PLEISTOCENE MOLLUSCAN FAUNAS OF THE JEWELL HILL DEPOSIT, LOGAN COUNTY, OHIO

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INTRODUCTION

Nature and Purpose of Investigation

This report is a paleontological study of the Pleistocene molluscan fauna occurring in a lacustrine deposit at Jewell Hill, Ohio. The paleoecology and quantitative distribution of the species yield information which has been used to reconstruct the environmental changes during the development of the lake. This study is one of several of the same nature, undertaken to provide data for correlation of Pleistocene freshwater deposits by the use of molluscan assemblages.

Location of Deposit

The Jewell Hill deposit lies in the western half of the southwest quarter of section 31, Liberty Township (see Fig. 1), Logan County, Bellefontaine Quadrangle, Ohio. The southwest corner of section 31 is at 83° 46' 45" west longitude and 40° 18' 15" north latitude.

Methods of Investigation

The geographical center of the lake deposit, as nearly as it could be determined, was chosen as the main collecting site. At this location a vertical column measuring 12 inches square was left in place on one side of an excavation approximately 6 x 6 x 6 feet. Most of the vertical column was sampled in successive two-inch layers. It was necessary, however, to vary the thickness of these layers to remain within a stratigraphic unit. The uppermost sample, collection 26, is 12 inches thick, and has been disturbed by the farmer's plow. Four other samples (collections 7, 9, 24, and 25) are each 2.5 inches thick and collection 8 is 3 inches thick.

A bayonet auger was used to sample below the excavation to obtain the lowermost fauna in the deposit. The stratigraphy and profile of the deposit were determined by the use of this auger.

Each sample was put in a plastic bag, sealed, and labeled with a collection number. The plastic bags retained the moisture in the samples; a few samples required additional soaking in beakers. Each collection was washed in a series of sieves of 2.5, 9, 20, 40, and 100 mesh. The material left after sieving was dried and placed in pint containers. The containers were carefully labeled to avoid mixing.

The volume of each collection of dry material left after sieving was reduced with a Jones sample splitter. A truly representative fraction could therefore be studied. The size of the fraction selected was dependent upon the abundance of fossils in each collection. After measuring the total volume of the fraction, portions of it were selected at random and sorted until 1,000 shells were counted. In two collections the entire sample contained less than 1,000 shells. The ratio of shells to other material in the fraction sorted was used to compute the total molluscan population and the relative amount of vegetation in each collection. The fossil shells were identified to species, and the percentage of each species was determined on the basis of total individuals sorted in a particular collection. In this way the quantitative distribution of the entire fauna could be evaluated in terms of paleoecological requirements of all species. These in turn permitted a reconstruction of the lake's history.

STRATIGRAPHY

Description of Deposit

The Jewell Hill lake deposit lies in two shallow depressions which are probably a kettle on a till (Forsyth, 1956, p. 137) that mantles a complex of buried kame moraines. (See Figs. 2 and 3). The two basins are almost separated by a kame ridge, and the northeastern bay is much smaller than the centrally located basin. The periphery of the lake deposit lies at an elevation between 1,140 and 1,145 feet as shown in Fig. 2. The longest dimension, which extends from the southwestern to the northwestern bays, measures approximately 2,100 feet and the average width of the lake deposit is about 260 feet.

The topography of the buried kame hills in the surrounding area indicates that Jewell Hill Lake did not have any apparent influent. There are two lower elevations in the direction of the projecting northwestern and southeastern bays of the lake (see Fig. 2). During periods of high water, the northwestern bay connected with another, smaller depression lake just northwest of Jewell Hill Lake.

DESCRIPTION OF FIGURES 1-5, OPPOSITE PAGE

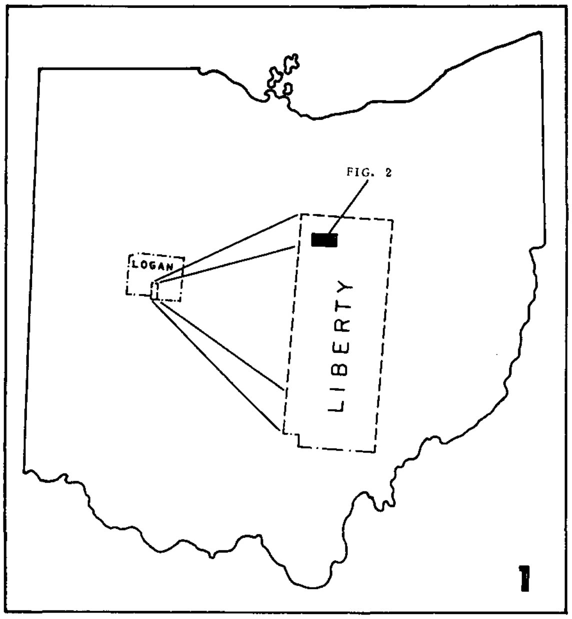
Fig. 1. Index map, showing location of Jewell Hill Deposit. The small rectangle represents the area of Fig. 2.

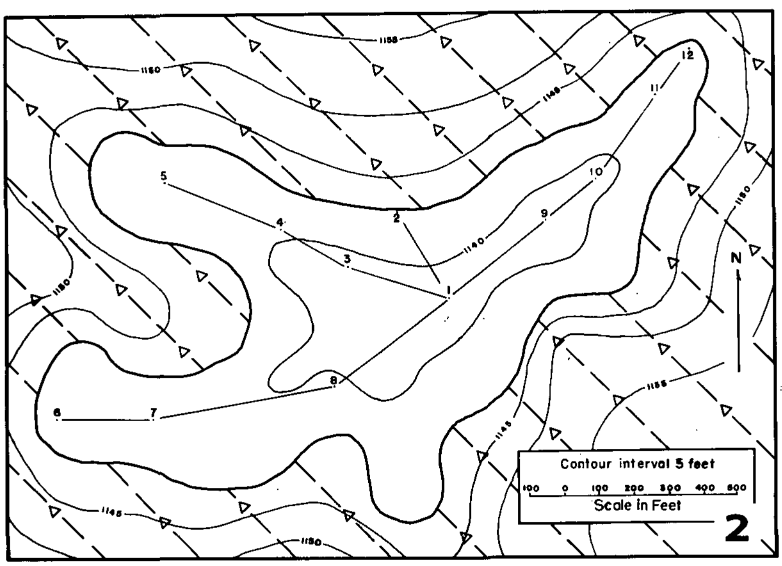
Fig. 2. Map of the area of the Jewell Hill Lake Deposit.

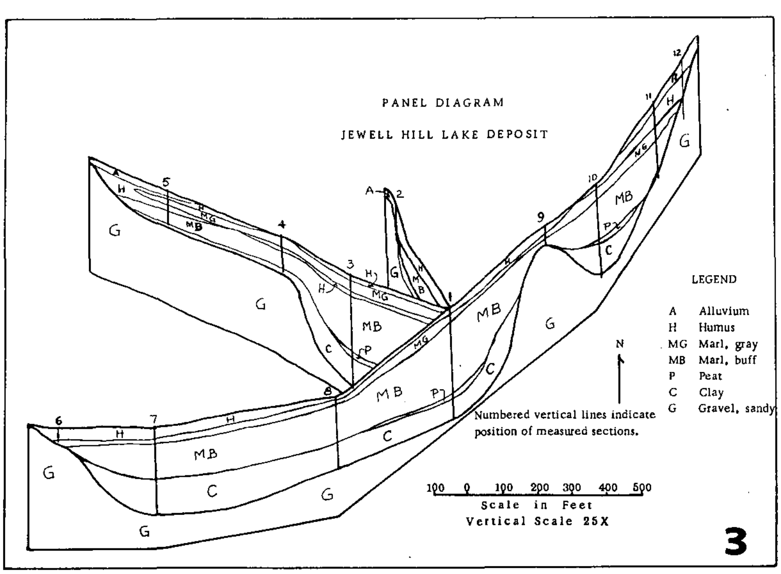
Fig. 3. Panel Diagram of the Jewell Hill Lake Deposit.

Fig. 4. Approximate total number of individuals in each collection of the Jewell Hill deposit.

Fig. 5. Quantitative distribution of <u>Gyraulus altissimus</u> (F. C. Baker) in the Jewell Hill deposit.







UNIT	COLL. NO.	THICKNESS (inches)	TOTAL NO. INDIVIDUALS	COMPARATIVE ABUNDANCE	GRAPHIC REPRESENTATION OF COMPARATIVE ABUNDANCE (Thousands) 10 20 30 40 50 60 70
	26	12	15,310	1,950	
7	25	2.5	1,420	947	
	24	2.5	501	332	
	23	2	8,480	8,480	
	22	2	78,820	78,820	
	21	2	79,270	79,270	
	20	2	59,230	59,230	
	19	2	53,740	53,740	
	18	2	41,610	41,610	
	17	2	51,260	51,260	
6	16	2	62,350	62,350	
	15	2	41,490	41,490	
	14	2	31,740	31,740	
	13	2	16,130	16,130	
	12	2	13,580	13,580	
	11	2	20,790	20,790	
	10	2	14,170	14,170	
	9	2.5	15,920	12,720	
5	8	3	50	33	
	7	2.5	10,640	8,520	
	6	2	19,190	19,190	
	5	2	23,610	23,610	
4	4	2	22,180	22,180	
	3	2	26,390	26,390	
	2	2	23,640	23,640	
	1	2	26,190	26,190	

4

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 20 40 60 80 100
26	407	40.7	
25	428	42.8	
24	207	41.4	
23	123	12.3	
22	336	33.6	
21	271	27.1	
20	349	34.9	
19	473	47.3	
18	384	38.4	
17	461	46.1	
16	524	52.4	
15	589	58.9	
14	502	50.2	
13	565	56.5	
12	389	38.9	
11	172	17.2	
10	551	55.1	
9	633	63.3	
8	33	67.4	
7	424	42.4	
6	384	38.4	
5	229	22.9	
4	225	22.5	
3	191	19.1	
2	138	13.8	
1	139	13.9	

5

The southeastern bay, which points toward the lowest elevation in the immediate area, served as outlet and as migration route for mollusks into the lake. The superfluous water during the rainy season probably emptied into a lower marshy depression and on into McKee Creek, a part of the tributary system of the Miami and Ohio Rivers. The assumptions above concerning the spillway were deduced from augering the periphery of the lake deposit.

The gray blue lake clay covers both shallow basins and rests on sandy gravel, which is impenetrable by a bayonet auger. It ranges in thickness from a trace at the extreme margins and on the sides of the kame ridge to a maximum of 8 feet at section 7 (see Fig. 3). A marly peat layer overlies the lake clay in the central area of both basins and never exceeds a thickness of 14 inches. Most of the buff colored marl rests directly on the lake clay and a sharp contact exists between the two. This buff marl is essentially pure and contains some vegetation, which increases upward. The thickness of the buff marl ranges from a trace at the shore lines to a maximum of 17.5 feet in the central area of the larger basin. A lower humus layer overlies the western and southeastern bays. This black humus layer measures 13 inches at section 5 and 5.5 inches at section 1. A silty, medium light gray marl overlies both the lower humus layer and buff marl. There is a sharp contact between both marl units. The gray marl is highly impure, coarse, and contains many thin peat lenses. It ranges in thickness from a trace at the extreme margins to a maximum of about 3 feet. An upper humus layer covers the entire area of the lake deposits. The black humus is thickest, approximately 3 feet, at the margins of the deposits. At these sites, the humus grades into peat, a few inches thick to a maximum of one foot at section 12.

Measured Sections

Twelve sections measured in the course of the work showed only minor variations in stratigraphy. Section No. 1, which was sampled in detail for Mollusca, is given below. Correlation of the other 11 sections with Section No. 1 is shown in Table 1, page 4.

Section No. 1

Unit	Description	Thickness (inches)	Coll. No.
7	Humus, black, porous, blocky, fossiliferous, bottom 0.5 inch gray marl undulating up into humus; upper 12 inches brownish black, disturbed	19	23-25
6	Marl, medium light gray, calcareous, coarse, silty, fossiliferous, interbedded with many thin peat lenses	29	9-22
5	Humus, black, porous, blocky; upper 3 inches slightly fossiliferous, lower 2.5 inches fossiliferous, interstratified with dark gray marl .	5.5	7-8
4	Marl, buff, pure, very fine, calcareous, clayey, fossiliferous, a few scattered plant stems; some calcareous tufa tubes, the size of pencil lead; upper 2 inches, light gray marl, calcareous, slightly silty, interbedded with minute peat lenses . . . . (Collections 1 through 6 represent the uppermost foot of this unit).	206	1-6
3	Peat, light yellowish brown, marly, compact, unfossiliferous	13	
2	Clay, gray blue, very fine, compact, plastic, unfossiliferous . . .	49	
1	Gravel, sandy	6	

TABLE I. CORRELATION OF MEASURED SECTIONS

Lithology	Section and Unit Numbers 1	2	3	4	5	6	7	8	9	10	11	12
Alluvium	abs.	6	abs.	abs.	7	abs.	abs.	abs.	abs.	abs.	6	4
Clay, gray	abs.	5	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.
Humus	7	4	7	6	6	4	5	6	4	7	5	3
Marl, gray	6	3	6	5	5	3	4	5	3	6	4	2
Humus	5	abs.	5	4	4	abs.	abs.	4	abs.	5	abs.	abs.
Marl, buff	4	abs.	4	3	3	abs.	3	3	2	4	3	abs.
Peat	3	abs.	3	abs.	abs.	abs.	abs.	abs.	abs.	3	abs.	abs.
Clay, blue	2	2	2	2	2	2	2	2	abs.	2	2	abs.
Gravel	1	1	1	1	1	1	1	1	1	1	1	1

Location of Faunas

In the Jewell Hill Lake deposits there are four fossil-bearing units: the upper humus layer, unit 7; the medium light gray marl, unit 6; the lower humus layer, unit 5; and the buff colored marl, unit 4. Each of the three upper units has corresponding collections, 6 through 26, as indicated by the measured section at section 1. The uppermost foot of unit 4 corresponds to collections 1 through 6. The bottom foot of unit 4 was collected with a bayonet auger at section 1. The species listed in Table II are those of the lowermost fauna in this unit.

TABLE II. COMPOSITION OF LOWERMOST FAUNA

SPECIES	NUMBER OF SPECIMENS	PERCENTAGE OF TOTAL INDIVIDUALS
Valvata tricarinata	328	45.5
Amnicola leightoni	131	18.2
Amnicola lustrica	73	10.1
Fossaria obrussa	5	0.7
Fossaria obrussa decampi	2	0.3
Helisoma anceps striatum	26	3.6
Gyraulus altissimus	127	17.5
Physa gyrina	8	1.1
Pisidium sp.	21	2.9
Vertigo ovata	1	0.1
TOTAL	722	100.0

QUANTITATIVE DISTRIBUTION

General Statement

The four fossil-bearing units of the Jewell Hill Lake deposit contain 37 species, collected at section 1 (Fig. 3). They include eight "finger-nail" clams, sixteen freshwater gastropods, and thirteen terrestrial gastropods. Samples from the other sections (2 to 12, whose locations are given in Fig. 3, did not reveal any other forms. The interpretation of the distribution of all forms is given under Paleoecology.

Variation in Numbers

The approximate total number of individuals in each collection is given in Fig. 4. Only two collections, numbers 8 and 24, contain less than 1,000 individuals. The comparative abundance column has been added because of the difference in volume of the collections. In this column the figure given is that for a sample 2 X 12 X 12 inches. To obtain the figure, samples thicker than 2 inches have been reduced proportionately.

Figure 4 exhibits an almost constant population in the uppermost foot of the buff colored marl, unit 4. The population was reduced in unit 5, the lower humus layer, until it reached the minimum comparative abundance of 33 individuals in collection 8. Unit 6, consisting of interbedded peat members and silty, gray marl, shows an almost constant increase, with slight fluctuations, to a maximum of about 79,000 individuals in collections 21 and 22. In the upper humus layer, unit 7, the population was again reduced to comparatively small numbers in collection 23. The population continued to decrease but reached a somewhat constant number in the upper collections of this unit. Collection 26 has been disturbed, but it retains some validity as a sample; of the 21 forms occurring in this unit only one, Vallonia gracilicosta, does not occur in the lower collections.

Comparative Abundance of Groups

The freshwater pulmonate snails form a somewhat meager 23.2 percent of the individuals in the lowermost fauna in unit 4 at section 1. This group is dominant in all collections except numbers 3 and 11, in which they form 43.5 and 24.6 percent of the total individuals, respectively. The numerical abundance of the freshwater gill-breathing snails is greatest, 73.8 percent, in the lowermost fauna of unit 4. This group is less numerous than the freshwater pulmonates of the uppermost fauna of unit 4 and the lower collections, from 9 to 12, of unit 6. In unit 6, from collection 13 through 22, and unit 7 the gill-breathing snails are in such small numbers that they suggest intruders struggling to survive in an environment favorable to freshwater pulmonates. The small pelecypods are persistent in minor percentages throughout section 1. This group is only 2.9 percent of the lowermost fauna of unit 4 and attains the maximum of 11.3 percent in the uppermost fauna of unit 4. The land snails are persistent in smaller percentages than the pelecypods. The percentages of this group are high in collection 6, unit 4; collection 7, unit 5; and attain a maximum of 28 percent in the upper two collections of unit 7, the upper humus layer.

Comparative Abundance of Species

INDIGENOUS SPECIES. Each form in the various groups is discussed in order of abundance and the numerical variation is listed from bottom to top. The lowermost fauna in unit 4 (Table II, p. 4) exhibits significant changes in abundance with the uppermost fauna of the same unit, collections 1 through 6.

Of the thirteen aquatic pulmonates, seven are significant. These are Gyraulus altissimus, Fossaria obrussa, Fossaria obrussa decampi, Physa gyrina, Promenetus exacuous, Stagnicola umbrosa, and Helisoma trivolvis (See Table II).

INTRUDERS. The forms in this group either occur sporadically or are insignificant in percentages of total individuals.

The six freshwater pulmonate snails in this group are: Lymnaea stagnalis jugularis, Helisoma anceps striatum, Helisoma campanulatum, Planorbula armigera, Gyraulus crista, and Ferrissia parallela. L. stagnalis jugularis occurs as 0.1 percent in collections 11 and 14, 0.2 percent in collection 12, and 0.4 percent in collection 13. H. anceps striatum remains almost constant from the lowermost to the uppermost fauna, with a maximum of 4.4 in collection 1, in unit 4. From collection 1 it decreases and occurs in minor percentages where the form is present in the deposit. H. campanulatum reaches its maximum percentage of 1.5 in collection 1 and fluctuates in minor percentages, between 0.1 and 0.9 percent, where the species is present in a collection. P. armigera occurs as twelve individuals in collection 24 and composes about 2.4 percent of the total individuals in collections 25 and 26. G. crista attains a maximum of 2.7 percent in collection 16. It occurs sporadically and fluctuates between 0.1 and 1.8 percent where it is present in the other collections. F. parallela occurs as 0.4 percent in collection 6, 0.9 percent in collection 7, 0.1 percent each in collections 4 and 18, and 0.2 percent in collection 19.

Five pelecypods are considered intruders into the environment of the Jewell Hill lake. These are Sphaerium lacustre, Pisidium adamsi, P. ferrugineum, P. compressum, and P. nitidum pauperculum. S. lacustre is absent in the first 8 collections and increases from 0.1 percent in collection 9 to a maximum of 1.6 percent in collection 16, and then decreases to 0.2 percent in collection 25. Each of the other four pelecypods forms less than 1.0 percent of the total individuals in any one collection and no particular significance is attached to their sporadic occurrence in the deposit.

All of the land snails are considered as intruders. Succinea avara occurs as 0.5 percent in collection 23, fourteen specimens in collection 24, 2.2 and 2.4 percent in collections 25 and 26, respectively. Succinea ovalis is in all collections except 8 and 10. It attains a maximum of 6.5 percent in collections 23 and 26. In the other collections it varies between 0.1 percent and 5 percent. Gastrocopta pentodon reaches a maximum of 15.2 percent in collection 25 and occurs sporadically throughout the collections. Vertigo ovata is absent in collection 1, has a maximum percentage of 6.6 in collection 23, and varies between 0.1 and 4.1 percent in the other collections. It occurs as 0.1 percent in the lowermost fauna of unit 4. Carychium exile occurs as twelve specimens in collection 24, 2.1 and 2.2 percent in collections 25 and 26, respectively. No particular significance is attached to the occurrence of the following eight land snails: Stenotrema leaii, Euconulus fulvus, Retinella binneyana, Hawaiia minuscula, Strobilops labyrinthica, Pupoides albilabris, Vallonia gracilicosta, and V. pulchella. Each of the above species forms less than 1.0 percent of the total individuals in any one collection.

PALEOECOLOGY

General Statement

The following information concerning conditions of environment has been paraphrased from publications by the following authors: F. C. Baker, E. G. Berry, J. Dawson, R. W. Dexter, C. Goodrich, H. B. Herrington, A. La Rocque, A. B. Leonard, J. P. E. Morrison, J. Oughton, H. A. Pilsbry, L. S. Russell, and M. L. Winslow.

Pelecypods

FAMILY SPHAERIIDAE. Almost all fresh-water bodies are inhabited by some species of this family unless the environment is completely unfavorable. These mollusks even occupy pools that dry up for a long period of time during the year. In these places a few survive, mainly the young, by burrowing deeply into the mud. The food supply is mainly diatoms and vegetation. The "finger-nail clams" in turn are a source of food for freshwater fish. They are also attacked by parasitic worms which may modify the form of the shell.

For some of the Sphaeriidae, listed below, the specific conditions of environment are those given under synonyms in the literature; the names used here follow Herrington's (1954, p. 131) revision.

SPHAERIUM LACUSTRE (Müller) prefers swamps, ponds, lakes, or streams on a firm bottom of fine deep or hard packed mud, fine gravel, and hard clay, in water up to 0.6 m. in depth. The pH is 6.4 to 7.64; fixed carbon dioxide 9.3 to 18.87 p.p.m.

PISIDIUM ADAMSI (Prime) appears to prefer quiet water, about 3 m. deep, in small and some large lakes or slow moving streams. The bottom usually consists of mud which has occasional vegetation and in depths of water ranging from 0.3 to 13.5 m. The pH is 6.05 to 7.7; fixed carbon dioxide 2.75 to 18.36 p.p.m.

PISIDIUM CASERTANUM (Poli) is a lake or pond inhabitant on a clay, sandy clay, or mud bottom in shallow water, between 0.5 and 3 m. in depth. It also occurs in swamps or protected bays among vegetation. It is able to resist desiccation at least several months in a swampy area during dry periods. The pH is 5.8 to 7.95; fixed carbon dioxide 5.5 to 30.50 p.p.m.

PISIDIUM COMPRESSUM (Prime) is confined principally to rivers and creeks. It occurs on a sandy, sandy silt, or mud bottom in water up to 3 m. deep among vegetation. The pH is 7.0 to 8.37; fixed carbon dioxide 9.3 to 30.56 p.p.m.

PISIDIUM FERRUGINEUM (Prime) inhabits the mud, sand, or marly clay bottoms of ponds, lakes, and some rivers in water 1 to 3 m. deep. It is usually found among vegetation and algae. The pH is 7.23 to 8.14; fixed carbon dioxide 10.8 to 22.5 p.p.m.

PISIDIUM NITIDUM (Jenyns) is an inhabitant of ponds, small and large lakes in shallow water, from 1 to 6 m. deep. It lives on various bottoms such as sand, clay, mud, and gravel. The pH is 7.48 to 7.64; fixed carbon dioxide 1.98 p.p.m.

PISIDIUM NITIDUM PAUPERCULUM Sterki lives in habitats similar to those of P. nitidum, but is a distinct varietal form. It prefers the same bottom condition and has been recorded in depths of water from 1 to 39.5 m., although the more dense population would probably be in water from 1 to about 5 m. deep. The pH is 7.0 to 8.0; fixed carbon dioxide 9.3 to 24.73 p.p.m.

PISIDIUM OBTUSALE ROTUNDATUM (Prime) is an inhabitant of ponds, large and small lakes, and lagoons with various bottoms consisting of mud, marly clay, sand, and sometimes gravel. This species occurs in water consistently deeper than do the other Sphaeriidae. The depth of water ranges from shallow, 1.6 m., to more than moderately deep, 12 m. The pH is 5.8 to 6.2; fixed carbon dioxide 1.97 to 9.0 p.p.m.

Aquatic Gastropods

VALVATA TRICARINATA (Say) occupies a wide variety of habitats which include rivers, lakes, and permanent ponds. It occurs on various bottoms such as mud, silt, sand, gravel, mixtures of these materials, and in vegetation, especially algae. The species has been found in water a few cm. to depths exceeding 9 m., but is more abundant in situations approximately 2 m. deep. *V. tricarinata* has been observed feeding on plants and algae, chiefly *Vaucheria*. The pH is 6.8 to 8.6; fixed carbon dioxide 8.16 to 30.56 p.p.m.

AMNICOLA LEIGHTONI (F. C. Baker) occurs exclusively in marl deposits of Wisconsin, Michigan, Illinois, Indiana, Ohio, and Ontario. The species undoubtedly flourished in lakes of glacial origin for it has been recorded in abundance mostly from this type of environment. Since *A. leightoni* is an extinct species of late Pleistocene time, the ecology must be derived from its closely related living counterpart, the *Amnicola limosa* group. Both *A. limosa limosa* and *A. limosa porata* are gill-bearing operculates occurring in very quiet bodies of fresh or brackish water. The wide variety of environmental occurrences of *A. limosa limosa* include rivers, creeks, many lakes, and swamps. It occurs on all types of bottoms and in various vegetation. The depth of water ranges from 0.2 to 7.5 m., but is more abundant in water less than 2 m. deep. Habitats listed for *A. limosa porata* are mostly lake occurrences. It is found on various bottoms, usually in vegetation, in water 0.3 to 3 m. deep. The abundance of *Amnicola* depends largely on the presence of vegetation. The amnicolids have been reported to eat various plants in the absence of fixed carbon dioxide in order to build shell material; however, the plants act as hosts for vast colonies of diatoms which supply the food for the snails. The group as a whole are burrowers and may burrow beneath the substratum during stormy weather. *Amnicola* can be exterminated by unusually high summer water temperatures; but low temperatures have no effect except on those near the shore which may be frozen. The seasonal abundance of the group remains almost constant; it increases in July when the new generation is produced, and drops to the lowest ebb in mid-August when the adults die off rather suddenly after the egg-laying period. The young generation enlarges the population to a maximum by mid-September. *A. limosa porata* occurs in situations with a wide tolerance of pH which may vary from 5.68 to 8.37, and the fixed carbon dioxide varies from 1.2 to 30.56 p.p.m.; *A. limosa* has a stable pH value of 7.95 and fixed carbon dioxide ratio of 30.56 p.p.m.

AMNICOLA LUSTRICA (Pilsbry) inhabits vegetation and is most abundant in filamentous algae. The ecology of this amnicolid is similar to that of *A. limosa* with which it is often associated. It occurs on the same type of substratum in rivers and lakes. The shell of this species exhibits a characteristic form in river and lake environments. The type form is the river form and the lake form is an ecological variation, with a wide umbilicus. The *A. lustrica* of the Jewell Hill Lake deposit exhibits the wide umbilicus. The same conditions for food, pH of the water, and fixed carbon dioxide in parts per million, are assumed for *A. limosa* since the two are often associated.

LYMNAEA STAGNALIS JUGULARIS (Say) usually occurs about decaying vegetation in the more stagnant waters of ponds, lakes, rivers, or in open swamps. Although it may be found on floating driftwood or debris and on a sandy or pebbly bottom, the more favored habitat is among vegetation near the shore. It is found in a depth of water ranging from 0.2 to 1.2 m. In the larger lake bays and inlets it occurs in protected areas near shore during the spring, while in August or September it may be found in abundance floating in the open waters on or near vegetation. L. stagnalis jugularis has been observed frequently floating, among pond weeds and algae, with the shell pointed downward and the foot on the under surface of the water film. The usual food supply is vegetal, although it has been observed feeding upon dead animals. Instances are recorded of its attacking small living animals for food. The pH is 7.6 to 8.16; fixed carbon dioxide 15.8 to 23.0 p.p.m.

FOSSARIA OBRUSSA OBRUSSA (Say) normally inhabits small bodies of water such as ponds and medium sized lakes, but it may be found in creeks, sloughs, bays, overflow ditches, swamps, and marshy areas near river banks. It is a semi-amphibious inhabitant of shallow water, up to 1.0 m. and as much as 3.0 m. deep, living among vegetation and on sticks, stones, and any other debris in the water or near the edge. It is capable of remaining out of water for considerable periods of time on debris or moist mud flats. Its food consists normally of the stems of water plants, diatoms, desmids, and pond scums. It may become carnivorous according to circumstances or by choice. The pH is 5.86 to 8.37; fixed carbon dioxide 1.26 to 25.75 p.p.m.

FOSSARIA OBRUSSA DECAMPI (Streng) probably has the same ecology as F. obrussa obrussa and the same conditions of occurrence and diet are inferred. F. obrussa decampi is very abundant as a Pleistocene fossil, and was associated with F. galbana, an extinct species, in the icy waters of Pleistocene time. Its less abundant occurrence in the living fauna has been noted, possibly indicating its coming extinction. This species occurs mostly on vegetation in water 1 m. deep with a bottom of sandy silt or mud. It has been collected from many different water plants. The pH is 7.5; fixed carbon dioxide 10.65 to 18.87 p.p.m.

STAGNICOLA UMBROSA (Say) inhabits tranquil waters of pond-like areas thick with vegetation either near a river or in ponds and sloughs which may become more or less dry in the summer. Since the ecology of this species is poorly known, more specific conditions of environment must be inferred from the closely related form Stagnicola palustris elodes. The preference of the latter for bodies of still water in both clear and stagnant situations is in agreement with the character of the closing stages of the Jewell Hill Lake. S. umbrosa occurs only in the upper two units of the Jewell Hill Lake deposit as shown in Fig. 10. S. palustris elodes occurs in large or small water bodies on floating sticks, submerged vegetation, and muddy bottoms; it is rarely found out of water. The more natural habitats are along margins of rivers, protected bays of lakes, and ponds. The depth of water ranges between 0.3 and 1.0 m., but it is more abundant in water 0.3 m. or less deep near the pool edge. Its food supply is both animal and vegetal. The species is both omnivorous and a scavenger. The pH is 7.4; fixed carbon dioxide 21.0 p.p.m.

HELISOMA TRIVOLVIS (Say) inhabits quiet, more or less stagnant bodies of water in swamps, marshes, pools, sloughs, and ponds; it is virtually absent from flowing streams. Its occurrence in a fossil fauna is a good indication of ponded environment because of the restricted conditions of habitat. H. trivolvis generally favors a depth of water ranging from a few cm. to 1.3 m., a mucky bottom, and presence of mass vegetation and sometimes algae. It is more abundant in water less than 0.5 m. deep. In the above environment the species is always abundant and is found on debris, driftwood, among vegetation and sometimes on shore. By burrowing into the mud bottom of drying pools, it can survive long periods of drought. It feeds on water weed, algae, desmids, and diatoms. The pH is 6.6 to 8.37; fixed carbon dioxide 7.5 to 30.56 p.p.m.

HELISOMA ANCEPS STRIATUM (F. C. Baker), once believed extinct, is known from the living fauna of two lakes in northern Minnesota and probably occurs in other lakes in the northernmost regions of the United States and northward into Canada. H. anceps striatum appears to be more abundant as a fossil and living form in the northern localities and its presence as a fossil farther south probably indicates a lake form which reinvaded the cold waters immediately following the retreating ice. Colder water could be a limiting factor of distribution. This variety occurs in shallow, quiet waters almost always on the abundant vegetation growing on a mud or silt, sandy silt, and clay bottom. It inhabits a depth of water ranging between 0.3 to 1 m. The food of the planorbids is largely vegetal; however, little is known concerning the food supply. The pH and fixed carbon dioxide values for this variety may be inferred from its nearest relative, Helisoma anceps sayi which is also a lake form. The inferred values, pH 7.13 to 8.37 and fixed carbon dioxide 9.59 to 25.75 p.p.m., compare well with those of other species in the Jewell Hill Lake deposit.

GYRAULUS ALTISSIMUS (F. C. Baker) is abundant as a Pleistocene fossil and may still be living in northern lakes. Specimens, probably alive, were collected from a number of lakes in North Dakota (Winslow, 1921, p. 11) which Baker (1922, p. 54) identified as "apparently the same species." Baker (1928, p. 383) reverted to the concept of "apparently an extinct form peculiar to the Pleistocene period" and listed the ecology as unknown. Russell (1934, p. 35) reported G. altissimus as living in Fishing Lake, Wadena, southern Saskatchewan. Baker (1937, p. 116) concluded that "its status as a living member of the fauna is not well known" and that a closely related form, G. arcticus, is probably confined to Greenland (Baker, 1939, p. 98). The ecology of G. altissimus may be derived from the association of other mollusks in a particular deposit. After comparing various faunas, in which this species was abundant in Pleistocene deposits, species regularly associated with G. altissimus and of approximately the same high abundance were: Helisoma campanulatum, H. anceps striatum, Physa gyrina, and especially Fossaria obrussa decampi. Other species either occurred erratically with G. altissimus or were so much less abundant that they would be considered insignificant in the environment, mostly ponds or lakes, where all these species flourished. Species of the same genus usually were rare in the same deposit. Of those that do occur in the same deposit with any abundance is G. parvus, a closely related species, which has about the same pH and fixed carbon dioxide values as the species most often associated with G. altissimus in a deposit. All of the above species, except G. parvus, occur in the Jewell Hill Lake deposit and their ecology is given elsewhere in this paper.

G. parvus exhibits a partiality to vegetation, for it is rarely found in other situations. It occurs usually in quiet bodies of water, often of small size, in depths between 0.5 and 2.2 m. and with various bottoms supporting the plant growth. It also is found on debris near the top of the water. During periods of drought G. parvus has but a slight burrowing reaction when faced with desiccation. It can live for a time upon various substrata provided moisture is present. G. parvus has been observed eating leaves and algae of various kinds. The pH is 7.0 to 8.16; fixed carbon dioxide 8.16 to 30.56 p.p.m.

GYRAULUS CRISTA (Linnaeus) inhabits very shallow water of ponds or small lakes and creeks. In the small lake habitat it has been found sparingly on dead leaves in stagnant water. In another lake occurrence G. crista was living in shallow water, 0.3 to 1 m., among vegetation on a mud or silt bottom which in most places was mucky. In a creek it occurred in a few cm. of water under logs and bark. No pH or fixed carbon dioxide values are available.

PLANORBULA ARMIGERA (Say) lives in small stagnant lakes or ponds. This snail is also found at the edges of marshes, in ditches, and small streams. It prefers situations with abundant vegetation and a mud bottom in water between 0.3 and 1 m. deep, but is capable of remaining out of water and lying dormant in dried mud until the wet season of the year. The pH is 6.6 to 7.6; fixed carbon dioxide 7.5 to 16.7 p.p.m.

PROMENETUS EXACUOUS (Say) is another inhabitant of quiet, shallow water bodies of marshes, ponds, lakes and on mud flats of small mountain streams. Apparently P. exacuous seeks the cool waters, a very important factor in its dispersal. It occurs in protected weedy places on driftwood, plants, lily leaves, and dead leaves on almost all varieties of bottoms from 0.5 to 5 m. deep; however, it is most abundant in water a few cm. to 1 m. deep. The preferred habitat is on the luxurious growth of vegetation that affords shade, tending to lower the temperature of the water. Besides the plants, P. exacuous has been observed to live and feed on dust-fine detritus. The pH is 6.0 to 7.64; fixed carbon dioxide 9.3 to 22.5 p.p.m.

FERRISSIA PARALLELA (Haldeman) is usually an inhabitant of shallow, quiet water of ponds or lakes. The depth of water ranges from 0.3 to 2 m. in which the animal is usually found near the surface on plant leaves but may occur near the bottom on other plants. The distribution of the species is undoubtedly controlled by the presence of vegetation for any other occurrence is rare. The food supply is limited to plants, normally in a state of decay. The pH is 6.05 to 8.37; fixed carbon dioxide 2.75 to 25.75 p.p.m.

PHYSA GYRINA (Say) is found in situations that are characteristically swampy, slow moving, and stagnant with a preference for a mud bottom. The occurrences include overflows from large rivers, small ponds behind river and lake beaches, drainage ditches, and other temporary pools and ponds. Optimum conditions of environment are shallow water usually less than 0.3 m. deep; a minimum amount of shade; few or no enemies such as fish and some birds; a minimum amount of debris; protection from waves and currents; a moderate amount of water weeds; and well aerated water. P. gyrina is usually found on vegetation, mostly on the upper side of pond lily leaves. Physa demands practically the same environmental conditions in lakes and ponds as in streams. P. gyrina can live for a time upon almost any kind of substratum providing it is moist. They survive for a few months when their apertures are turned down and buried in clay, even though they do not form an epiphragm. However, in periods of long drought desiccation takes place for it has only a slight burrowing reaction to enable it to withstand these periods during summer months. Physa depends on plants for both food and aerated water. A great part of the life of Physa is spent in floating upon the surface water where it feeds upon particles of decaying vegetation. It feeds on a variety of animal and vegetable food either fresh or partly decayed. The pH is 7.1 to 8.37; fixed carbon dioxide 9.5 to 22.75 p.p.m.

Terrestrial Gastropods

STENOTREMA LEAII (Binney), occasionally in large colonies, usually inhabits quite damp areas near water such as the margins of ponds, streams, and marshes. It has been observed thriving in rather humid forests or occurring on seeping hillsides and flood plains of streams, under leaves, logs, and rocks.

EUCONULUS FULVUS (Müller) prefers damp situations in woodland areas, especially those of deciduous trees, among the forest debris. Here, it is abundant under started bark, under wet pieces of bark or wood of fallen logs, and rotting stumps of trees. Although it occurs among damp leaves or other vegetation in well-shaded situations, it may as easily occupy the drier, more open woods or fields.

RETINELLA BINNEYANA (Morse) inhabits the more damp situations of woodlands, especially those of deciduous trees. Here, it is common on the forest floor under debris, logs with started bark, at the base of stumps, and under brush. Another occasional occurrence is in sphagnum bogs.

HAWAIIA MINUSCULA (Binney) is a small snail which usually inhabits the moist woodland environment, but is able to withstand desiccation under semi-arid conditions. In woods it lives in leaf mold, on and beneath the bark of trees, among mosses, and under fallen logs. It also thrives along banks of streams and lakes in piles of moist drift or under a light layer of decaying vegetation.

SUCCINEA AVARA (Say) inhabits environments which are widely variable; however, it prefers the more moist situations. It has been found thriving in the following places: low swampy areas, crawling about on mud or living among the debris; along the wet margins of ponds, streams, and marshes; seeping hillsides, living under leaves, logs, sticks, or damp rocks which are limestone and moss-covered. It is also abundant on the grass and reeds near or above the water in roadside ditches.

SUCCINEA OVALIS (Say) inhabits the damp situations of woodlands, especially those of deciduous trees, but may just as easily occupy the drier, open woods or fields. This snail is able to avoid desiccation for a considerable period of time, some five to nineteen weeks. It occurs often among the shrubs and weeds of moist situations near ponds, swamps, and streams. It is also abundant along the floodplains of rivers living among grasses and hedges on mud flats.

STROBILOPS LABYRINTHICA (Say) is probably more or less confined to moist shaded woodland areas. Here, it may be found under loose bark of logs, in half-decayed wood, among dead leaves, crawling on old stumps and logs and other forest debris. The species also occurs abundantly under debris close to the water line of lakes.

GASTROCOPTA PENTODON (Say) lives on wooded hillsides, more abundant on the drier slopes; in well drained groves, among leaves in the underbrush; it also occurs in the more damp woodlands, especially those of deciduous trees. It is common among moss and grass in forests and on open slopes.

PUPOIDES ALBILABRIS (C. B. Adams) is unusual in its ability to dwell in both semi-arid or more than moderately wet regions. The wide range of occurrences includes limestone areas, where populations are denser; in woodlands, under leaf mold and loose bark of fallen logs; in dead grass of prairies; among roots of short grass in unshaded areas; moist grass of untimbered slopes; flood plains of creeks and rivers; beneath rocks in open country; and common on limestone ledges.

VERTIGO OVATA (Say) exhibits a preference for the more moist situations afforded by shaded slopes among vegetation in swampy areas, ponds, marshes, and on flood plains of creeks and rivers. In some regions the species is uncommon because of its failure to adapt itself to periodic droughts. It has been observed thriving in locally favorable habitats, such as marshes near springs, in an area where snails are generally absent or rare.

VALLONIA GRACILICOSTA (Reinhardt) is an inhabitant of situations where organic or rock debris offers protection. The animal may burrow into earth where the soil is not too compact. It usually occurs among vegetation, slightly damp humus, or rotting stumps of birch in wooded areas, and also under rocks and rotting logs on the flood plain of intermittent streams.

VALLONIA PULCHELLA (Müller) occupies the wetter margins along ponds, streams, and marshes; seeping hillsides; sandy flats which receive water by percolation; and occasionally inhabits the drier, more open woods and fields. It is able to withstand desiccation for periods of three to seventeen weeks. This snail is characteristic of lime-rich soils.

CARYCHIUM EXILE (H. C. Lea) is a minute land snail whose environmental conditions have not been extensively recorded in the literature. C. exile dwells in the more damp situations of woodlands, especially those of deciduous trees, and also inhabits the moist soil near streams. It has a preference for a more basic soil. C. exile inhabits the margins of swamps or marshes under decaying vegetation.

Nature of Environment

GENERAL STATEMENT. The environment occupied by the aquatic mollusks in the Jewell Hill Lake was a small, quiet body of water contained in the shallow basin of a kettle. This small lake offered a habitat around its margins for terrestrial snails and was shallow enough for the aquatic mollusks to occupy the entire area of the lake bottom. The successive quantitative distribution of the fauna in each collection of the four units reflects a small lake progressively filling, at first by sediments and later with the aid of encroaching hydrophytes.

The transformed area of the shallow lake to pond-like conditions became a more favorable habitat for the aquatic pulmonates. The invasion of Lymnaea stagnalis jugularis, Stagnicola umbrosa and Helisoma trivolvis and the change of dominant forms to the aquatic pulmonates indicates very shallow water, a soft mud bottom, and thick vegetation.

The increased numerical proportion of the land snails in both humus layers and the uppermost collection of unit 4, the buff colored marl, suggests a shifting shore line and the possible proximity of a deciduous forest. Oughton (1948, p. 93) concluded that the greater land snail population inhabits the damp deciduous woodlands and also the wet margins of small and large bodies of water. These snails thrive in leaf mold and under vegetable debris, inches thick, which remains moist. In this situation the eggs and young snails have a chance of survival against desiccation hazards.

VEGETATION. The relationship between the molluscan population and plant growth is intimately brought out in the deposits of the Jewell Hill Lake. Although the fauna depends on plant growth largely for food and aeration of the water, an increase of luxuriant plant growth beyond a certain point is disastrous for the aquatic mollusks. Dawson (1911, p. 29) also states that the population is greatest where there is a moderate amount of plants and organic debris. These conclusions are clearly demonstrated in the Jewell Hill Lake deposit. Twice in the history of the lake plant growth captured the quiet water and extremely reduced the molluscan population. This is well exemplified by comparing the total abundance in each collection, Fig. 4 and the volumetric data, Fig. 17.

PROBABLE HYDROGEN ION CONCENTRATION. The usual pH range for most present day lakes is between 6.0 and 9.0 (Hutchinson, 1957, p. 690). Both the pH and the fixed carbon dioxide values as determined from the indigenous species in the Jewell Hill Lake indicate a similarity to conditions in present day lakes. These values have been derived for each fossil-bearing unit and are discussed later in the environmental history of the lake.

Significant Species

Almost all of the freshwater mollusks discussed in this paper could be indigenous in present day small lakes. Ten aquatic mollusks in the Jewell Hill Lake deposit occur in very small numbers indicating their intrusion into the environment. All land snails, also intruders, occur in collections that are indicative of an aquatic habitat. These have been washed into the deposit or occur on old shore lines of the lake.

Other aquatic mollusks occurring in minor percentages but continuously throughout the deposit are considered indigenous. These are the small shelled forms such as Promenetus exacuous, Pisidium casertanum, P. nitidum, and P. obtusale rotundatum. In present day occurrences these mollusks live in a habitat usually in much less numbers as compared with others of the molluscan fauna.

In order to ascertain the probable environmental limiting factors of the Jewell Hill Lake, discussed later under Environmental History, the most significant species have been selected. These forms, which have the largest proportional abundance in numbers, exhibit pronounced fluctuations in the quantitative distribution according to repeated changes in favorable and marginal unfavorable environments. These species are Valvata tricarinata, both species of Amnicola, P. obrussa and G. altissimus. The changes in environmental conditions usually do not show as well in the less abundant indigenous species. Other significant species are those which occupy more actual volume because of the much larger shell of the animal. The large forms in this category are S. umbrosa, H. trivolvis, and at times P. gyrina, which often occurs as an immature shell.

Environmental History

GENERAL. This discussion is an attempt to outline the probable events in the development of the Jewell Hill Lake. Inferences are drawn from the information given under Paleoecology and the occurrence of mollusks collected at section 1. The conclusions, therefore, are limited to the immediate area of the collection site. With this reservation in mind, each fossil-bearing unit is presented separately.

UNIT FOUR, LOWERMOST FAUNA. Table II shows the fauna that lived in the lake just after the initial invasion of mollusks into Jewell Hill Lake. The significant species are V. tricarinata, G. altissimus, A. leightoni, A. lustrica, and H. anceps striatum. Water approximately 5 to 6 m. deep was present in which the fauna flourished. This depth of water at section 1, the deepest portion of the lake, corresponds very well to the known thickness, 5.2 m., of this unit, the buff colored marl. The above depth of water is the probable mean annual water level derived from the known ecology of the significant forms, especially V. tricarinata which lives in deeper water than the others listed. The pH of the water at this time may have been between limits of 7.1 and 8.16. V. tricarinata does not occur in water where the pH is lower than 6.8 or in water softer than 8 p.p.m. The probable limits of the fixed carbon dioxide are between 8.16 and 30.56 p.p.m.

UNIT FOUR, UPPERMOST FAUNA. From the lowermost fauna in the bottom foot of unit 4, up to collections 1 through 6, different species became significant. The change of significant forms indicates filling of the lake and gradual decrease in depth of water. V. tricarinata and A. leightoni decreased in numbers until in the upper part of this unit they assume an unimportant role. A. lustrica increased to about 32 percent in collection 1 and gradually decreased to 20 percent in collection 5. P. gyrina and Pisiddium nitidum exhibit parallel conditions as they increase to 19 and 9 percent, respectively, in collection 1 and gradually decreased to 13 and 6 percent, respectively, in collection 5. Just before the time of accumulation of collection 1 and continuing through collection 5, the specific conditions inferred were as follows: small amount of water weeds with a corresponding minimum of shade and well aerated water about 1 m. or more deep. In collection 6 Pisidium nitidum, Physa gyrina, and Amnicola lustrica drop to an insignificant small number. Conditions here indicate the beginning encroachment of a luxuriant plant growth in very shallow water. The total population already shows a slight reduction in absolute numbers. The encroachment and continued shallowing of water, possibly less than 0.6 m. deep, produced a habitat most favorable for G. altissimus and F. obrussa, the semi-amphibious inhabitant of shallow water among vegetation and debris. These species account for 58 percent of the total individuals in collection 6.

The increase of land snails from 1.5 percent in collection 5 to 8.4 percent in collection 6 shows the possible inward shifting of the shore line. The pH values of about 7.0 to 8.16 are inferred from the significant species in the uppermost part of the unit. The fixed carbon dioxide value probably ranged between 9.5 and 25.75 p.p.m.

UNIT FIVE. Conditions continued to become more adverse for the molluscan population in unit five. In collection 7 the fauna had been reduced to less than half of the population by the continued encroachment of plant growth. In this environment Gyraulus altissimus increased in percentage of total individuals. However, it too was reduced to less than half of its total numbers in unit four, uppermost fauna. The upper part of collection 7 and all of collection 8 represent complete capture of the centrally located area of the lake deposits. In collection 8 the total population was reduced to 0.15 percent of the once vast population in unit four. The decomposition of peat to humus in unit five took place during periods when parts of the vegetal debris was out of water. Undoubtedly some shifting pools of water remained in the area of the lake and provided a source from which the surviving species later repopulated the lake.

In collection 7 the land snails such as S. ovalis, V. ovata, G. pentodon, R. binneyana, and E. fulvus occupied their preferred habitat along the same probable shore line as in collection 6 of unit four, uppermost fauna. Only one land snail, V. ovata, was found in collection 8. This could possibly mean that the shore area would be located elsewhere in the area of the lake deposit.

The pH and fixed carbon dioxide values are about the same as those given for the uppermost part of unit four.

UNIT SIX. A seasonal increase in rain, ending the drought-like or low-water-level period, began another cycle of sedimentation and plant growth in the lacustrine deposit. Again V. tricarinata, along with G. altissimus, became significant during the time of accumulation of collections 9 through 12. Both species of Amnicola are also significant in collections 10 through 12. The presence of these forms, during the accumulation of the lowermost part of this unit, indicated moderately thick vegetation, a level of water more than 1 m. deep, and a mud bottom.

Three species migrated into the pond-like environment during the accumulation of collections 9 through 11. Two of these, S. umbrosa and H. trivolvis, indicate pond conditions. The other, L. stagnalis jugularis, came into a favored habitat of stagnant water in collection 11 but lasted through only to collection 14.

Four species, S. umbrosa, F. obrussa, H. trivolvis, and G. altissimus, are indigenous and remain significant throughout the unit, from collections 13 to 22. Both species of Fossaria are especially valuable in interpreting the conditions. They gradually increase from about 25 percent in collection 13 to about 45 percent of the total individuals in collection 22. These species indicate very shallow water; however, there were times when the water deepened as shown in collections16 and 17. In collections 16 and 17 V. tricarinata and G. altissimus soar to combined percentages of 63 and 57 respectively.

This unit indicates prevailing pond conditions with shallow water and muddy bottom supporting thick pond weeds. The vegetation continued to increase throughout most of the unit as shown in Fig. 18, and a gradual decrease in depth of the already shallow water is inferred from the ecology of the indigenous species. The above inferred habitat is also exemplified by the stratigraphy of the interbedded peat and silty, medium light gray colored marl.

The influx of sediments from the surrounding kame hills was sufficiently great to bury the vegetal debris. The choking vegetation and organic debris so adverse to a flourishing fauna were held in check by the accumulation of sediments. The total population fluctuates in this unit, but increases steadily until a culmination is attained in collections 22 and 23 as shown in Fig. 4. Collections 22 and 23 and those immediately preceding them represent a habitat of optimum conditions for an abundant molluscan assemblage.

The pH value derived from the significant species ranges between 6.6 and 7.8. The fixed carbon dioxide value was probably 7.5 to 25.75 p.p.m.

UNIT SEVEN. The late stage of the lake probably developed as a result of insufficient influx of sediment to check the plant growth. The filling of the lake had raised to such a level that the influx of sediment no longer had much effect. The plant growth finally gained supremacy in the struggle to capture the quiet, shallow water. In this unit the only species to survive were those able to live in mass vegetation. These species include F. obrussa, which reached its highest percentage of 54 in collection 23; and G. altissimus, which attained a percentage of approximately 41 percent in the upper three collections of the unit. The pH and fixed carbon dioxide values would be approximately the same as those in unit six.

The land snails again probably followed the shrinking shore line where they occupied the cool, damp lower layers of vegetal debris. In collections 24 through 26 these land snails attained percentages from 26 to 28 percent of the total individuals. An aquatic habitat is still indicated, however, by the greater percentages of the aquatic mollusks.

AGE AND CORRELATION OF DEPOSIT

General Statement

The molluscan assemblage collected at section 1 is similar to various Pleistocene and living faunas recorded in the literature. In order to determine a probable age relationship based on mollusks, certain faunal occurrences have been selected to illustrate possible correlation. The dissimilarities between the fauna studied and others offer additional information to support a more complete conclusion. The Jewell Hill fauna is compared with one living and five fossil assemblages. In each faunal occurrence names have been brought up to date where necessary.

Living Fauna

NORTH STAR LAKE, ITASCA COUNTY, MINNESOTA. Baker (1935, p. 257) made exhaustive collections of freshwater mollusks in this deep glacial lake, and also of land snails in nearby forests and along the margins of the lake. The freshwater mollusks are largely confined within depths of water less than 4 m. deep. An extensive marl bed lies beneath three feet of peat and bog at Little North Star Lake. Baker (1935, p. 260) states that this deposit of marl "belongs to the time of greater expansion of the lake, probably in late Wisconsin time." Gyraulus altissimus occurred only in the marl bed and was associated with species still living in the lake.

The lake had 27 living freshwater species of which the following eleven also occur in the Jewell Hill deposit: Pisidium sp., Valvata tricarinata (Say), Lymnaea stagnalis jugularis (Say), Fossaria obrussa decampi (Streng), Helisoma anceps striatum (F. C. Baker), Helisoma campanulatum (Say), Planorbula armigera (Say), Promenetus exacuous (Say), Gyraulus crista (Linnaeus), Ferrissia parallela (Say), and Physa gyrina Say.

Seventeen species of land snails lived near the lake, of which 6, listed below, have been washed into the Jewell Hill deposit: Euconulus fulvus (Müller), Retinella binneyana (Morse), Hawaiia minuscula (Binney), Strobilops labyrinthica (Say), Vallonia gracilicosta Reinhardt, and Succinea ovalis Say.

Pleistocene Faunas

URBANA, ILLINOIS. Baker (1918b, p. 660) states that the Urbana deposit is in the Champaign till sheet, which is early Wisconsin in age. The deposit lies in a kettle hole on the north side of the Champaign moraine at the University of Illinois. He suggests that the mollusks may have inhabited the lake or pond when the late Wisconsin ice sheet was "resting at the Valparaiso moraine."

The fauna of the Urbana and Jewell Hill deposits show a dissimilarity in that Pisidia are more abundant in the former and comparison of quantitative data may be made for only a few species. Only eight are common to both deposits. These eight species, together with Baker's indications of abundance, are: Pisidium adamsi Prime - a single valve; P. nitidum Jenyns - the most abundant mollusk; P. ferrugineum Prime - next to P. nitidum the most abundant; Valvata tricarinata (Say) - not common; Fossaria obrussa decampi (Streng) - common; Helisoma trivolvis (Say) - not common, majority of individuals are immature; Gyraulus altissimus F. C. Baker - a few adult individuals and a number of young and immature specimens; and Physa gyrina (Say) - occurs in abundance; the greater number are immature.

RUSH LAKE, LOGAN COUNTY, OHIO. This marl deposit has been dated as post-Wisconsin in age since "Logan County is within the late Wisconsin drift border" (Baker, 1920, p. 440). Noting the absence of land snails and the presence of certain species that have a wide distribution in lakes, Baker concluded "the Ohio deposit may, therefore, be considered as having lived in a larger Rush Lake, perhaps not long after the ice had disappeared from Ohio."

The assemblages of the two deposits, Rush Lake and Jewell Hill Lake, are similar in character and comparative abundance of freshwater mollusks. The most abundant species are the same for both deposits except for one species, Fossaria obrussa. The list of the same species, together with Baker's indications of abundance, follows: Sphaerium lacustre (Müller) - a dozen odd valves; Pisidium casertanum (Poli) - 2 valves; P. compressum Prime - common; P. ferrugineum Prime - a score; P. nitidum Jenyns - the most abundant Sphaeriidae; P. nitidum pauperculum (Sterki) - 2 valves; V. tricarinata (Say) - one of the most abundant species, several hundred; Amnicola leightoni F. C. Baker - "Together with Amnicola lustrica variety, it is the most abundant species in this deposit." A. lustrica Pilsbry - nearly 40 percent of total; Fossaria obrussa decampi (Streng) - quite common; Helisoma anceps striatum (Baker) - "about 10 percent of the antrosus (anceps) may be referred to this variety"; H. campanulatum (Say) - a dozen specimens; Gyraulus altissimus (F. C. Baker) - after Amnicola lustrica and A. leightoni it is the most abundant shell in this deposit; Promenetus exacuous (Say) - fairly common; and Ferrissia parallela (Haldeman) - a single specimen.

ORLETON MASTODON SITE, MADISON COUNTY, OHIO. The molluscan assemblage of this deposit is remarkably similar to that of the Orleton deposit. La Rocque (1952, p. 26) reports that "The age of the Orleton faunas can definitely be stated as Wisconsin" and "both lists of species .... indicate a late Wisconsin age." Both the Jewell Hill and Orleton deposits exhibit more or less parallel development, geologic nature, and environmental conditions.

The significant species in both small lake deposits are comparable in abundance, except for the greater number of Pisidia in the gray layer, and the absence of Amnicola in the Orleton deposit. La Rocque (1952, p. 18) suggests that in the Orleton deposit the establishment of Amnicola and Helisoma, other than H. trivolvis, was prevented due to unknown barriers. The difference between the two assemblages, therefore, becomes minor.

Eleven of the 21 forms present in the Orleton deposit are common to both deposits; they are: Helisoma trivolvis (Say), Planorbula armigera (Say), Gyraulus altissimus (F. C. Baker), Gyraulus crista (Linn.), Promenetus exacuous (Say), Physa gyrina Say, Ferrissia parallela (Haldeman), Succinea ovalis Say, Stenotrema monodon (Rackett), Hawaiia minuscula (Binney), and Vertigo ovata Say.

Six species in the Orleton deposit have ecological requirements similar to those in the Jewell Hill deposit. They are: Pisidium sp., Sphaerium sp., Stagnicola palustris elodes (Say), Stagnicola lanceata (Gould), Fossaria galbana (Say), and Valvata lewisi Currier.

CLEVELAND, OHIO. This loess deposit, studied by Leonard (1953, p. 368), contains two molluscan assemblages, of which the lower faunule is correlated with the Farmdale substage of Wisconsin age and the upper faunule is correlated with the Tazewellian substage. The disparity between the Cleveland loess and Jewell Hill deposits is shown by the number of different species in both faunas. Leonard (1953, p. 370) has listed a number of individuals that "clearly attest" the age of the loess deposit to be early Wisconsin. The list follows: Fossaria dalli grandis Baker, Gyraulus pattersoni Baker, Columella alticola (Ingersoll), Discus mcclintocki Baker, Hendersonia occulta (Say), Succinea avara gelida Baker, S. grosvenori Lea, and Vertigo alpestris oughtoni Pilsbry.

SIDNEY CUT, SHELBY COUNTY, OHIO. The fauna of this deposit consists largely of terrestrial snails that have been washed into puddles or pools of a hollow developed on a ground moraine (La Rocque and Forsyth, 1957, p. 85). The evidence supports a Wisconsin age, and "an 'Early' rather than a 'Late' Wisconsin age" is indicated because of the presence of certain species.

especially Columella alticola and Vertigo alpestris oughtoni. The comparison of land snails in the Sidney Cut deposit with those that have been washed into the deposit under study illustrates a striking disparity of terrestrial snails. Only 3 species and 3 genera out of a total of 15 forms are the same in both deposits. The following list is composed of terrestrial species that occur in the Sidney deposit and not in the Jewell Hill deposit: Carychium exile canadense Clapp; Cionella lubrica (Müller), Columella alticola (Ingersoll), Deroceras? sp., Discus cronkhitei (Newcomb), Helicodiscus sp., Helicoid, undetermined fragments; Succinea grosvenori Lea, and Vertigo alpestris oughtoni Pilsbry. Hawaiia minuscula, Succinea avara, and Vallonia gracilicosta are common to both deposits.

Age of Deposit

The Jewell Hill fauna is Wisconsin in age, as shown by comparison of the fauna with others of known Wisconsin age. That the Jewell Hill deposit is pre-Recent is demonstrated by the presence of 5 species which are no longer a part of the living molluscan fauna of Ohio. These are Amnicola leightoni, Helisoma anceps striatum, Gyraulus altissimus, and Vallonia gracilicosta. All of these forms, except Amnicola leightoni, are still found living at higher latitudes.

A "Late" rather than an "Early" Wisconsin age is preferred because of the character of the fauna and the geologic nature of the deposit. The terms "Late" and "Early" Wisconsin are used here with the meaning assigned by Goldthwait and Forsyth and explained by La Rocque and Forsyth (1957, p. 81, footnote). The absence in the Jewell Hill deposit of species which may be indicative of an "Early" Wisconsin age, further supports the preference stated above. These "Early" Wisconsin species, which are also absent from the living molluscan fauna of Ohio, include Columella alticola, Succinea grosvenori, Discus mcclintocki, Vertigo alpestris oughtoni, Gyraulus pattersoni, and Fossaria dalli grandis. The Jewell Hill deposit lies on a till sheet that covers a kame deposit. This mantle of till has been assigned a "Late" Wisconsin age by Forsyth (1956, p. 183).

The writer concludes, therefore, that the Jewell Hill Lake deposit is "Late"Wisconsin in age because of the evidence presented.

Acknowledgements

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DESCRIPTION OF FIGS. 6 - 11, OPPOSITE PAGE

Fig. 6. Quantitative distribution of Fossaria obrussa (Say) in the Jewell Hill Deposit.
Fig. 7. Quantitative distribution of Physa gyrina Say in the Jewell Hill Deposit.
Fig. 8. Quantitative distribution of Fossaria obrussa decampi (Streng) in the Jewell Hill Deposit.
Fig. 9. Quantitative distribution of Promenetus exacuous (Say) in the Jewell Hill Deposit.
Fig. 10. Quantitative distribution of Stagnicola umbrosa (Say) in the Jewell Hill Deposit.
Fig. 11. Quantitative distribution of Helisoma trivolvis (Say) in the Jewell Hill Deposit.

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	202	20.2	
25	167	16.7	
24	88	17.6	
23	541	54.1	
22	407	40.7	
21	474	47.4	
20	395	39.5	
19	242	24.2	
18	341	34.1	
17	188	18.8	
16	159	15.9	
15	169	16.9	
14	199	19.9	
13	259	25.9	
12	44	4.4	
11	18	1.8	
10	47	4.7	
9	39	3.9	
8	2	4.1	
7	167	16.7	
6	171	17.1	
5	167	16.7	
4	114	11.4	
3	59	5.9	
2	57	5.7	
1	55	5.5	

6

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	3	0.3	
25	7	0.7	
24	8	1.6	
23	44	4.4	
22	53	5.3	
21	96	9.6	
20	56	5.6	
19	67	6.7	
18	53	5.3	
17	72	7.2	
16	30	3.0	
15	20	2.0	
14	15	1.5	
13	34	3.4	
12	16	1.6	
11	18	1.8	
10	18	1.8	
9	21	2.1	
8	0	0.0	
7	18	1.8	
6	45	4.5	
5	133	13.3	
4	151	15.1	
3	137	13.7	
2	194	19.4	
1	195	19.5	

7

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	39	3.9	
25	47	4.7	
24	18	3.6	
23	138	13.8	
22	46	4.6	
21	41	4.1	
20	43	4.3	
19	23	2.3	
18	38	3.8	
17	16	1.6	
16	13	1.3	
15	38	3.8	
14	53	5.3	
13	16	1.6	
12	3	0.3	
11	0	0.0	
10	7	0.7	
9	17	1.7	
8	0	0.0	
7	58	5.8	
6	27	2.7	
5	42	4.2	
4	51	5.1	
3	20	2.0	
2	61	6.1	
1	50	5.0	

8

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	6	0.6	
25	10	1.0	
24	5	1.0	
23	1	0.1	
22	11	1.1	
21	1	0.1	
20	12	1.2	
19	22	2.2	
18	33	3.3	
17	46	4.6	
16	58	5.8	
15	26	2.6	
14	17	1.7	
13	25	2.5	
12	11	1.1	
11	13	1.3	
10	27	2.7	
9	25	2.5	
8	0	0.0	
7	13	1.3	
6	22	2.2	
5	4	0.4	
4	1	0.1	
3	1	0.1	
2	2	0.2	
1	1	0.1	

9

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	9	0.9	
25	5	0.5	
24	2	0.4	
23	0	0.0	
22	8	0.8	
21	5	0.5	
20	4	0.4	
19	6	0.6	
18	6	0.6	
17	2	0.2	
16	3	0.3	
15	3	0.3	
14	4	0.4	
13	6	0.6	
12	8	0.8	
11	1	0.1	
10	0	0.0	
9	0	0.0	
8	0	0.0	
7	0	0.0	
6	0	0.0	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	0	0.0	

10

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	3	0.3	
25	2	0.2	
24	1	0.2	
23	0	0.0	
22	3	0.3	
21	2	0.2	
20	8	0.8	
19	5	0.5	
18	13	1.3	
17	8	0.8	
16	4	0.4	
15	7	0.7	
14	6	0.6	
13	2	0.2	
12	1	0.1	
11	1	0.1	
10	3	0.3	
9	2	0.2	
8	0	0.0	
7	0	0.0	
6	0	0.0	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	0	0.0	

11

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	1	0.1	
25	0	0.0	
24	1	0.2	
23	1	0.1	
22	3	0.3	
21	3	0.3	
20	1	0.1	
19	29	2.9	
18	5	0.5	
17	113	11.3	
16	102	10.2	
15	6	0.6	
14	2	0.2	
13	0	0.0	
12	109	10.9	
11	163	16.3	
10	156	15.6	
9	102	10.2	
8	2	4.1	
7	70	7.0	
6	61	6.1	
5	50	5.0	
4	59	5.9	
3	68	6.8	
2	33	3.3	
1	28	2.8	

12

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	1	0.1	
25	0	0.0	
24	6	1.2	
23	0	0.0	
22	1	0.1	
21	0	0.0	
20	0	0.0	
19	6	0.6	
18	1	0.1	
17	2	0.2	
16	1	0.1	
15	6	0.6	
14	94	9.4	
13	3	0.3	
12	209	20.9	
11	369	36.9	
10	91	9.1	
9	52	5.2	
8	3	6.1	
7	11	1.1	
6	35	3.5	
5	71	7.1	
4	67	6.7	
3	101	10.1	
2	45	4.5	
1	51	5.1	

13

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	0	0.0	
25	0	0.0	
24	5	1.0	
23	0	0.0	
22	0	0.0	
21	0	0.0	
20	0	0.0	
19	0	0.0	
18	0	0.0	
17	0	0.0	
16	1	0.1	
15	0	0.0	
14	0	0.0	
13	0	0.0	
12	129	12.9	
11	134	13.4	
10	7	0.7	
9	6	0.6	
8	3	6.1	
7	18	1.8	
6	66	6.6	
5	201	20.1	
4	232	23.2	
3	301	30.1	
2	312	31.2	
1	324	32.4	

14

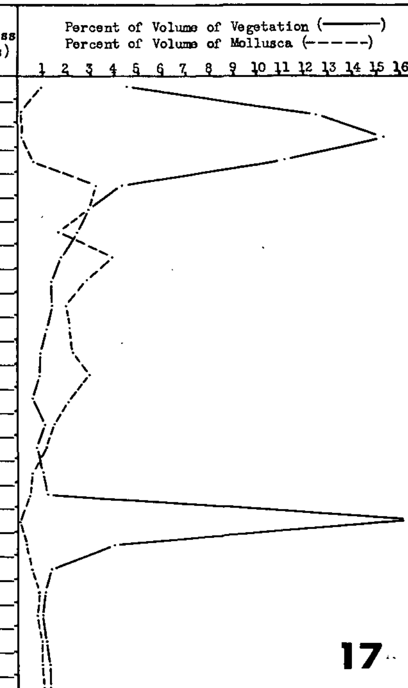
COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	4	0.4	
25	11	1.1	
24	9	1.8	
23	9	0.9	
22	40	4.0	
21	36	3.6	
20	44	4.4	
19	16	1.6	
18	49	4.9	
17	15	1.5	
16	14	1.4	
15	57	5.7	
14	40	4.0	
13	5	0.5	
12	0	0.0	
11	1	0.1	
10	11	1.1	
9	24	2.4	
8	4	7.8	
7	44	4.4	
6	37	3.7	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	1	0.1	

15

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	0	0.0	
25	0	0.0	
24	1	0.2	
23	3	0.3	
22	6	0.6	
21	3	0.3	
20	6	0.6	
19	8	0.8	
18	23	2.3	
17	25	2.5	
16	14	1.4	
15	9	0.9	
14	16	1.6	
13	11	1.1	
12	1	0.1	
11	0	0.0	
10	0	0.0	
9	2	0.2	
8	1	2.0	
7	12	1.2	
6	18	1.8	
5	1	0.1	
4	1	0.1	
3	2	0.2	
2	0	0.0	
1	1	0.1	

16

UNIT	Coll. No.	Thickness (inches)
7	26	12
	25	2.5
	24	2.5
	23	2
6	22	2
	21	2
	20	2
	19	2
	18	2
	17	2
	16	2
	15	2
	14	2
	13	2
	12	2
	11	2
	10	2
	9	2.5
5	8	3
	7	2.5
4	6	2
	5	2
	4	2
	3	2
	2	2
	1	2



17

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DESCRIPTION OF FIGS. 12-17, OPPOSITE PAGE

Fig. 12. Quantitative distribution of Valvata tricarinata (Say) in the Jewell Hill Deposit.

Fig. 13. Quantitative distribution of Amnicola leightoni F. C. Baker in the Jewell Hill Deposit.

Fig. 14. Quantitative distribution of Pisidium nitidum Jenyns in the Jewell Hill Deposit.

Fig. 15. Quantitative distribution of Pisidium casertanum (Poli) in the Jewell Hill Deposit.

Fig. 16. Quantitative distribution of Pisidium obtusale rotundatum (Prime) in the Jewell Hill Deposit.

Fig. 17. Variation in relative abundance of vegetation and mollusks in the Jewell Hill Deposit.