest some trends. However, most of these tend to be negated when they are related to the very small numbers of specimens upon which the percentages are based. *Succinea grosvenori gelida, Pupilla muscorum,* and *Vallonia gracilicosta* appear to be the hardy species that first occupied the area before the habitat became well established. *P. muscorum, V. gracilicosta,* and *S. grosvenori* (*S. g. gelida* is extinct) are known from more extreme environments with less vegetation, a situation that is quite probable in the early stages as the ice vacated the area.

Vertigo elatior, V. gouldii, V. gouldii hannai, V. modesta, and *Columella alticola* are all forms (see *Ecology* section for each species) that exist today in Canadian latitudes. Those that do occur in the United States do so in the very northern part, or in higher altitudes farther south. Their presence suggests a cooler climate than exists at the present time. Gooding (1963) and Kapp and Gooding (1964) indicate that in Indiana some of the same units that contain cool-climate mollusks also contain pollen, mosses, and wood fragments characteristic of cooler latitudes. Thus, the Hamilton interstadial which correlates with the Connersville Interstadial of Indiana, represents a significant but relatively short fluctuation of the Wisconsin ice.

CONCLUSIONS

Paleoecology

Lacustrine deposits

The quantitative study of the three deposits demonstrated that two were quite similar and the third was considerably different. The Clark deposit consists of a typical lacustrine marl assemblage indicating a shallow, rather quiet and protected lake, with a soft substrate and considerable vegetation. The lakes must have had a history of progressive shallowing and encroachment of the surrounding bog and terrestrial environment. The Champaign deposit consists also of a lacustrine marl assemblage in its upper part. The lower part, however, is a sandy unit containing both freshwater and terrestrial mollusks. The lithology and distribution of the mollusks suggest that an early history of deepening and occasional flooding preceded a later history much like that interpreted for the Clark deposit.

The Greene deposit is not typically lacustrine. It consists of a sequence of peat, muck, and travertine over clay, and its fauna is almost completely terrestrial. A low swampy area would afford a suitable environment for the fauna.

Cooler temperatures were indicated for the time during which the above deposits accumulated. Such species as *Helisoma anceps striatum, Pisidium ferrugineum, Vertigo modesta, V. gouldii, V. elatior,* and *Columella alticola* exist today only in higher latitudes and altitudes. Pollen studies by Ogden (1966) of Silver Lake, Logan County, Ohio, confirm this interpretation. Silver Lake, which is located less than ten miles north of the Champaign deposit, contains pollen in the lower parts of the lake that is characteristic of the Northern Clay Belt region of Ontario.

Similar faunal assemblages have been studied by many previous workers. Confir-

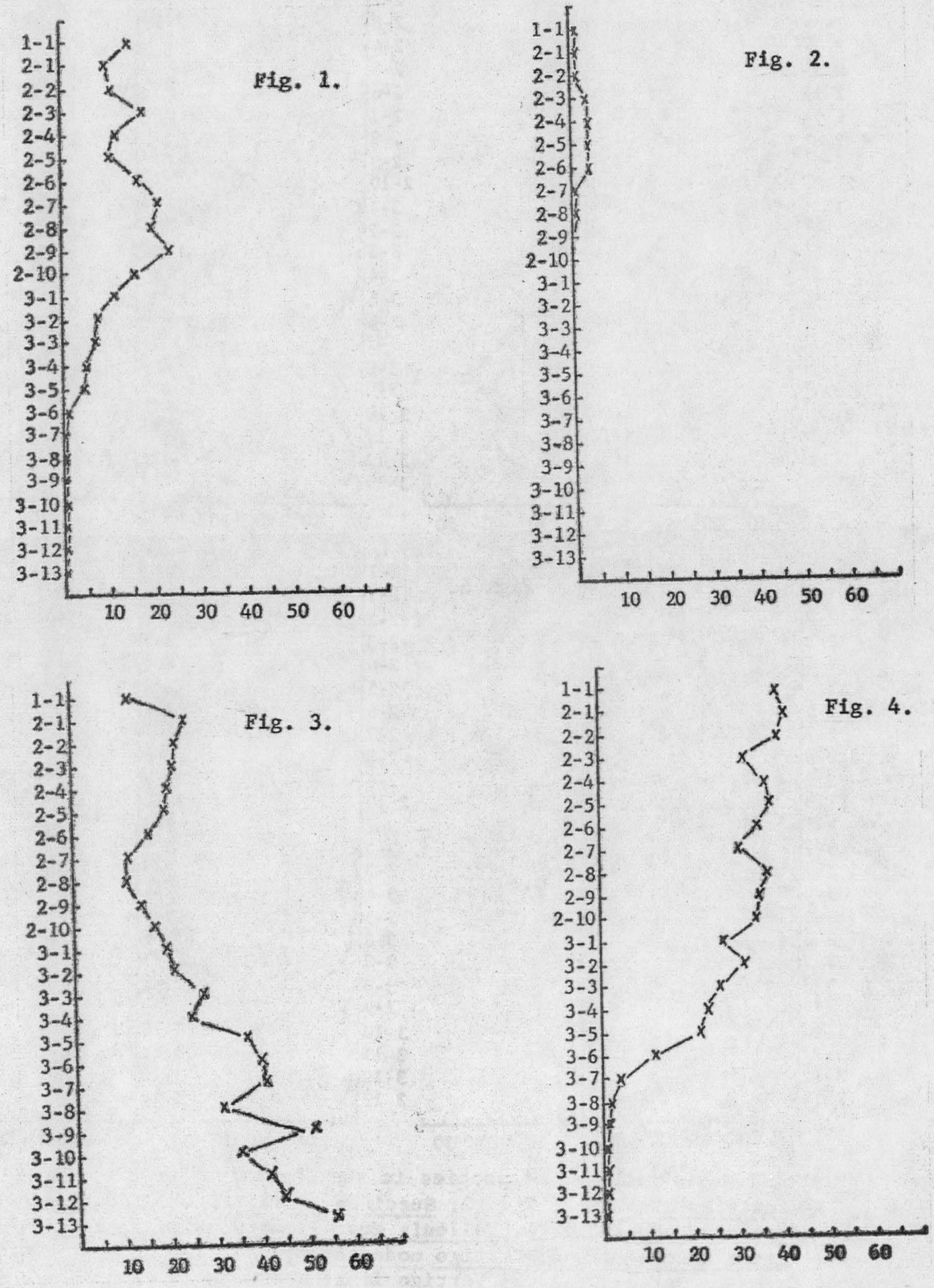


Plate I. Distribution of species in the Champaign Deposit. Fig. 1: Valvata sincera; Fig. 2: Valvata tricarinata; Fig. 3: Fossaria obrussa decampi; Fig. 4: Gyraulus parvus.

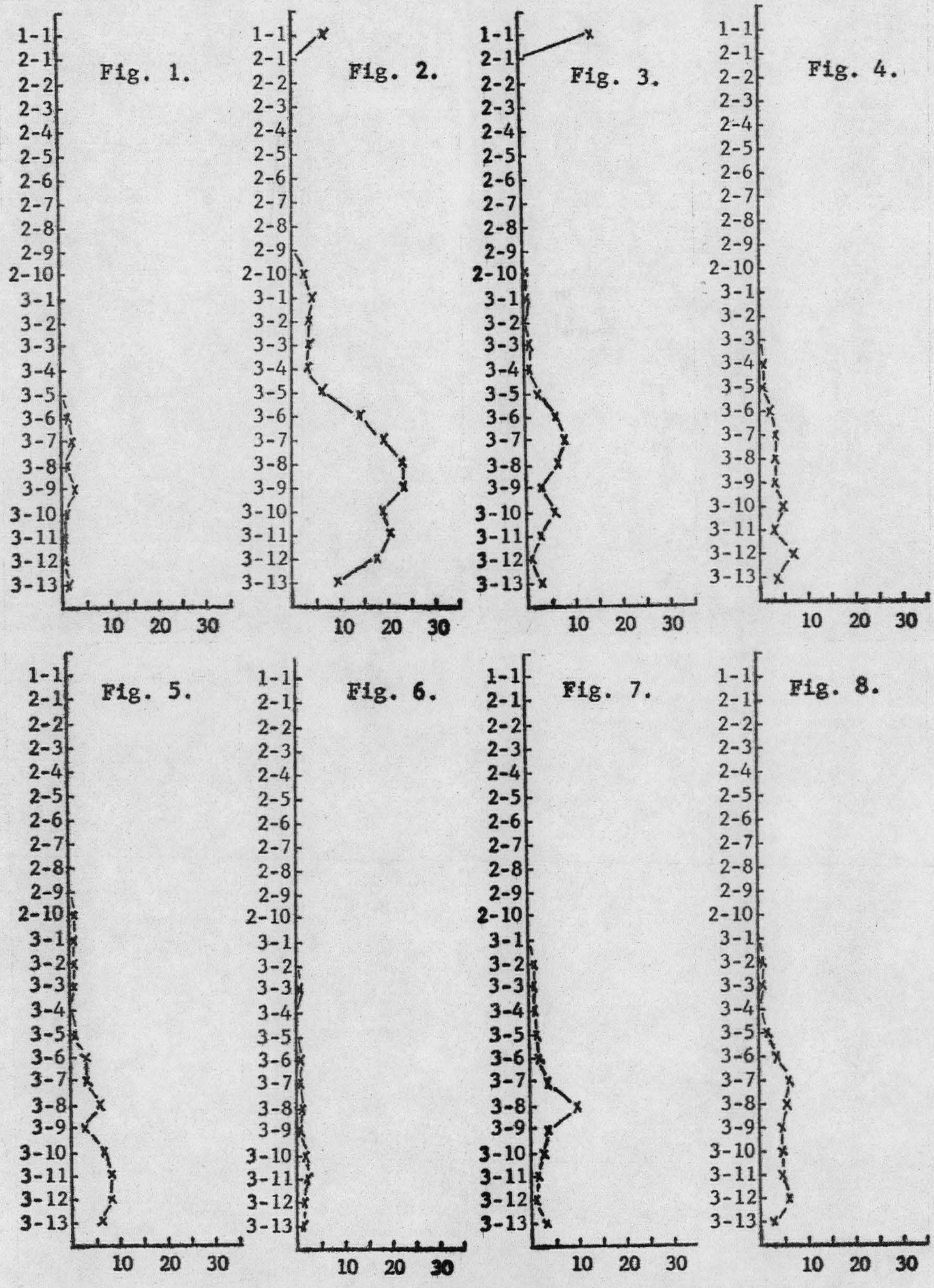


Plate II. Distribution of species in the Champaign Deposit. Fig. 1: Nesovitrea binneyana; Fig. 2: Succinea avara; Fig. 3: Gastrocopta pentodon; Fig. 4: Vallonia gracilicosta; Fig. 5: Vertigo elatior; Fig. 6: Vertigo modesta; Fig. 7: Vertigo morsei; Fig. 8: Vertigo immatures.

mation of interpretations and more accurate determinations of past environments can be made by comparison with other fossil and especially living assemblages. La Rocque (1966, p. 19-111) has compiled a number of these assemblages, both fossil and living, into a convenient volume. No fossil or living assemblage can be expected to conform exactly to any other assemblage. However, a number of those listed show reasonably close similarities to the ones studied. Two fossil assemblages most like the Clark and Champaign (upper marl lithology) deposits in over-all content include the W (Wisconsin) 45-47, Newell Lake deposit (p. 44), and W-48 to 51, Jewell Hill deposit (p. 45), both of Logan County, Ohio. The fossil assemblage most like the Clark, Wayne, and Champaign deposits in content of *Pisidium* is 2-52 to 55 (p. 46), the Aultman deposit of Stark County, Ohio. Most similar to the lower unit of the Champaign deposit in land snail content is the Castalia deposit (W-56 to 59, p. 47) of Erie County, Ohio. No fossil assemblage could be found that closely resembled the Greene deposit in over-all content. However, the Castalia deposit just mentioned fits most closely in its land snail assemblage. The Newell Lake, Jewell Hill, and Aultman deposits have peat and marl lithologies similar to the Clark and Champaign deposits. The Castalia deposit, which has the greatest similarity in land snail content, consists of marl, clay, sand, peat, and travertine. These resemble in some parts the lithologies of the Greene deposit and the lower unit of the Champaign deposit.

A living assemblage fairly close to the three lacustrine deposits is given by La Rocque (1966, p. 69). Assemblage Minnesota-10, Itasca County, west shore of the north bay of North Star Lake, indicates that the species lived in two to three feet of water on a sandy silt and mud bottom. The vegetation present included *Chara*, *Potamogeton*, *Vallisneria*, *Scirpus*, *Lemna*, *Nymphaea*, *Castalia*, and *Myriophyllum*.

The Hamilton Interstadial

The assemblage of the Hamilton deposit suggests that the mollusks lived in an area that was fairly moist, with considerable vegetation and plant debris, located along the flood plains of a meltwater stream. The presence of many northern species such as *Columella alticola*, *Vertigo elatior*, *V. gouldii*, *V. g. hannai*, and *V. modesta* suggest a cooler climate than exists presently. Gooding (1963) and Kapp and Gooding (1964) demonstrate cooler climates through the identification of mosses, coniferous and herbaceous pollen, and wood fragments in each of three interstadials in Indiana. One of these interstadials, the Connersville, was shown to be a correlative of the Hamilton deposit.

Watts and Bright (1968, p. 860-862) made a study of Pickerel Lake, Day County, in northeastern South Dakota. For the lake area the authors identified eight fairly well-defined habitats which are outlined below. Characteristics of each habitat and the species that are common to the Pickerel Lake region and the area of this report are given.

A. *Open lacustrine habitat*
substrate: marly silt and sand; water 3 m.; moderate current and waves; species: *Pisidium casertanum*, *Amnicola limosa*, *Gyraulus parvus*, *Helisoma anceps*, *Valvata tricarinata*.

B. *Sheltered lacustrine habitat*
substrate: marl, gyttja, marly silt, some sand; vegetation more dense than A. (*Potamogeton* common); water quiet and protected; water 3 m.; species: all from A above and *Sphaerium* sp., *Pisidium compressum*, *P. nitidum*, *Armiger crista*, *Ferrissia parallela*, *G. deflectus*, *Physa gyrina*, *Promenetus exacuous*.

C. *Perennial-stream habitat*
variable substrate, vegetation, and water conditions; drains both woods and grasslands; species: *P. compressum*, *Sphaerium* sp., *G. parvus*, *H.*

anceps, P. gyrina, V. tricarinata.

D. *Marsh habitat*
marginal to A or B; water level fluctuates; semiaquatic reeds dominant; moist vegetation to open muddy areas; species: *P. casertanum, Lymnaea stagnalis jugularis, Carychium exiguum, Gastrocopta tappaniana, Vertigo ovata.*

E. *Littoral habitat*
much affected by water level and storms; substrate wet mud, rocks, plant debris; species: *Fossaria obrussa,* cf. *Succinea.*

F. *Moist to wet habitats adjacent to water.*
Terrestrial snails found under logs, bark, litter, wooded slopes, or grasslands; moist, cool, more humid than other terrestrial habitats; species: *Carychium exiguum, G. tappaniana, V. ovata.*

G. *Moist woodland habitat*
Like F but farther from water; species include those from F, and *Discus cronkhitei, Euconulus fulvus, Zonitoides arboreus.*

H. *Dry woodland and grassland habitat*
Protected sites in grassland and woodland; snails live in debris of various kinds; drier than G; species: *Gastrocopta armifera, G. contracta, Hawaiia minuscula, Helicodiscus parallelus, Vallonia gracilicosta, Vertigo* sp.

The above list seems quite significant in that it gives in a very general way possible habitats for almost all of the deposits studied. However, the absence of the species of higher latitudes and altitudes so prevalent in the deposits of this study would indicate a cooler or more northerly latitude than northeastern South Dakota.

Origin of the Fauna

During the warm Sangamon Interglacial Stage, the life zones of plants and animals were well established for that climate. In the subsequent Wisconsin glaciation these established zones were obliterated by the ice as it advanced, forcing the migration of life southward before it. After reaching its maximum advance, the ice receded northward across the region, vacating the land for repopulation and migration by the various types of life, including the mollusks. In western Ohio the mollusks that migrated northward came from the Kentucky region. An examination of Bickel (1967), La Rocque (1959), Goodrich (1932), and Oughton (1948) indicates that a large number of the mollusks living today in Kentucky also live in Ohio, Michigan, and Ontario. Browne *et al.*, (1960, 1968) have studied the Mollusca of numerous deposits of Wisconsin loess in the area south of Louisville, Kentucky. A large part of the snails present in the Kentucky deposits are present also in the deposits of this study, representing a later stage in the recession of the Wisconsin ice northward. In addition, almost all of Browne's species are living today in Ohio, Michigan, and at least as far north as central Ontario, and in most cases beyond.

No doubt the major factor determining the rate at which the mollusks migrated was the speed of the melting back of the ice barrier. From the study of the deposits in this report, it would seem that many of the snails, both freshwater and terrestrial were living in the vicinity of the ice and were hardy enough to repopulate the area fairly soon after the ice receded. In some cases, however, certain species were not able to migrate as quickly. *Lymnaea stagnalis jugularis* and *Acella haldemani* are latecomers into the three lacustrine deposits in the area, and apparently represent less hardy and/or more slowly migrating forms. Roy (1964, p. 71) noted that in northeastern Wisconsin these species were absent from five Pleistocene lacustrine deposits, but living in the region today. Their presence in Ohio (Zimmerman, 1960, p. 20; Aukeman, 1960 p. 68 and 72), absence in the Pleistocene of Wisconsin, but presence living today prompted Roy to suggest slower migration for these two species.

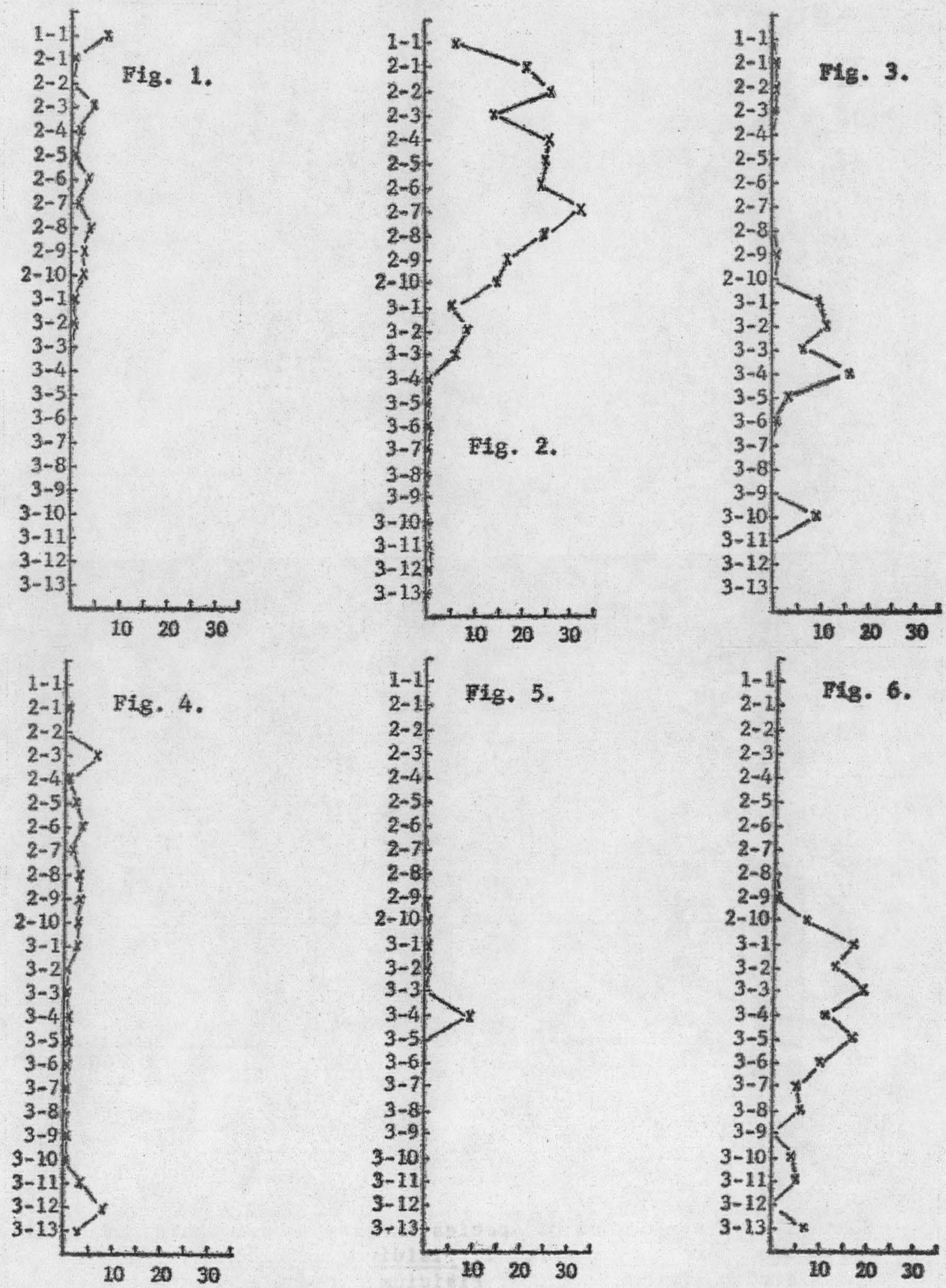
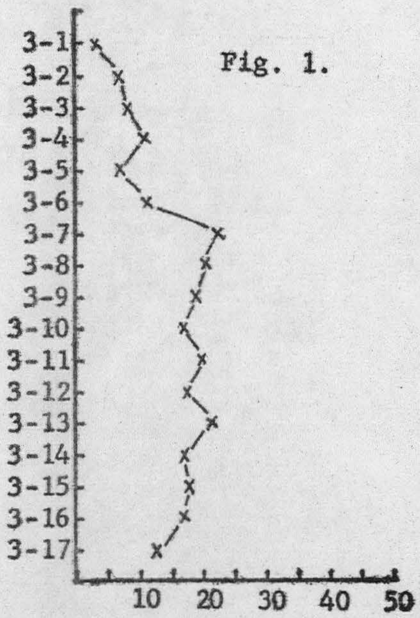
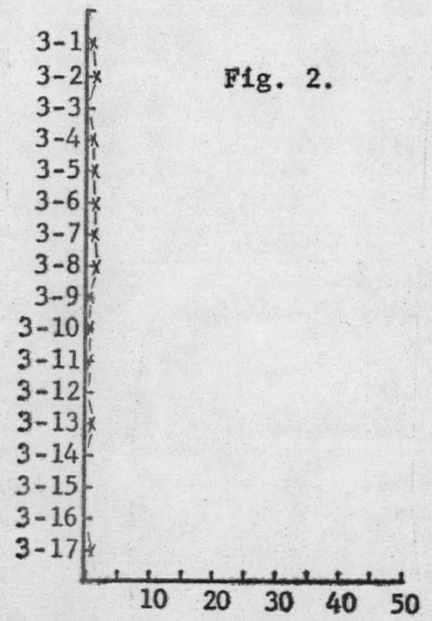
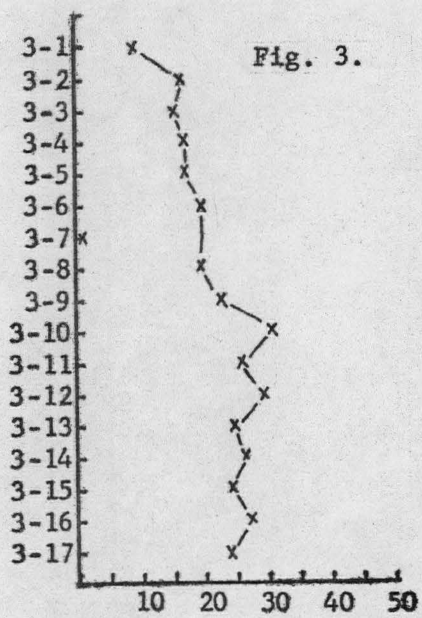


Plate III. Distribution of species in the Champaign Deposit. Fig. 1: Pisidium variabile; Fig. 2: Pisidium nitidum pauperculum; Fig. 3: Pisidium nitidum; Fig. 4: Pisidium compressum; Fig. 5: Pisidium ferrugineum; Fig. 6: Pisidium casertanum.







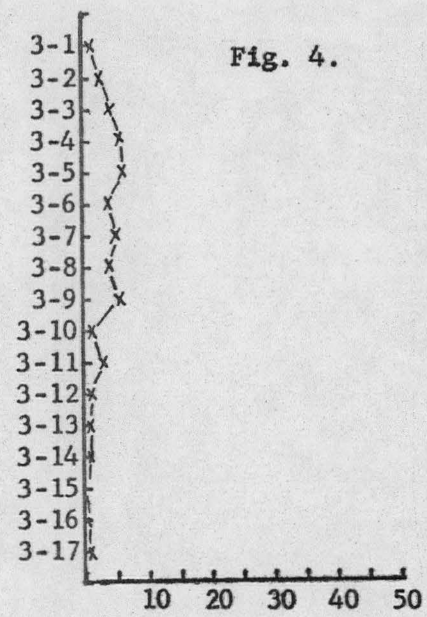


Plate IV. Distribution of species in the Clark Deposit. Fig. 1: *Pisidium ferrugineum*; Fig. 2: *Pisidium ventricosum*; Fig. 3: *Pisidium nitidum*; Fig. 4: *Pisidium nitidum* f. *contortum*.

These same two species are not living today in Ohio, but are limited to more northerly latitudes. Others showing a similar distribution pattern are *Helisoma anceps striatum, Columella alticola, Vertigo modesta,* and *Vertigo elatior*. Such species have already been used to demonstrate cooler climates in Ohio shortly after the ice retreat. They are snails that have migrated northward in response to the warming temperatures in the south.

Age and Correlation

The lacustrine deposits are all located within the same general area geologically. This is the area designated as the Champaign drift--Miami 60 soils (with Russell soils in the Springfield area) on Figure 1. It is possible and reasonable to assume that these lakes came into existence at approximately the same time. However, since the deposits are located on different sides of the Miami Lobe this is not certain.

Goldthwait (1958, p. 210) and Forsyth (1961, p. 6) indicate that the 'Late' Wisconsin ice reached its maximum extent 20,000 years ago in the Miami Lobe and 18,000 years ago in the Scioto Lobe. Dates of 13,000 to 14,000 years ago mark the later position of the glacier in the Lake Erie Basin. Thus the lacustrine deposits came into existence some time during this five to six thousand year period. Estimates for the time when the ice was receding through the area of this study were, until recently, only speculation. Dates of around 16,000 to 18,000 have been suggested. Ogden (1966, p. 398) in attempting to arrive at a date for the beginning of Silver Lake in Logan County, Ohio, states, '. . . radiocarbon dates from glacial and non-glacial deposits elsewhere in Ohio indicate that an age of 11,000 - 14,000 years, B.P. is appropriate for this part of Ohio.' A radiocarbon date of 10,778 ± 200 (OWU-39) corrected to 9,800 ± 200 for Paleozoic carbonate content in the lake system was given for material at a depth of 600-615 cm. in the lake. The core encountered till at 890 cm. Since Silver Lake is located just within the Farmersville moraine, it should be slightly younger than the lacustrine deposits of this report, which are located beyond the moraine.

The age and correlation of the Hamilton deposit was given under the discussion of the geology of the deposit on page 9. The suggested correlation of the interstadial silt at Hamilton with the Connersville Interstadial of southeastern Indiana was made on the basis of stratigraphic relations and radiocarbon dates. The mollusks yielded general information about the environment of the deposit and supplemented pollen data (by correlation) in demonstrating relatively cool climate intervals. Although the mollusks did not establish index fossils for the Pleistocene, the study did produce additional information which may eventually lead to a list of species and ranges applicable to the Ohio-Indiana area.

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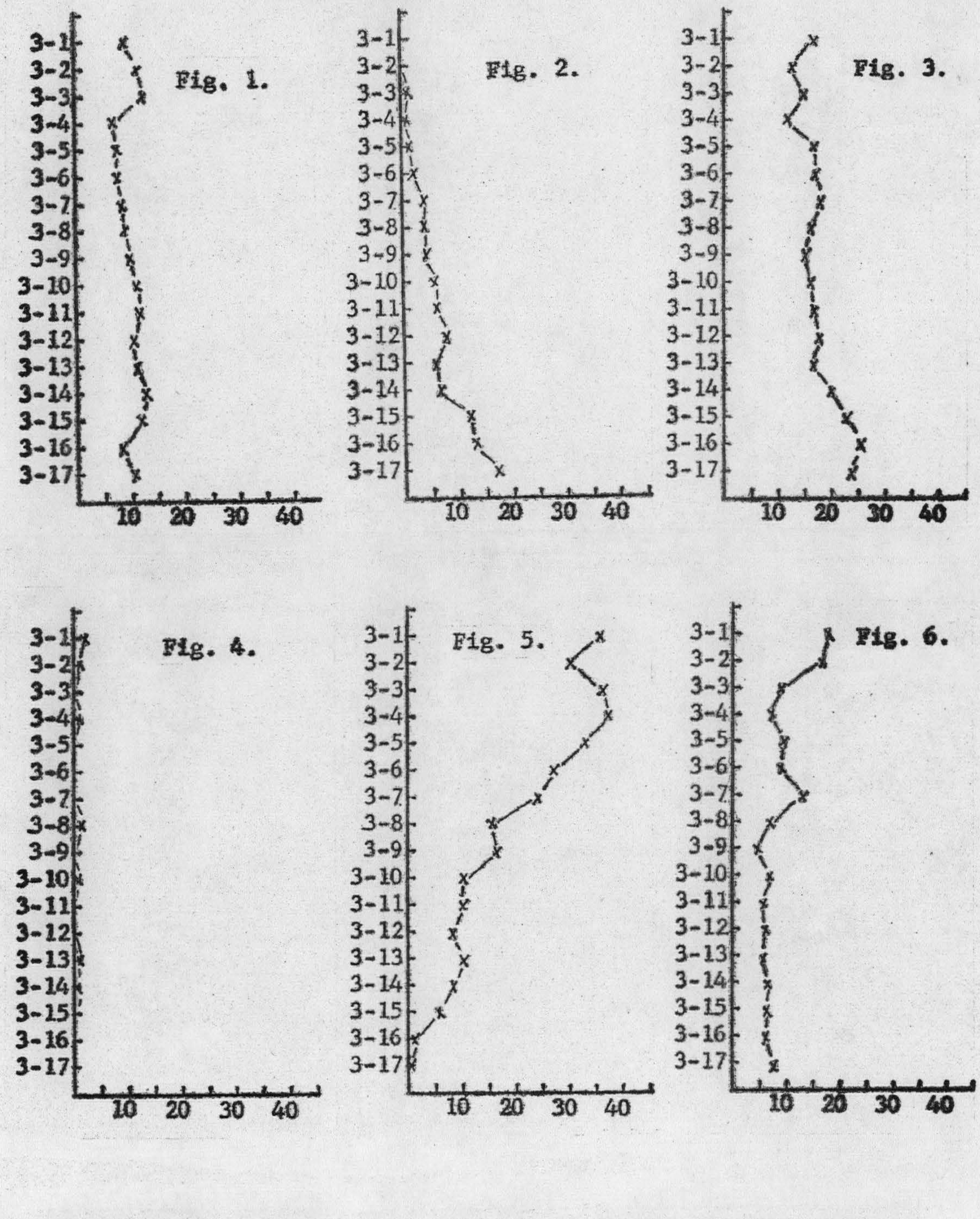

Plate V. Distribution of species in the Clark Deposit. Fig. 1: Valvata tricarinata; Fig. 2: Valvata sincera; Fig. 3: Gyraulus parvus; Fig. 4: Amnicola limosa; Fig. 5: Amnicola lustrica; Fig. 6: Fossaria obrussa decampi.

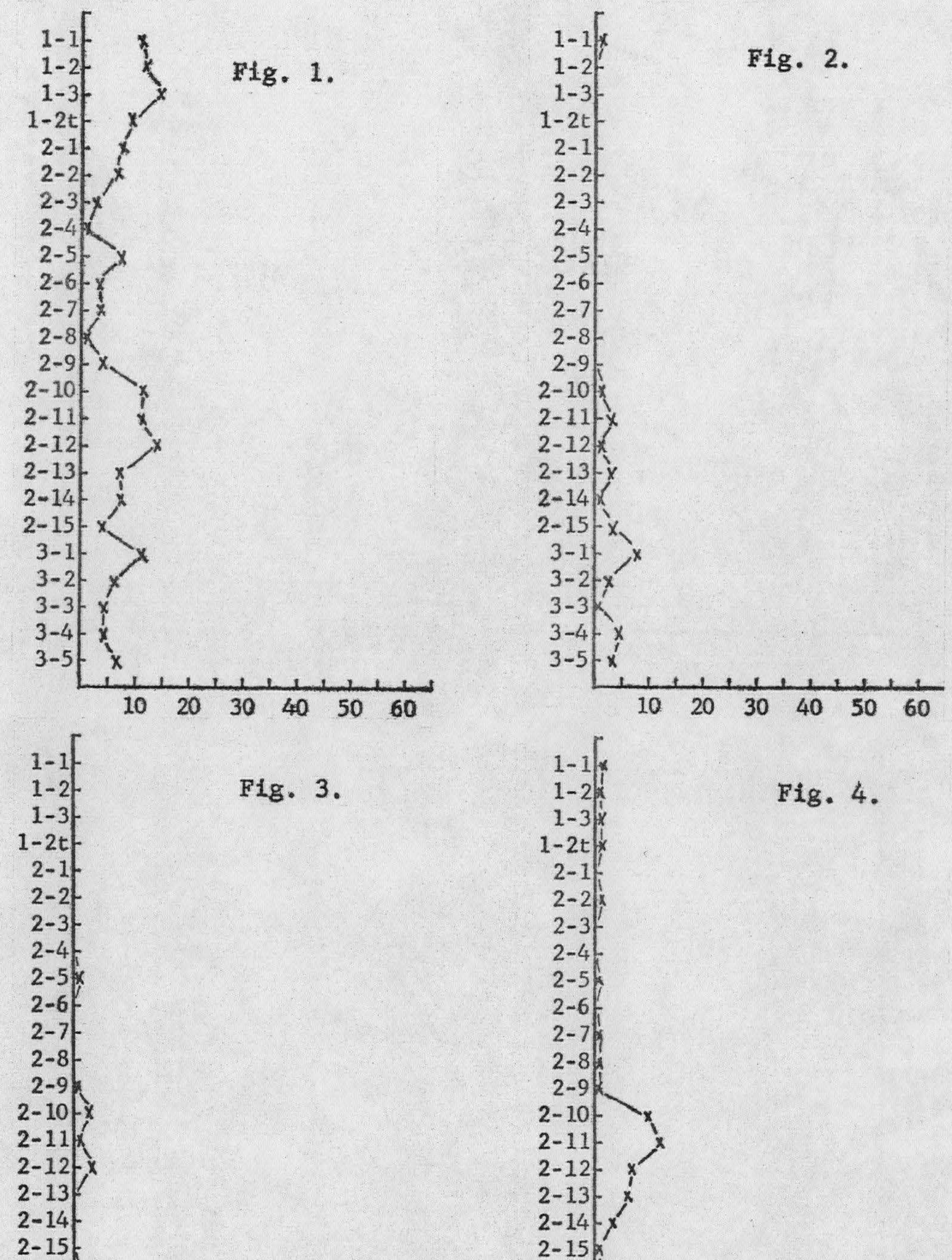

Plate VI. Distribution of **species in** the Greene Deposit. Fig. 1: Fossaria obrussa decampi; **Fig. 2**: Gyraulus parvus; **Fig.** 3: Physa gyrina; Fig. 4: **Pisidium** casertanum.

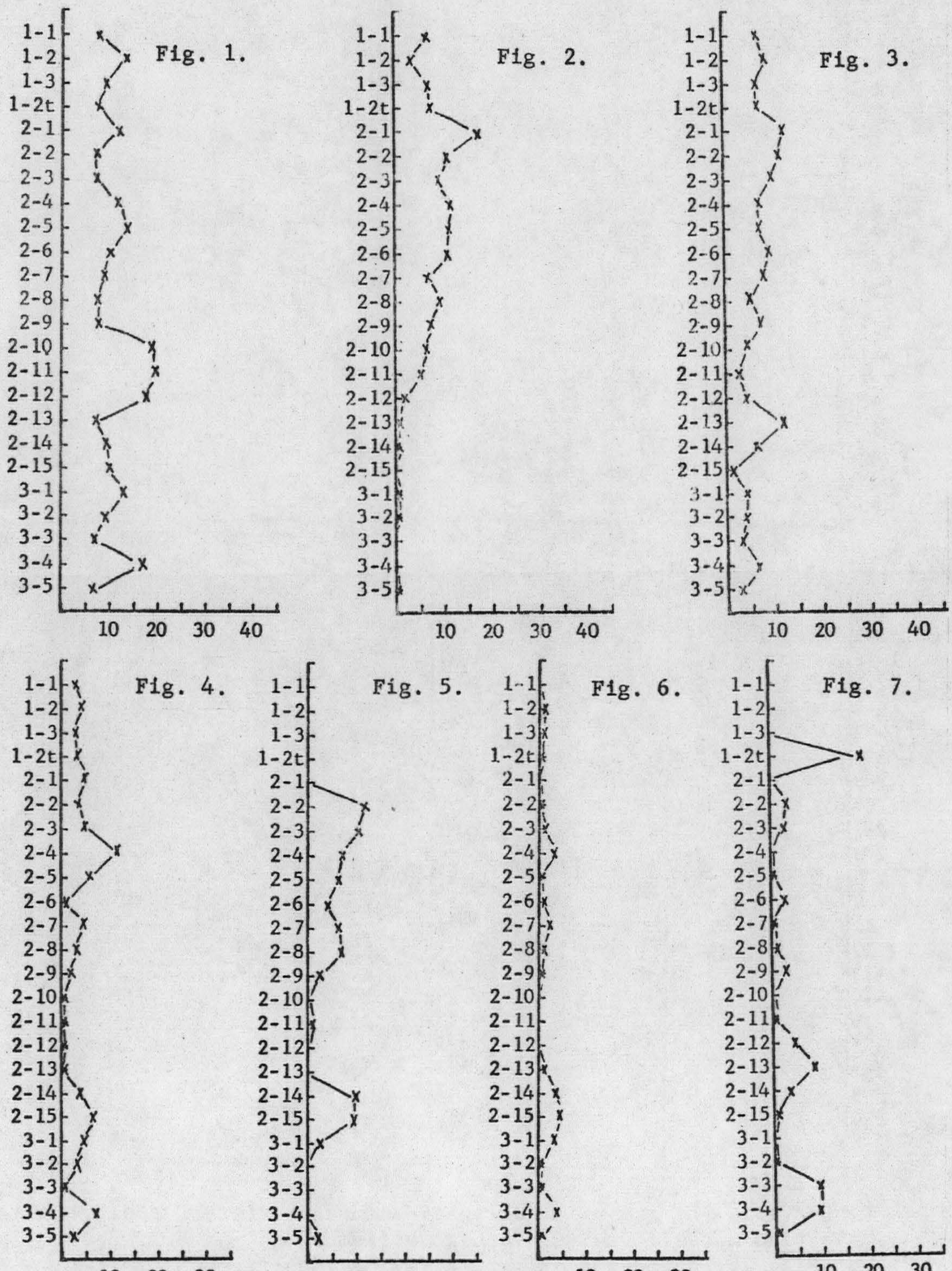

Plate VII. Distribution of species in the Greene Deposit. Fig. 1: Oxyloma retusa; Fig. 2: Succinea grosvenori gelida; Fig. 3: Strobilops labyrinthica; Fig. 4: Helicodiscus parallelus; Fig. 5: Hawaiia minuscula; Fig. 6: Glyphyalinia indentata; Fig. 7: Carychium exiguum.

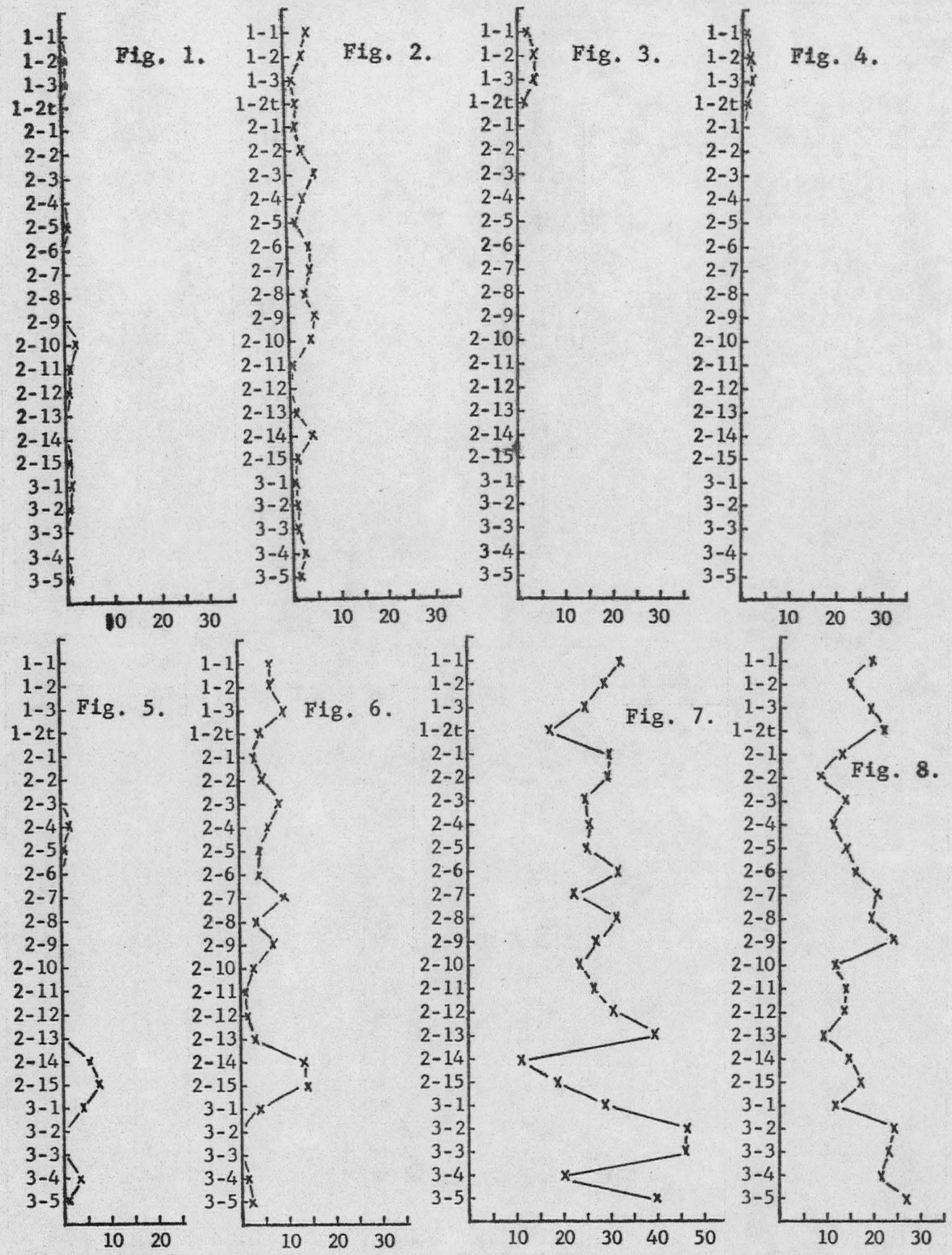

Plate VIII. Distribution of species in the Greene Deposit. Fig. 1: *Vertigo morsei*; Fig. 2: *Vertigo milium*; Fig. 3: *Vertigo ovata*; Fig. 4: *Pupoides albilabris*; Fig. 5: *Gastrocopta armifera*; Fig. 6: *Gastrocopta contracta*; Fig. 7: *Gastrocopta tappaniana*; Fig. 8: *G. contracta* and *tappaniana* immatures.

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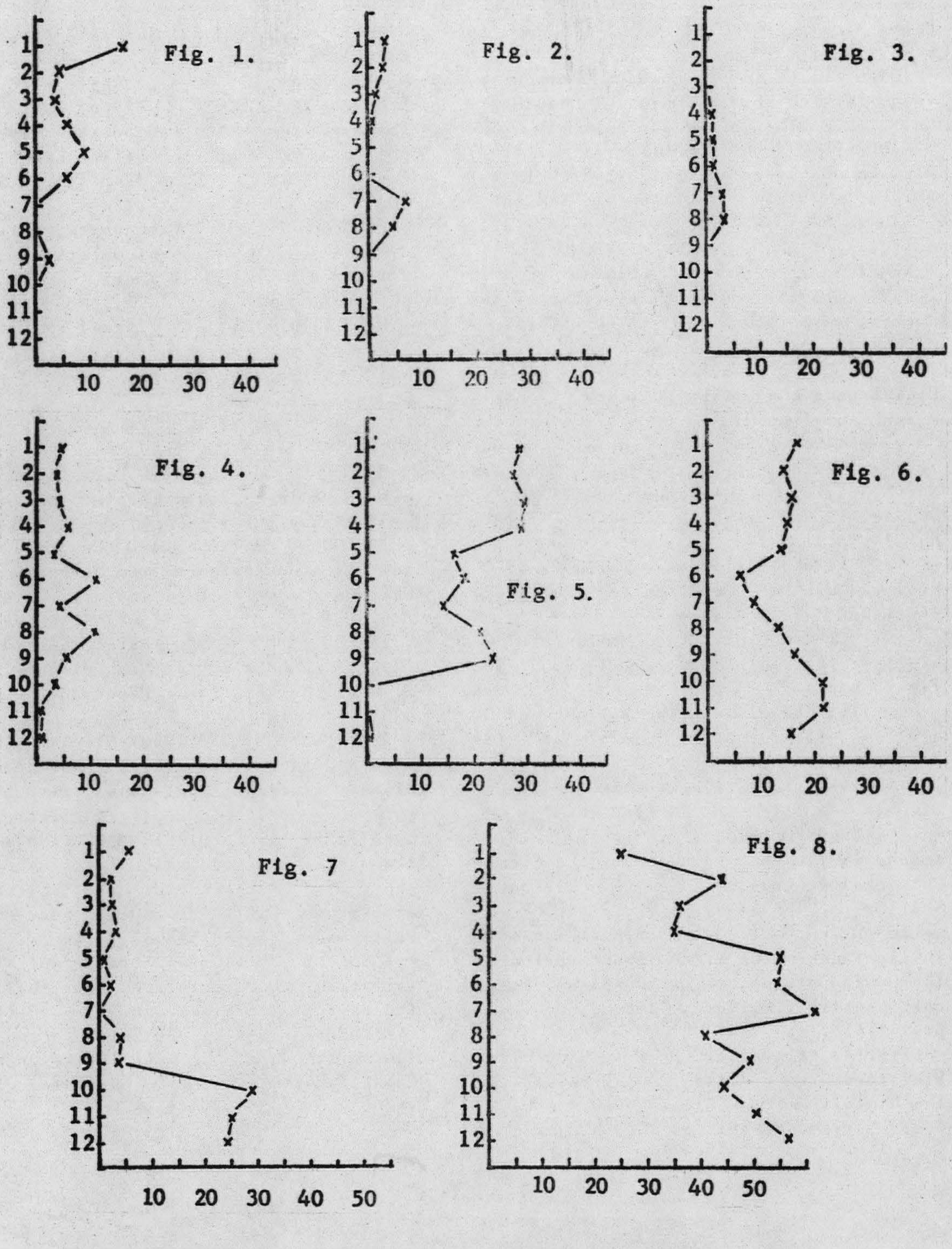

Plate IX. Distribution of species in the Hamilton Deposit. Fig. 1: Columella alticola; Fig. 2: Vertigo gouldii; Fig. 3: Vertigo gouldii hannai; Fig. 4: Vertigo modesta; Fig. 5: Vertigo elatior; Fig. 6: Vallonia gracilicosta; Fig. 7: Pupilla muscorum; Fig. 8: Succinea grosvenori gelida.