A COMPARATIVE STUDY OF THE ANIMAL POPULATION OF CERTAIN SUBMERGED AQUATIC PLANTS [1]

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The importance of aquatic vegetation as a place of abode for aquatic animals has long been recognized and animal population studies of aquatic habitats have usually included at least some reference to the animals on the vegetation. It is quite generally recognized that the submerged, leafy types of vegetation are more densely populated than are the emergent, hard surfaced, non-leafy types, but exact and comprehensive quantitative or even qualitative information of a more specific nature is conspicuously meager.

Among the studies made on submerged vegetation are those of Moore ('13), Baker ('16, '18), Richardson ('21), and more recently those of the staff of the State of New York Conservation Commission including P. R. Needham ('28, '29), Pate ('32), Nevin and Townes ('35). Moore's observations were restricted to the potamogetons and were essentially qualitative, numbers being indicated by the general terms "abundant" and "scarce." Baker ('16), in his Oneida Lake studies on molluscs, made a closer approach to specific quantitative information by counting the molluscs on each leaf of each plant. Richardson ('21), using the general designation "weeds," made a quantitative examination of the upper nine inches of aquatic plants, the count being based on the animals which were washed off as the plants were shaken in water. In the studies carried on under the auspices of the State of New York Conservation Commission pure stands of submerged plants were designated but no distinction was made between the animals on the plants and those on the underlying substratum, and no attempt was made to determine the population on a plant by plant basis. There is thus clearly much room for precise information both with respect to the population of aquatic plants in general and with respect to given species of plants.

The results reported in this paper are based on a plant by plant examination of seven species of submerged, leafy aquatic plants, from the western region of Lake Erie, the examination being made with a view to determining both the composition and the quantity of the animal population. The plants were *Potamogeton compressus, Potamogeton pectinatus, Potamogeton crispus, Myriophyllum spicatum, Elodea canadensis, Naias flexilis,* and *Vallisneria spiralis* (Fig. 1). I am indebted to Prof. L. H. Tiffany for the identifications.

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One of the primary requisites in a comparative study of this sort is that the plants compared be growing under essentially the same conditions. Otherwise the rôle of the plants as a responsible factor in accounting for such differences in the animal populations as may be observed cannot, readily, be

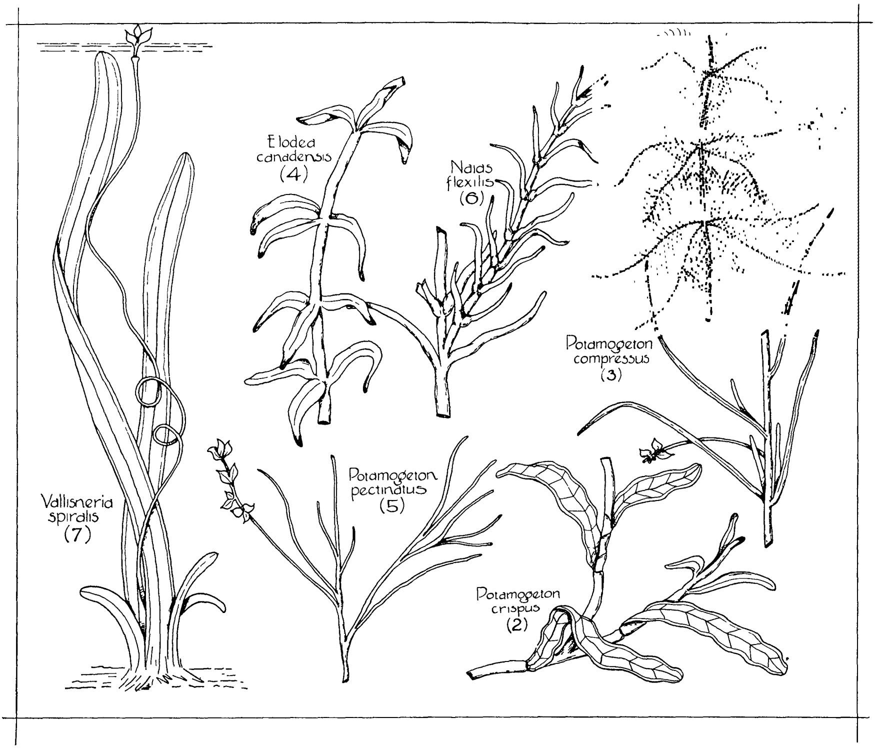

FIG. 1. The plants examined.

differentiated from the rôle of the environment. This uncertainty is one of the weaknesses in comparisons based on studies of pure stands, since, of course, two or more species of plants, each growing in a pure stand, are not necessarily growing under the same conditions. The requirements are obviously most nearly fulfilled when the plants to be compared are growing closely intermingled in a common bed of vegetation, and, thus, as nearly as possible under common environmental conditions. The plants selected for this study were chosen because they were thus growing together. Fortunately it so happens that they are among the more common species of aquatic plants. Beds of vegetation were selected in different sections of Put-in Bay Harbor, South Bass Island, Lake Erie (where the investigation was conducted during the summers of 1935 and 1936), and also in East Harbor, a marshy backwater on the neighboring mainland. In both of these regions dense mats of submerged vegetation grow on a muddy substratum protected from the agitation of the open lake. In Put-in Bay Harbor, a bed of vegetation was examined in a section known as Squaw Harbor, another in the Hatchery Bay section, and a third in a row boat slip on Gibraltar Island.

Methods

There is as yet no commonly accepted standard for comparing the population of one type of plant with that of another. In Baker's ('16) Oneida Lake study of molluscs, an entire plant was taken as the unit, all the animals on each plant having been counted. Accurate comparison by this method depends upon all plants being of the same size, a requirement which is difficult to fulfill and which Baker does not indicate was met. A more widely used but decidedly less precise method has been to express density of population in terms of the area covered by the plants examined. This method quite obviously does not lend itself to exact comparative studies since the number of plants is likely to vary in different areas. It is entirely inapplicable to a study in which the different plants to be compared grow in the same area.

In casting about for a more satisfactory basis of comparison it appeared that one depending upon linear feet of stem provides a criterion which can be applied to all plants regardless of their size and distribution and which can be based upon a single plant or upon parts of several plants of the same species as conditions make possible or desirable. In this study at least ten linear feet of each species of plant was examined from each of the situations in which the plant was found. In computing feet, branch growths more than an inch or two in length were not included in the unit being measured, but were treated as part of an additional foot. The particular number of feet was chosen rather arbitrarily, although it was influenced by the amount of plant which could be examined within a reasonable period and yet provide a surface area sufficiently large to furnish representative results. In most instances more than ten feet of a particular species was examined from a single locality in which case the results were reduced to a ten foot basis.

The plants were collected from a boat by reaching down into the water as far as possible and cutting off a single plant at a time. As the severed portion was lifted clear of the water, it was placed in a glass dish, a small amount of water was added and the dish was covered to prevent drying. Usually only as much plant was gathered as could be examined in the time immediately available so that all counts could be made while the animals were still alive. When it occasionally became necesssary to continue the count at a later time, it was found that the animals could be kept in good condition in the laboratory from one day to the next, provided the vegetation was kept in a covered container so as to retain the moisture.

In the laboratory, sections of a plant were measured as needed. The leaves were clipped off into a petri dish containing water, the stalk was cut into inch lengths and the dish was then placed under a wide field binocular for examination. The total number of feet of each species examined in this way depended upon the number of situations in which the species was found. Thus, over seventy feet each of *Myriophyllum* and of *Potamogeton crispus* were examined, forty feet of *Naias* and of *Elodea,* twenty feet of *Potamogeton pectinatus,* and ten feet each of *Potamogeton compressus* and *Vallisneria.*

The animals were identified to genera (in a few instances to order only, or to family, and nematodes to class), counted and recorded according to plant and locality for later analysis. Identification stopped short of species for several reasons among them, the method used in making the count. This was based on the fact that it is practically impossible to disentangle all the animals from the vegetation and that they are most easily found on the vegetation, while their own movements aid in discovering them. To have stopped for the examination of detail which in many instances is needed for species identification would have necessitated preserving the material and thus really defeating the end desired. Highly valuable as specific identification is, the order of events held in mind has been that it is first of all desirable to learn which plants are the most densely populated after which attention can be devoted to the specific character of the inhabitants.

The Animal Population

The results have been analyzed in terms of the distribution of genera among the plants and also in terms of the frequency with which members of the respective genera occurred on a given plant.

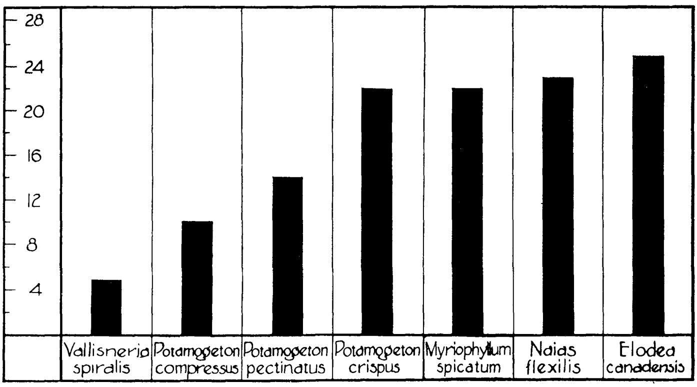

Fig. 2. Distribution of genera among the plants. The numerals on the left indicate the number of genera per plant.

Representatives of twenty-nine genera were found (Table I). Their distribution among the plants is graphically shown in figure 2, from which it will be seen that the number of genera per plant ranged from a maximum of 26 on *Elodea* to a minimum of 4 on *Vallisneria.*

An entirely different picture is presented when one compares the plants on the basis of the average number of individuals present on a ten foot length. In this case *Myriophyllum* with 1442 individuals and *Potamogeton crispus* with 1139 led all the others by a wide margin (Fig. 3).

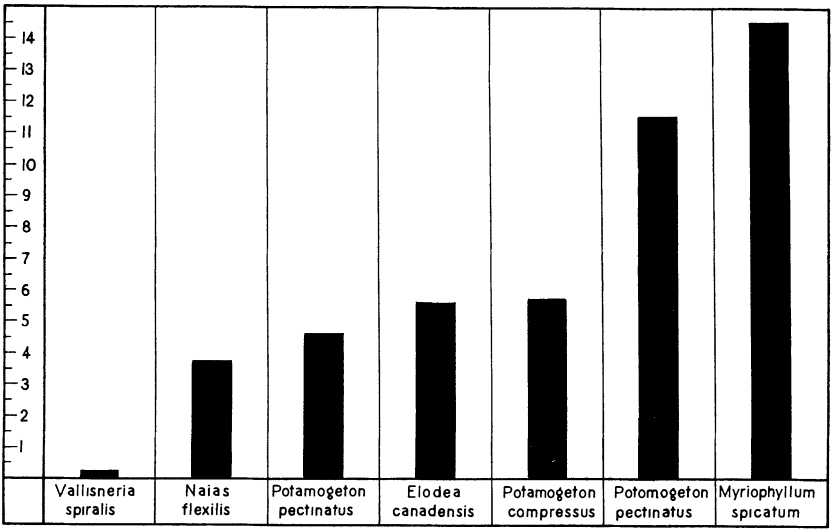

FIG. 3. The average animal population per ten feet of plant. The numerals on the left indicate the population in hundreds.

Average figures do not, of course, necessarily give a true picture of the distribution of numbers or of kinds of animals among the plants and cannot of themselves serve as an index of the suitability of one plant or another as a place of abode. Such suitability it was thought could be more clearly determined if a comparison were made based on the number of stations at which leading genera occurred on a plant and in addition on the number of stations at which a given plant was the most densely populated of the group. Since *Myriophyllum spicatum* and *Potamogeton crispus* completely outranked the other plants this comparison was limited to these two species. In considering their relative density of population, a comparison was made only when the animal in question was represented on both plants.

The results of the first comparison are graphically shown in figure 4. It will be seen that in eleven instances animals occurred on *Myriophyllum* but not on *Potamogeton crispus* and that in only four instances were animals on *Potamogeton crispus* but not on *Myriophyllum,* while in six instances animals occurred at the same number of stations on both plants.

With respect to the relative number of individuals on *Myriophyllum* and *Potamogeton crispus* a glance at figure 5 will show that in 25 instances a given animal was more abundant on *Myriophyllum* than on *Potamogeton crispus* at a given station, whereas in only 13 instances was a given animal more abundant on *Potamogeton* than on *Myriophyllum.*

The number of individuals by which one plant exceeded the other at a given station ranged in the case of *Myriophyllum* (Fig. 6), from a majority of 10 in six instances through majorities of 20–40 in another set of six instances, 50–90 in eight cases, 100–400 in twelve cases up to a maximum of 1400 in

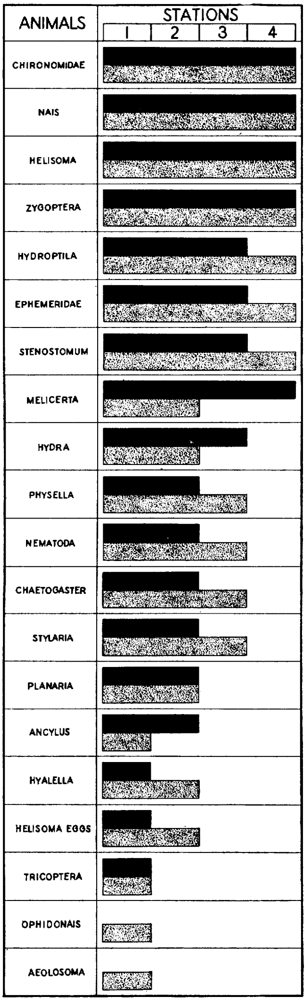

Fig. 4.

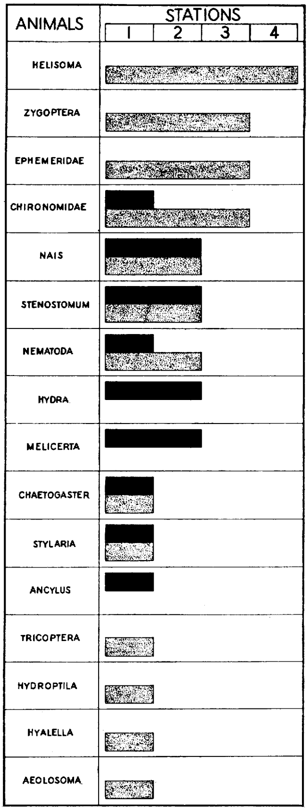

Fig. 5.

Fig. 4. Number of stations at which leading animals occurred on *Myriophyllum* and *Potamogeton crispus.* Black areas indicate *Potamogeton,* stippled areas *Myriophyllum.*

Fig. 5. Number of stations at which either *Myriophyllum* or *Potamogeton crispus* was the more densely populated by a given group of animals. Black areas indicate *Potamogeton,* stippled areas *Myriophyllum.*

TABLE I. *Average and maximum population of ten linear feet of different species of plants*
The maximum number found on a ten foot length of plant is not on the same ten feet for all animals.

	Elodea canadensis		*Naias flexilis*		*Myriophyllum spicatum*		*Vallisneria spiralis*		*Potamogeton compressus*		*Potamogeton pectinatus*		*Potamogeton crispus*	
	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
ANNELIDA														
Aeolosoma	1	1	3	13	2	16	—	—	—	—	—	—	—	—
Chaetogaster	5	8	8	31	26	166	—	—	17	17	6	9	19	70
Dero	2	8	—	—	—	—	—	—	—	—	—	—	1	6
Nais	40	111	169	323	435	1955	12	12	410	410	193	255	256	712
Ophidonais	—	—	—	—	17	120	—	—	—	—	—	—	—	—
Stylaria	34	93	19	73	90	228	—	—	2	2	5	10	37	181
Total	82		199		570		12		429		2[illegible]4		313	
ARTHROPODA														
Crustacea														
Hyalella	2	7	6	16	89	365	—	—	—	—	2	4	2	15
Total	2		6		89		—		—		2		2	
Insecta														
Anisoptera	1	2	—	—	1	1	—	—	—	—	—	—	1	1
Chironomidae	70	200	88	153	360	700	8	8	49	49	210	221	312	970
Coleoptera	1	1	1	2	—	—	—	—	—	—	—	—	5	30
Ephemeridae	1	1	21	70	63	260	—	—	—	—	3	3	3	11
Hydroptila	1	2	2	4	26	135	2	2	2	2	9	16	16	74
Leptoceridae	1	1	—	—	4	20	—	—	—	—	—	—	3	12
Zygoptera	15	30	11	27	64	200	—	—	4	4	6	8	16	43
Total	90		123		518		10		55		228		356	
MOLLUSCA														
Amnicola	—	—	—	—	1	3	—	—	—	—	—	—	—	—
Ancylus	4	10	1	2	2	7	—	—	—	—	—	—	20	96
Goniobasis	1	3	1	2	—	—	—	—	—	—	—	—	—	—
Helisoma p.	15	24	8	10	60	116	—	—	—	—	16	30	26	64
Helisoma e.	8	16	8	10	23	78	—	—	—	—	4	7	1	9
Physella	3	7	1	3	4	12	—	—	1	1	—	—	3	9
Total	31		19		90		—		1		20		50	
PLATHELMINTHES														
Planaria	12	26	5	10	23	110	—	—	—	—	2	2	21	80
Stenostomum	40	123	19	30	71	156	2	2	4	4	6	6	47	90
Total	52		24		94		2		4		8		68	
MISCELLANEOUS														
Plumatella	2	5	1	1	2	14	—	—	—	—	3	6	32	170
Urnatella	—	—	2	7	—	—	—	—	—	—	—	—	—	—
Melicerta	264	616	1	1	4	19	6	6	60	60	—	—	263	590
Nematoda	13	51	1	1	55	372	—	—	—	—	—	—	4	23
Hydra	22	50	4	6	20	67	—	—	15	15	3	4	50	172
Spongilla	1	3	—	—	—	—	—	—	—	—	—	—	—	—
Fish Eggs	5	20	1	5	—	—	—	—	—	—	1	1	—	—
Snail Eggs	—	—	—	—	—	—	—	—	8	8	—	—	1	1
Total	307		10		81		6		83		7		350	
Grand Total	564		381		1442		30		572		469		1139	

the single instance of *Nais*. The differences in favor of *Potamogeton crispus* were in general less, ranging from a majority of 10 in four instances through majorities of 20–60 in twelve cases, to maximum majorities of 180–290 in four instances for *Melicerta.*

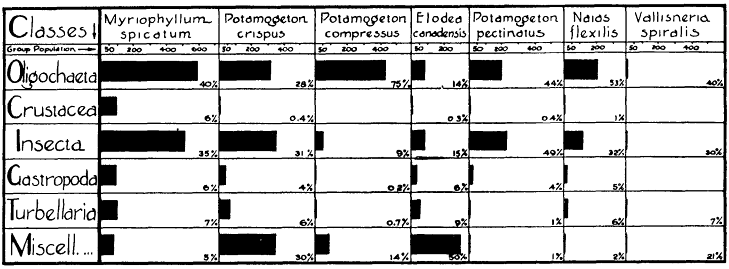

FIG. 6. Analysis of the average population on each plant in terms of the taxonomic classes represented.

Details of the distribution of the various animals among the plants examined, their average numbers, and the maximum numbers of a given animal found at a single time and station are given in Table I. Among the interesting points brought out by this table is the fact that *Nais,* the Chironomidae, the larva of the caddis *Hydroptila,* and the flatworm *Stenostomum* were found on all the plants. The term *Stenostomum* here and elsewhere includes other rhabdocoels. Least widely distributed among the plants were the annelid, *Ophidonais,* the snail *Amnicola,* the bryozoan *Urnatella,* and the sponge *Spongilla,* each of which was found on only a single type of plant, and in some cases at only a single station. Another item of interest is the record that in one instance 1955 individuals of the small annelid, *Nais elinguis,* were found on a single ten foot length of the plant *Myriophyllum* and that on a ten foot length of *Potamogeton crispus* 970 chironomid midges were counted. *Nais* and the midges were with the exception of the rotifer, *Melicerta,* throughout the most abundant members of the population on each of the plants.

The Basis for Population Differences

The basis for the differences in density of population brought out by this study can with some assurance be looked for in the character of the plants rather than in the physical conditions of the environment since the plants always grew closely intermingled and hence under essentially similar environmental conditions.

Any one of several features might, of course, make a plant a favorable or an unfavorable place of abode. One of these is its chemical constitution although no data are available in this particular case and other features appear to be more directly involved. Some incidental observations indicate, however, that animals were not as abundant on unthrifty or decaying plants as on those in good condition. The plants on which the population counts were made were all thrifty. The extent to which the morphological features of the plants appeared to afford protection and foothold showed some degree of correlation with their density of population. *Myriophyllum,* the optimum plant, has finely subdivided leaves (Fig. 1), which seem to be particularly well suited to the type of animals that occurred most abundantly on all the plants, namely, the annelids and midges. The midges were able to cling to such leaves with their hook-bearing appendages and the annelids could coil about them with ease. It is noteworthy, however, that most of the other animals also occurred in relatively large numbers on *Myriophyllum* (Table I). *Potamogeton crispus,* which is next in line, has a broad, unbroken leaf that is crenulated and often curled and thus fitted to provide favorable footing and protection. *Potamogeton compressus* and *Potamogeton pectinatus* have relatively slender, simple leaves. Both of these plants seem to provide rather favorable conditions for the annelid, *Nais,* while *P. pectinatus* also harbored a goodly number of midges. The leaves of *Naias* are likewise relatively slender. *Elodea* possesses broad, blunt leaves which are rather smooth and widely spaced. Neither the annelids nor the midges occurred on it in large numbers. It is interesting to observe, however, that both *Elodea* and the other broad-leaved plant *P. crispus* harbored the largest number of the sessile *Melicerta* and the semi-sessile *Hydra. Vallisneria,* the most sparsely populated plant of the group has smooth ribbon-like leaves which provide surface without protection.

Conclusions

In the foregoing paragraphs, the animal population of seven species of submerged aquatic plants has been described and analyzed on the basis of a plant by plant examination under the microscope. It was found that most of the taxonomic divisions considered (chiefly genera), were represented on each of the plants examined. It was quite obvious, however, that two of the plants, *Myriophyllum spicatum* and *Potamogeton crispus,* were by far more densely populated than the rest. Of these, four, *Naias flexilis, Potamogeton compressus, Potamogeton pectinatus,* and *Elodea canadensis* each harbored about the same number of animals. Still another plant, *Vallisneria spiralis* was entirely outclassed by all plants and harbored a negligible number of individuals. Actual numbers ranged from an average of 1442 individuals per ten linear feet of plant stem on *Myriophyllum* to a mere 30 on a similar length of *Vallisneria.* Midge larvae and freshwater annelids together made up from 59 per cent to 93 per cent of the population on all but one of the plants. On this one, which was *Elodea,* midges and annelids comprised 29 per cent of the individuals while the sessile rotifer, *Melicerta,* made up 50 per cent.

Practical fish culturists have long been concerned with learning what species of plants afford the best shelter and place of abode for the various small animals which serve as food for young fish, and in some cases even older fish. The findings disclosed by this study point rather obviously to *Myriophyllum* and to *Potamogeton crispus* with special emphasis upon *Myriophyllum* since it led the *Potamogeton* in total average population for all localities examined as well as in the average population for most of the specific areas from which plants were taken. *Myriophyllum* also led in the number of animals which occurred on it in maximum numbers. Although only one species of *Myriophyllum* was examined, the structural similarities which exist between various species make it seem probable that the results would hold in the case of other species as well.

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