Journal of the Minnesota Academy of Science

Volume 35 | Number 2 Article 6

1968

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BIOLOGY

Distribution and Abundance of Molluscs in a Fresh Water Environment

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ABSTRACT — The molluscs of a northwestern Minnesota lake were sampled using transects, a sampling frame, and SCUBA. The species sampled were: *Amnicola limosa, Valvata tricarinata, Gyraulus parvus, Physa* cf. *P. gyrina, Helisoma anceps, H. campanulata, Promenetus exacuous, Ferrissia parallela, Anodonta marginata, Lampsilis siliquoidea,* and *Sphaerium* cf. *S. striatum.* The unionid clams, the adult *Helisoma* spp. and the *Physa* adults were associated with the absence of aquatic vegetation. Distinct associations of snail species were found with each plant association: *G. parvus* and *V. tricarinata* with the deep water *Nitella opaca* association, *A. limosa* and *V. tricarinata* with the mid-depth mixed macrophyte association, and *H. anceps* and *Physa* adults with the shallow water, rocky bottom macrophyte association. Two estimates of snail abundance were made for each depth. Neither proved very satisfactory, but they did indicate that snail abundance was related to the type and abundance of aquatic plants.

Despite the conspicuousness of molluscs in the fresh water environment, their ecology is not well known. For the midwestern United States, the principal source of ecological information on molluscs is still Baker (1928), supplemented with such non-quantitative local studies as Dawley (1947) and Dennis (1928). In recent years some quantitative work has been done in European waters (summarized in Oklund, 1964) or with snails that are vectors for economically important parasites (Hubendick, 1958; Malek, 1958; Howard and Walden, 1965). One of the main reasons for the small number of quantitative reports on mollusc ecology is the difficulty in obtaining adequate samples (Oliver and Schneiderman, 1956). This paper presents a quantitative sampling method which can be used in lakes where SCUBA diving is possible, as well as the information collected using this method. During the study special emphasis was placed on the snails *Amnicola limosa*(Say), *Valvata tricarinata*(Say), *Gyraulus parvus*(Say), *Physa* cf. *P. gyrina*(Say) and *Helisoma anceps*(Menke). Some information was collected on the snails *Helisoma campanulata*(Say), *Promenetus exacuous*(Say), and *Ferrissia paralella*(Haldeman), as well as on the clams *Anodonta marginata*(Say), *Lampsilis siliquoidea*(Barnes) and *Sphaerium* cf. *S. striatum*(Lamarck).

The Study Area

Long Lake (T. 144, N.R. 36, 37 W.) is a clear, lake in the northwestern section of Minnesota, about 1¼ miles long and 1/5 mile wide (Fig. 1). The banks of the lake are high and covered with conifers; the lake bottom is very marly and plunges steeply down to a maximum depth of 27 meters. The lake is spring fed, with a single outlet, and the water level does not fluctuate greatly.

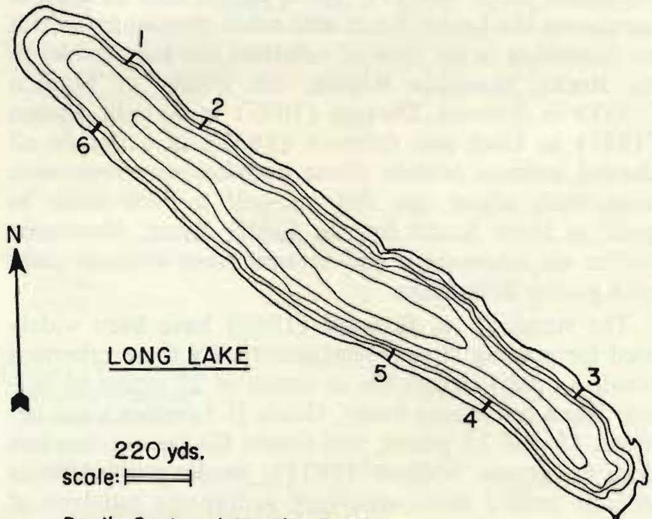

FIGURE 1. Long Lake, showing the location of the six transects.

Schmid (1965) showed that three aquatic plant associations exist in the lake: (1) a shallow water association consisting of a sparse growth of *Chara contraria* A. Br., *Najas flexilis* (Willd), *Potamogeton pectinatus* L. and *Heteranthera dubia* (Jacq.); (2) intermediate depth association (1-5m) dominated by *Chara contraria, Najas flexilis, Myriophyllum exalbescens* (Fern.) and several species of *Potamogeton*; (3) a deep water association of *Nitella opaca* Ag. and *Chara contraria* between six and eight meters and of *Nitella opaca* alone between eight and eleven meters. Below eleven meters the bottom consists of cobbles covered by a thin layer of marly silt. Schmid also noted that vegetation is more abundant on the northeast side of the lake and grows to greater depths,

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apparently because the orientation of the lake allows more sunlight to fall on the northeast side. Thus, at a depth of nine meters on the northeast side, *N. opaca* grows upright in luxurient masses up to a meter high, while on the southwest side it is present only as small strands, sprawled on the bottom.

Field Procedure

Six transects, running from deep to shallow water, were set up on September 1 and 2, 1967, three on each side of the lake (Fig. 1). On each transect samples were taken at one meter depth intervals, from nine meters to one meter, plus an additional sample at ½ meter. For each sample a diver equipped with SCUBA gear went to the bottom with a light sampling frame, ½ meter on a side, and a large metal pail. The frame was placed gently on the vegetation or lake bottom. For sampling of areas with a heavy growth of vegetation, the bucket was placed next to the sampling frame so that the diver could pull all the vegetation into the bucket quickly. The bucket was then taken to the surface and handed to a partner in the boat, who washed the snails carefully from the plants and the bucket. The snails were preserved in a ten per cent formalin solution. Few snails were lost in this procedure, since the jostling of the plants by the sampling frame was not severe enough to cause the snails to drop off and the sampling area was small enough so that most of the plants were in or over the bucket by the time any snails dropped off.

In areas where vegetation was scant, four samples were collected instead of one in order to obtain data on clam abundance, but snails were taken from only the first of these samples. More than one sample of snails at one location was taken only in vegetation-free shallow areas where snail numbers were low. In each sampling area the per cent of bottom occupied by each plant species was recorded, as well as the average height of each species. From these data the approximate volume of water occupied by vegetation was calculated and used as a rough index of vegetation abundance per cubic meter. In bare areas, the bottom type was recorded.

Laboratory Procedure

In the laboratory, each sample was sorted according to species. Snails of the more abundant species were classified as either adults or immatures, according to size. The minimum size chosen to distinguish the adults was 1.75 mm. for *Valvata tricarinata* and *Gyraulus parvus* and 2.0 mm. for *Amnicola limosa.* For each of these species an adult/juvenile ratio was calculated for each depth, on the assumption that the depth with the lowest ratio for a given species would be the depth at which the most successful reproduction was occurring.

Assessment of Results

From this study, estimates of mollusc abundance in the lake were obtained, as well as evidence that there is a distinct snail association with each plant association.

Because the two sides of the lake are different, results from the three transects on each side of the lake were lumped together for separate analysis. For snails, abundance estimates were based on the total number of snails collected at each depth, regardless of species (Table 1). Two abundance (density) estimates were used: snails per square meter of bottom and snails per cubic meter of water occupied by the aquatic vegetation. The former is perhaps the most useful for comparison with bottom fauna studies, such as that of Oklund (1964) and Eggleton (1952). However, it ignores the obvious effects that plant character and abundance have on snail numbers. These factors are particularly important in Long Lake, since the snails are found almost exclusively on the plants, except in shallow water.

TABLE 1. Estimates of small abundance based on snails collected from three transects on each side of the lake.

	northeast transects			southwest transects		
Depth (m)	N	Snails/m² bottom	Snails/m³ vegetation	N	Snails/m² bottom	Snails/m³ vegetation
9	500	667	575	22	29	1100
8	844	1125	1017	96	128	3200
7	476	635	1587	224	299	3733
6	193	257	689	67	89	738
5	994	1335	2616	150	200	556
4	1123	1497	2955	119	159	290
3	964	1285	2537	276	368	708
2	449	589	847	170	227	472
1	519	692	1331	139	185	811
½	54*	8	...	6	8	...

* Collected from 27 samples.

The estimate, snails per cubic meter of vegetation, is an attempt to take these effects into account but it ignores the following two factors: (1) aquatic plant species differ in their suitability for supporting snails, those with finely branched leaves supporting the largest invertebrate populations (Krecker, 1939; Andrews and Hasler, 1943). (This actually was a problem only in some of the samples taken along the southwest shore where *Potamogeton zosteriformes* was abundant. In most of the samples the dominant plant species, (*Chara contraria, Nitella opaca, Potamogeton pectinatus, Myriophyllum exalbescens*) had finely branched leaves). (2) The amount of plant actually available as potential snail substrate varies with plant species and plant abundance. Most of the stems and leaves of tall, loosely-clumped plants like *P. pectinatus* or *P. zosteriformes* may be utilized by snails, while in a dense bed of *C. contraria,* the bottom half of the plants may be unavailable to the snails because the closely packed stems trap a large amount of marl and other debris. This is probably the reason for the snail density differences between the two sides of the lake at 9, 8, and 7 meters. At these depths on the southwest side, vegetation was very sparse, while on the northeast side it was very thick. In the areas of sparse vegetation the number of snails per plant was high, even though the absolute number of snails was low, resulting in high estimates of snails per cubic meter of water occupied by the vegetation.

At the intermediate depths, snails are much more abundant on the northeast side than on the southwest side. This probably reflects the differences in plant species and abundance (Schmid, 1965) and possibly differences in the availability of epiphytic diatoms as food for the snails.

Although snails were more abundant on the northeast side, the unionid clams, *Lampsilis siliquoidea* and *Anodonta marginata*, were more abundant on the southwest side because there was more area free of vegetation. Ninety per cent of the 66 clams collected were from the southwest transects. No clams of any species were found below nine meters.

Associations of snail species were found to be related to the three plant associations in the lake. This relationship was most conspicuous on the northeast side of the lake (Fig. 2). At nine meters, where the dominant plant was *Nitella opaca, Gyraulus parvus* and *Valvata tricarinata* were the dominant snails. Both snail species had low adult/juvenile ratios at this depth, compared to the ratios at other depths (Table 2). *Amnicola limosa* was present at nine meters only in comparatively low numbers, with a high adult/juvenile ratio. The only other snails present at this depth were a few immature *Physa cf. P. gyrina*. At eight meters, where the vegetation was predominantly *Chara contraria* mixed with clumps of *N. opaca, A. limosa* was the dominant snail although *G. parvus* was still present in large numbers. Between seven and three meters, *A. limosa* reached its maximum numbers, while the numbers of *G. parvus* were much reduced.

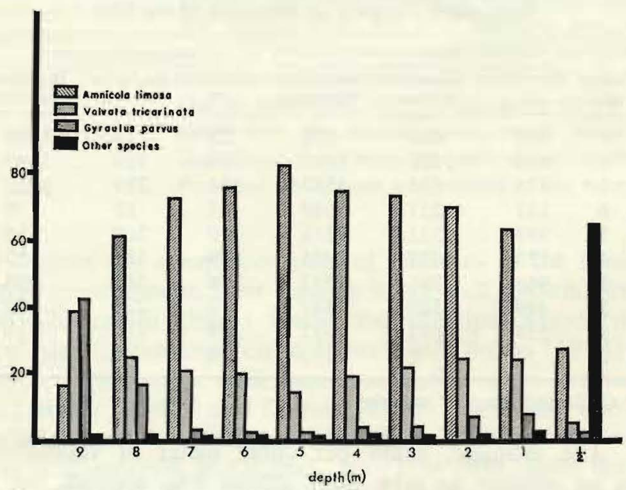

FIGURE 2. Percentages of snail species at different depths, collected on the northeast side of Long Lake (transects 1-3). The 'other species' are small *Physa* cf. *P. gyrina* from 1-9 meters and large *Physa* and *Helisoma anceps* at ½ meter.

TABLE 2. Adult/juvenile ratios in snail samples.

	A. limosa		V. tricarinata		G. parvus	
Depth (m)	No.	Ratio	No.	Ratio	No.	Ratio
9	79	0.93	195	0.11	214	0.13
8	514	0.78	157	0.31	144	0.15
7	354	0.65	100	0.27	16	1.29
6	149	0.96	39	0.56	3	0.50
5	834	0.51	139	0.26	20	1.22
4	851	0.24	216	0.42	49	0.96
3	711	0.76	215	0.18	41	0.41
2	318	0.92	112	0.72	31	0.48
1	330	2.51	122	0.28	41	0.46
½	15	6.50	5	. . .	1	. . .

The lowest adult/juvenile ratios for *A. limosa* occurred at four and five meters, where its population was highest (Table 2). The percentages of *V. tricarinata* (Fig. 2) remained fairly constant at the intermediate depths except for the low at five meters and the apparent increase towards shallow water. A chi-square test ($P. < :05$) showed that this increase was significant. Other snails collected on the mid-depth plant association were a few immature *Physa* and two *Promenetus exacuous*. In shallow water, the snails were found primarily on the rocks rather than on the few plants present. The dominant

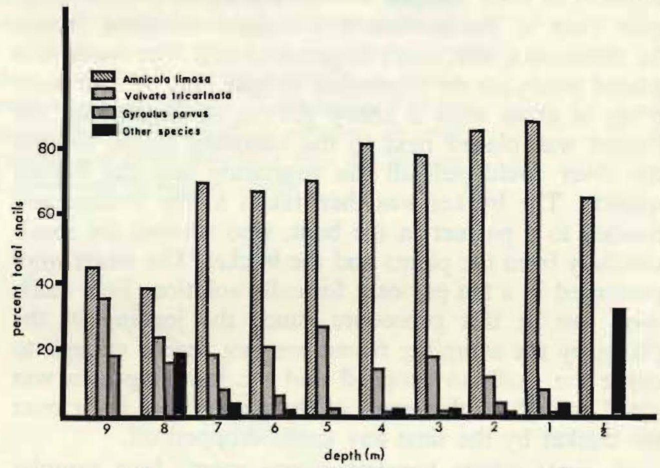

FIGURE 3. Percentages of snail species at different depths on the southwest side of Long Lake (transects 4-6). The 'other species' are *Physa* cf. *P. gyrina, Helisoma anceps,* and *H. campanulata.*

snails here were large *Helisoma anceps* and *Physa*, together with a few adult *A. limosa, G. parvus* and *V. tricarinata.* A chi-square test ($P. < .05$) indicated that the distribution of population densities among depths for *A. limosa* and for *V. tricarinata* was significantly different from an even distribution.

Although a nonparametric rank correlation test (Steel and Torrie, 1960, p. 409) showed that the distributions with depth of *A. limosa* and *V. tricarinata* on the northeast side of the lake were not significantly ($P. < .05$) different from those on the southwest side, Figures 2 and 3 indicate some differences. The differences reflect, at least in part, the differences in sample sizes (Table 1), but the sample size differences in turn reflect the less abundant vegetation on the southwest side. The vegetation on the southwest side at eight and nine meters consisted solely of a sparse growth of *N. opaca*. Associated with this were the highest percentages of *G. Parvus* and *V. tricarinata,* although *A. limosa* was the most abundant single species (Fig. 2). At eight meters the high percentage of snails of other species was due to *Physa* and *Helisoma campanulata.* Both mature and immature snails of these species were collected. The *H. campanulata* were collected only from transect five, at nearly all depths. The adults of both species were found on the bottom. (The only other spot in the lake were *H. campanulata* was noticed in any numbers was a silty bottomed shallow area at the north end.) The adult/juvenile ratios for all species varied widely, probably because of the small sample sizes. Only six snails were collected from shallow water (four *A. limosa* and two *H. campanulata*) although a few *Ferrisia parallela* were present on rocks in the vicinity.

Discussion

One of the problems with a study of this sort is its limited nature: it is really a study of the distribution of molluscs in Long Lake in early September, 1967. Fortunately Long Lake is very stable limnologically, so the plant-snail associations found in this study are most likely constant. The plant associations in September, 1967, were the same as those found by Schmid (1965) in July, 1963. Once these plant associations have become well established (by mid-June) the snail associations probably have also become established. Observations on snail distribution made by the senior author in July, 1967, indicated snail associations similar to those found in September.

The factors that determine the snail associations in Long Lake appear to be related primarily to the complex of environmental variables in the lake itself and only secondarily to the specific ecological requirements of each snail species. These requirements, according to Hubendick (1958), are very broad. The studies of Baker (1928) and Eggleton (1952) indicate that any of the snail species present in Long Lake should be able to do well in most of the habitats present, since they all do well in apparently equivalent habitats in other midwestern lakes.

The adults of *H. anceps, H. campanulata,* and *Physa,* as well as the clams *L. siliquoidea* and *A. marginata,* were found only where vegetation was absent. Adult *H. anceps*, adult *Physa* and *Ferissia parallela* were found primarily on rocky bottoms in shallow water, probably because of their ability to withstand wave action. *H. campanulata* was found on silty bottom regardless of depth. The effects of the nature of the plant association, depth, and temperature cannot be separated, although the fact that clams were rare below seven meters and non-existent below nine meters is probably related to the depth of the thermocline, which usually began at about seven meters. The *G. parvus-V. tricarinata* dominated snail association, however, occurred only on *N. opaca* which was found only in deep water, mostly below the thermocline. Possibly these two species dominate here because they can out reproduce other species, particularly *A. limosa,* only in cold water, as indicated by the low adult/juvenile ratios. In shallow water predation may be a main limiting factor: the chief snail predators in the lake, the sunfishes, *Lepomis* spp. occur in greatest numbers between one and two meters (Moyle, unpublished data). Selective predation on *A. limosa* may allow other snail species to exist in greater numbers at these depths.

Acknowledgment

The authors wish to thank Dr. Robert Bright and Dr. James Underhill of the University of Minnesota for advice and help, and Dr. William H. Marshall for permitting use of the Itasca Forestry and Biological Station during the field period of this study.

References

ANDREWS, J. B. and A. D. HASLER, 1943. Fluctuations in the animal populations of the littoral zone in Lake Mendota. T. Wisc. Acad. Sci. 35: 175-186.

BAKER, F. C. 1938. The freshwater mollusca of Wisconsin. Wisc. Geol. Nat. Hist. Surv. Bull. 70, parts 1, 2.

DAWLEY, C. 1947. Distribution of aquatic molluscs in Minnesota. Am. Midl. Nat. 38: 671-697.

EGGLETON, F. E. 1952. Dynamics of interdepression benthic communities. T. Am. Nicros. Soc. 71: 189-228.

HOWARD, T. E. and C. C. WALDEN. 1965. An ecological study of the snail hosts for the agent *Schistosoma dermatitus* in Culter's lake, B. C. J. Appl. Ecol. 2: 121-135.

HUBENDICK, B. 1958. Factors conditioning the habitat of freshwater snails. Bull. Wor. Health Org. 18: 1072-80.

KRECKER, F. 1939. A comparative study of the animal populations of certain submerged aquatic plants. Ecol. 20(4): 553-563.

MALEK, E. A. 1958. Factors conditioning the habitat of *Bilharziasis* intermediate hosts of the family Planorbidae. Bull. Wor. Health Org. 18: 785-818.

MEGARD, R. O. 1967. Limnology, primary productivity and carbonate sedimentation of Minnesota lakes. Interim Rpt. 1, Limnol. Res. Center, Univ. Minn. 69 pp.

OKLAND, J. 1964. The eutrophic lake Borrevan (Norway)—an ecological study on shore and bottom fauna with special reference to the gastropods, including a hydrographic survey. Folia Limnol. Scand. 13: 1-337.

OLIVER, L. and M. SCHNEIDERMAN. 1956. A method for estimating the density of aquatic snail populations. Exp. Parasit. 5: 109-117.

SCHMID, W. D. 1965. Distribution of aquatic vegetation as measured by line-intercept with SCUBA. Ecology 46(6): 816-823.

STEEL, R. and J. H. TORRIE. 1960. Principles and procedures of statistics. McGraw-Hill, New York.