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OF

The Roosevelt Wild Life Forest Experiment Station

OF

THE NEW YORK STATE COLLEGE OF FORESTRY

AT

SYRACUSE UNIVERSITY



Entered at the Post Office at Syracuse, N. Y., as second-class mail matter

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The serial publications of the Roosevelt Wild Life Forest Experiment Station consist of the following:

1. **Roosevelt Wild Life Bulletin.**
2. **Roosevelt Wild Life Annals.**

The *Bulletin* is intended to include papers of general and popular interest on the various phases of forest wild life, and the *Annals* those of a more technical nature or having a less widespread interest.

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** Resigned as Station Ichthyologist October 1, 1921.

THE RELATION OF FORESTS AND FORESTRY TO HUMAN WELFARE

"Forests are more than trees. They are rather land areas on which are associated various forms of plant and animal life. The forester must deal with all. Wild life is as essentially and legitimately a part of his care as are water, wood and forage. Forest administration should be planned with a view to realizing all possible benefits from the land areas handled. It should take account of their indirect value for recreation and health as well as their value for the production of salable material; and of their value for the production of meat, hides and furs of all kinds as well as for the production of wood and the protection of water supplies.

"Unquestionably the working out of a program of wild life protection which will give due weight to all the interests affected is a delicate task. It is impossible to harmonize the differences between the economic, the æsthetic, the sporting and the commercial viewpoints. Nevertheless, the practical difficulties are not so great as they appear on the surface."

HENRY S. GRAVES,

Former Chief Forester, U. S. Forest Service.

Recreation, Vol. 52, p. 236; 1915.

"Outdoor recreation is a necessity of civilized life, and as civilization becomes more intensive the demand grows keener. The vast extent of our present National Forests, their enticing wildness, and the notable beauty of the native landscape lure men and women thither by hundreds of thousands. The really enormous extent and value of this kind of forest product has been generally overlooked in America. This oversight, however, is only local and temporary. In older countries, where public forests have existed for centuries, the recreation use of such areas has always been recognized. It would be perfectly easy to show that recreation was, in fact, the original and primary purpose in the creation of public forests.

"The moment that recreation (using this word in a very liberal meaning) is recognized as a legitimate Forest utility the way is opened for a more intelligent administration of the National Forests. Recreation then takes its proper place along with all other utilities. In each particular case these utilities are weighed against one another and a plan of administration devised to adjust and harmonize, to the utmost point practicable, the various forms of use so that the largest net total of public good may be secured. Where one must be subordinated to another, preference is given to that of highest value to the public."

FRANK A. WAUGH,

Collaborator, U. S. Forest Service.

*Recreation Uses on the National
Forests*, pp. 3-4, 5; 1918.

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PLATE 1. LEECHES OF THE PALISADES INTERSTATE PARK

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- | | | |
|-----------------------------------|----------------------------------|-------------------------------|
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THE CONTROL OF BLOOD-SUCKING LEECHES, WITH AN ACCOUNT OF THE LEECHES OF PALI- SADES INTERSTATE PARK

BY DR. J. PERCY MOORE

Professor of Zoology, University of Pennsylvania

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INTRODUCTION

In the spring of 1919 Dr. Charles C. Adams, of the New York State College of Forestry, acting on behalf of the Commissioners of Palisades Interstate Park, consulted me concerning the possibility of exterminating or repressing the blood-sucking leeches that infested certain of the lakes and ponds in the Park to the annoyance and alarm of bathers. I was engaged, at that time, under the auspices of the United States Bureau of Fisheries, in continuing a study of the control of mosquitoes by natural biological agencies in the fresh waters of the northern States which had been begun the previous summer as a piece of war work. A cooperative plan was therefore arranged between the Bureau of Fisheries, the College of Forestry and the Park Commissioners, by which work on the two problems could be conducted simultaneously. Accordingly I spent most of July and August of 1919 in field work at the Harriman section of the Palisades Interstate Park. Headquarters in the Park were established at the Guest House on Little Long Pond (Upper Kanahwauke Lake) where excellent living accommodations and field laboratory facilities were provided by the Commissioners. After a preliminary examination in company with Dr. Adams, Carr Pond was selected as the most favorable place for investigation and experiment, although visits were made to many other bodies of water within the Park. The results of the cooperative investigations on the control of mosquitoes

by fishes within the Palisades Interstate Park have been published in "Use of Fishes for Control of Mosquitoes in Northern Fresh Waters of the United States." (Ann. Rep. U. S. Bur. Fisheries for 1922. Appendix IV., pp. 1-60. Document No. 923.) It is a pleasure to acknowledge the numerous courtesies received from Dr. Charles C. Adams, Mr. Edward F. Brown, Superintendent of Camp Activities, and Major William A. Welch, Chief Engineer and General Manager of the Park; and the invaluable services of my assistant, Mr. Robert K. Fletcher, especially during the latter part of the season.

DESCRIPTION OF CARR POND AND THE LEECH PROBLEM

Carr Pond (Lake Stahahe) is an irregular hatchet-shaped body of water about a mile long and nearly half as wide, having an area of sixty acres (figures 1 and 2). It is situated on the main park road (Seven Mile Drive) about two miles from the Guest House and one and one-quarter miles from Southfields on the Erie Railway. Its long axis inclines about 30° east of north. The present dimensions of the lake have been attained by the erection of a concrete dam across a narrow steep-sided valley, thus backing up and retaining the overflow from the original pond, which was a small body of water of about twelve acres area, in the midst of a bog now covered by the large end of the lake. A temporary dam had first been constructed farther up the valley just below Kennedy House Camp, impounding an area of more than forty-five acres which is referred to as the old part of the lake, the lower extension being the new part. The outline map (figure 3) shows these features. At the enlarged southwestern end several rocky points jut out, and here also are three small, rocky wooded islets (figure 1). The banks are in part steep and rocky and in part shelving and earthy. At the southern end are two shallow protected coves or basins in which the depth over a considerable area seldom exceeds four feet (figures 5 and 6). These shallows appear to have been formed by flood deposits by the brook which flowed through them on its course to the original pond. Around the body of the lake are other shallow bays and indentations (figures 7, 8 and 10). These are rich in aquatic and emergent vegetation. Into the larger of the coves empty a small brook and several springs, and additional small springs add their flow into other parts of the lake, whose water, however, consists chiefly of melted snow from the surrounding hills impounded during the spring thaws.

The lake bottom may be roughly divided into two parts. One covers an area of several acres, representing the original bog pond near the middle of the large end (figure 3). It is a soft ooze of acid reaction, rich in slowly decaying organic matter and contains little animal life except red chironomid larvae, which are plentiful. This is the deepest part of the lake, the soundings varying from twenty-one to thirty feet; it also has the lowest bottom temperature, registering 60°F . on July 23, when the surface temperature was 78°F . The remainder is chiefly the flooded forest floor consisting of peaty turf

with the stumps of felled trees, etc. In some places considerable areas of matted fibrous roots become detached, and buoyed up by the water rose to the surface as floating islands (figure 7), leaving the underlying soil exposed. Soft muddy bottoms filled with decaying organic matter are found in the shallow coves and flooded bogs.

The temperature of the shallower parts of the lake down to ten feet ranged from 72° to 74°F., being from 2° to 6° below the surface temperature. The flooded boggy area at the original pond site had a lower bottom temperature ranging from 60° to 68°, the lowest temperature being within the limits of the original pond and doubtless due to the springs common there.

Around the shores of Carr Pond are scattered the camps, numbering fourteen during the summer of 1919. The older camps are mostly situated on the eastern shore of the body of the lake, while the newer ones line both sides of the narrow handle-like extension completed in 1918. These camps are occupied for the most part by hundreds of children of both sexes brought from New York City and Brooklyn by various welfare organizations. Naturally a favorite pastime is bathing (figure 9), and an important part of the discipline consists in instruction in swimming. Most of the camps are provided with swimming docks (figure 11), and those occupied by younger children with safety cribs or stages built of wood weighted and held in place by piles of broken stone. The report has been that bathers were attacked and bitten by the leeches, thereby causing much alarm among the more timid, some of whom refused to subject themselves to a repetition of the experience. Complaint among the camp directors had become so general that the lake had gained a bad reputation. As a means of estimating the importance of the problem all of the camp directors were interviewed immediately after my arrival. As a result several points became clear. No cases of actual serious injury were reported. One case was described of a girl (probably a natural "bleeder") in whom the hemorrhage from a bite continued for several days, until it became necessary to take her to New York City for medical treatment. In another instance one of several girls who were swimming beyond their depth became so panic-stricken on discovering a leech attached to her body that she lost self-control, sank and was rescued only with some difficulty. In most cases the attacking leech is pulled off, disposed of, and the incident quickly forgotten. Any detrimental effect was in general psychological rather than physical. It was noticeable that complaint was much more general and vigorous among directors of girls' than of boys' camps. Although leeches were little more familiar to the boys than to the girls, the former as a rule quickly learned their harmlessness and gave them little heed, regarding their attacks as merely of passing interest. Moreover, in many cases the widespread belief that leeches suck out the bad blood only, and are therefore beneficial, led many of the boys to consider a bite an asset rather than a liability. With the girls however, it was different. They regarded the leeches with disgust and horror, and

many of them fled from them in real terror. It was found, however, particularly among the older girls, that a little instruction in the real nature of the animals, their essential harmlessness and their beauty and gracefulness, did much to calm these fears and to arouse interest. In some cases aquaria were placed in the camps and the study of leeches became a regular part of the natural history lessons.

The frequency of the bites was much less than had been anticipated from early reports. Very rarely is any one child attacked by more than a single leech, and it is seldom that as many as three or four out of a group of fifty or so swimming at one time will be bitten. For all the camps throughout the season the total number bitten daily would scarcely average ten. Altogether the actual problem seems not very urgent. Nevertheless it presents some aspects of interest and its potential importance renders its solution desirable. Some of these aspects may profitably be considered.

A usual effect of a leech's bite is a more or less intense and prolonged itching, which probably results from the injection into the wound of a natural haemolytic agent in the saliva. If the leech be permitted to complete its meal this substance is largely or entirely withdrawn from the wound, but if the meal be curtailed much of the haemolysin remains and acts as an irritant. Some persons are much more sensitive to the irritant qualities of leech bites than others, just as some are more sensitive to the poison of the bites of mosquitoes or other insects. To allay the itching a styptic pencil such as the barbers use, weak ammonia water, or witch-hazel extract may be applied with benefit. This is desirable, as scratching with dirty fingernails may lead to infection of the wound, and apparently this entirely secondary effect is the chief source of injuries complained of, as in the case of many biting insects.

The hæmolysis prevents coagulation of the blood, which is the reason why a leech bite continues to bleed so much longer than an ordinary slight cut. The styptic pencil is the readiest means of stopping the hemorrhage. In the case of hæmophilics or "natural bleeders," like the girl mentioned above, whose blood does not readily coagulate, the addition of a further deterrent may cause the hemorrhage from even so minute a wound as a leech bite to become a possibly serious matter. Fortunately, such persons are rare.

The species of leech under consideration will draw at a meal about two to two and one-half times its weight of blood, while the European medicinal leech is reported to take from four to seven or even ten times its weight. As the usual weight of the leech in Carr Pond runs between three and five grams it is apparent that the amount of blood extracted from a vigorous child by one or even several leeches is negligible. Very rarely indeed does a child lose as much as one-half ounce of blood. It is obvious, however, that if many large and vigorous leeches should simultaneously attack a small, weakling child the resulting loss of blood might entail serious consequences. Many of the children attending these camps are ill-nourished, anaemic, and little able to afford any considerable loss of blood. Fortunately, from this point of view the leeches are present in the Palisades



Fig. 1. Carr Pond, as seen from a point on Seven Lakes Drive directly above Brooklyn Industrial Camp and Station 3, looking north-northwest.



Fig. 2. Carr Pond. Lower extension of lake partly filled, looking northerly from the old dam. (Figures 1 and 2 together cover the greater part of the lake except the section between the old dam and Jacob Riis Camp).

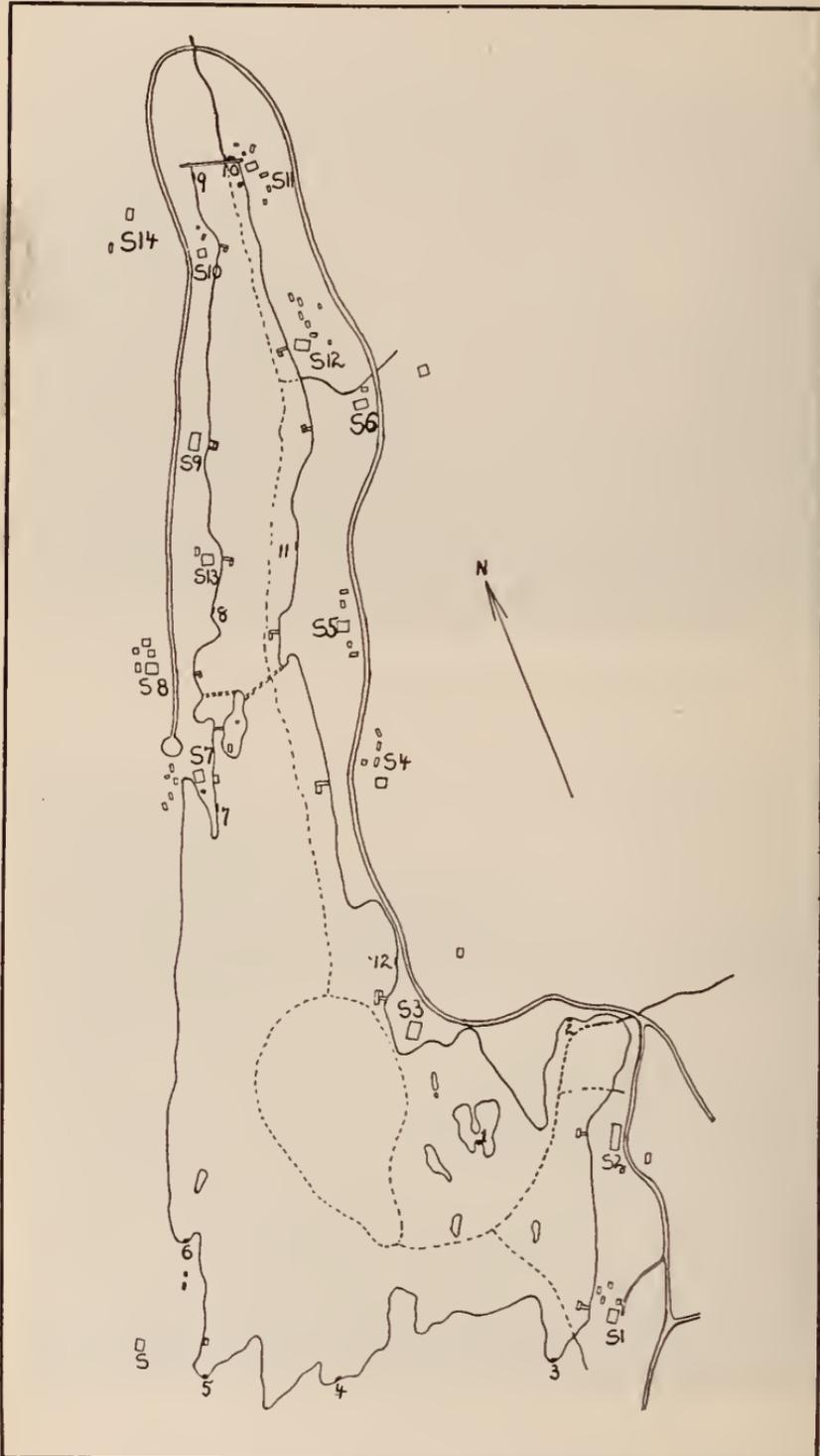


Fig. 3. Outline map of Carr Pond showing the road, camp sites, leech census stations, and in broken line, the old dam, the approximate location of the original pond, and the portion of Stahab Creek submerged by the completed lake. Numbers 1-12, the leech census stations; S1-S14, the permanent camp sites; those mentioned specially in the text are Brooklyn Industrial (S1), Globe (S2), Jacob Riis (S3), and Kennedy House (S7).

Interstate Park in numbers insufficient to prove such a menace to any child sufficiently vigorous to enter the water. Cases have been reported from other localities, however, in which most serious consequences have resulted from the attacks of leeches upon children. A recent effort to secure authentic information relating to such reports concerning *Macrobdella decora* has failed. The older medical literature relating to blood-letting is filled with cases of accidents to young children through the careless application of leeches.

Blood-sucking leeches may be instrumental in the transmission of disease also. This may occur in two ways. A leech that has bitten and been removed may shortly after bite another individual. In this way bacterial or protozoan diseases may be carried mechanically. This sometimes happened in the practice of leeching when the same leech was used successively upon two patients without due precautions being taken. The danger is increased because of the habit of leeches of attaching to open sores, ulcers or boils. They will also attach to dead and decaying animals and thus may carry septic bacteria. The second possibility is that blood-sucking leeches may be the intermediate hosts of human parasitic diseases. No such cases are known at present but it is known that they bear this relation to certain parasites of the lower animals.

THE SPECIES OF LEECHES IN CARR POND

In all only nine species of leeches were found in Carr Pond and several additional ones in other waters of Palisades Interstate Park. Of these *Helobdella stagnalis* and *Glossiphonia picta*, the snail leeches, together with *Placobdella phalera*, *P. rugosa* and *P. parasitica*, the turtle leeches, belong to the family Glossiphoniidae; *Erpobdella punctata*, the worm leech, to the Erpobdellidæ; and *Hamopsis grandis*, *H. marmoratis* and *Macrobdella decora*, the jawed leeches, to the Hirudinidae.

It will be noted that there are three species of large, jawed leeches. These are not discriminated by the campers, all being held equally guilty of blood-sucking. Much the largest of the three is *Hamopsis grandis* (Verrill). When extended in swimming this species ordinarily has a length of nine or ten inches and may be much larger, but it is seldom seen abroad during the day. It is possible that upon occasion it may attach itself to a bleeding wound but I have never known it to do so, and, as its jaws are entirely toothless, it cannot cut the skin as do the true blood-sucking leeches. Normally it burrows in the wet soil at the water's edge and feeds upon earthworms, smaller leeches and insect larvae. It will eat the young of the true blood-sucker and probably is a factor of some importance in checking that species. In Carr Pond it is very plentiful on the shores of shallows, especially at one open area along the southwestern shore where there is good garden soil.

Hamopsis marmoratis is a related species but is much smaller and darker colored. It seldom exceeds four or five inches in length

and bears a few coarse irregular teeth in two rows on each jaw. While its usual food consists of insect larvae and small worms it will attack men and especially cattle wading in its haunts. In Carr Pond it is quite rare and of no significance in the present connection.

Finally there is the American medicinal leech, which must not be confused with the European medicinal leech (*Hirudo officinalis* Linnaeus) which has been introduced and become established in some parts of New York State. The following remarks on the European Medicinal Leech and *Hirudo colchica* by Dr. H. Grimm ('83, p. 54) are of interest. "The medicinal leech is spread all over Russia, being met with in the governments of St. Petersburg, Novgorod and Olonetz, and all the governments to the south of these. The number of places infested by leeches of course increases towards the south; but the real land of leeches is Trans-Caucasia, viz., the districts of the Black Sea, Poti and Lenkoran. The deeply-shaded rivers and forest-bogs of the Lenkoran district regularly teem with leeches so that it is impossible to bathe there. In every net full of ooze one draws up, some 20 or 30 leeches are sure to be found. In the forties, fifties and sixties of this century, when the use of leeches in medicine had reached its height, when the leeches in the Parisian hospitals alone sucked out 90,000 kilogrammes of human blood, and when 7,000,000 leeches were not enough for the London hospitals,—the demand for leeches, and therefore the sale of them, was very considerable in Russia. As the central and northern governments had not leeches enough of their own, the latter were brought (to Moscow as a centre) from Bessarabia, Astrakhan and Trans-Caucasia. It is true, a certain quantity of leeches was imported from Hungary, but then the Lenkoran leeches were exported.

"How great the sale of leeches was, can be judged (not having any statistics) by the fact that many Trans-Caucasians (chiefly the sectarian exiles) enriched themselves by exporting leeches.

"However great our natural supply of leeches might have been, it was apparently too small to satisfy the demand for them. So, on one hand, special orders were issued by Government (§ 562 v. XII C. of L.) 'rules for catching leeches in ponds and lakes,' (issued Sept. 21, 1848), which, by the bye, 1) forbade leeches to be caught during May, June and July, and 2) to take leeches either of too small a size (not less than $2\frac{5}{8}$ inch.) or, large, old leeches, which were not fit for medicinal purposes, but only for propagation of the species, and 3) recommended the breeding of leeches.

"And on the other hand, leech-breeding establishments were started (apart from the above recommendation). Artificial leech-ponds (or parks) were built on Sauvet's system, for instance, in Moscow (M-r Parman), in St. Petersburg (M-r Gavriloff), in Piatigorsk, in Nijni-Novgorod, on the Ural (by Malysheff, the pisciculturist of 1855).

"Soon, however, all these measures became unnecessary. Doctors repudiated leeches. Yesterday, leeches were benefactors, today—they were dangerous and harmful, and were therefore left in peace in their native bogs."

The American medical leech, *M. decora*, though smaller than *H. grandis*, seldom exceeding six to eight inches in full extension and much less bulky, is nevertheless far more powerful and active. In spite of the belief of some of the camp directors to the contrary, all of my investigations showed that this is the only species that need be considered in connection with the attacks on bathers, though both *H. marmoratis* and *E. punctata* will attach themselves to bleeding cuts.

The following description shows that *M. decora* is a very clearly characterized species distinguished at a glance from any other American leech except the nearly related *M. sestertia* Whitman, which is a little known species not reported from this State.

THE NATURAL HISTORY OF MACROBELLA DECORA (SAY) VERRILL

Description. The American medicinal leech may reach a length of ten or even twelve inches and a width of three-quarters to one inch, but such huge examples are rarely found, the usual length in extension being from three to six inches and the width about half an inch. The body is flattened throughout and the margins are sharp, much more so than in the species of *Hæmopsis*, which in life are rather rounded. During life, however, the body is very soft and plastic and assumes an astonishing variety of shapes and interesting attitudes.

The anterior or oral sucker is a powerful organ provided with a rather wide, unsegmented, and very mobile border, which very materially increases its extent. Anteriorly, a distinct median notch corresponds with a deep ventral furrow which divides the upper lip and is flanked by a pair of slightly shallower furrows (figure 12, A). The upper lip can be folded into the mouth cavity and almost concealed by the lateral lobes that close beneath it. As usual in the family there are five pairs of eyes, which are larger than those of the species of *Hæmopsis*, but similarly arranged in a regular submarginal arch.

When fully developed the clitellum or girdle is firm and thick and extends over eighteen annuli, from the last ring of the tenth segment to the second ring of the fourteenth segment inclusive, but it is seldom so well-marked or so extensive. In the ordinary condition the male genital pore appears as an opening of considerable size in the furrow between the eleventh and twelfth segments into which the surrounding rugosities converge. The inflected parts may be everted, as they are during sexual activity, when they form a prominent conical organ with deeply fluted sides and the small male aperture at the apex. The female orifice is a small opening with furrowed margins situated five rings behind the male pore. Very characteristic are the copulatory glands, which may be seen already in the leeches immediately after emerging from the egg capsules or when only three-quarters of an inch long. When fully developed they form a conspicuous group behind the female opening, occupying a

large part of the middle area of the thirteenth and fourteenth segments. They open exteriorly on the ventral surface by four pores arranged at the angles of a nearly perfect square, two of them in the furrow between segments thirteen and fourteen and two in the furrow between the first and second rings of the latter segment. Surrounding each of the pores is a slightly swollen region extending over the contiguous halves of the two rings between which the pore lies. When fully developed in sexually active leeches the four swellings together form a conspicuous rough quadrate area extending over three rings and divided into quarters by narrow longitudinal and transverse diametral furrows.

The surface of the body is quite smooth and free from papillae although in some preserved specimens it may be somewhat roughened by the projection of the scattered sense-organs. This refers especially to the organs of touch or mechanical sense which are distributed over the surface of the skin generally but are especially numerous on the lips. Other sense-organs are those of taste, or chemical sense, located on the lips; the eyes, already referred to, which are strongly sensitive to changes in the intensity of light; and the sensillae, of which a circle occurs regularly on the middle ring of each segment and which are weakly sensitive to the same stimuli. The latter appear as minute clear white spots of which those on the dorsal surface stand out very conspicuously on the dark green background.

The external openings of the nephridia or kidney tubes appear as a pair on the under surface of the second ring of each of the fully developed or five-ringed segments of the middle region of the body. These are not, as formerly supposed, organs of respiration. It has been observed when the leech is drawing blood in the open air, as in blood-letting, that drops of clear fluid appear at these openings and flow over the surface of the body. This is believed to be derived from the blood-serum which is drawn off, thus greatly increasing the animal's capacity for the solid parts of the blood and at the same time serving to keep the skin moist. The anus is a small dorsal opening in segment twenty-seven immediately above the posterior or caudal sucker, which is a large and circular disk attached by a broad pedicle.

The mouth is of large size and may be considered as coextensive with the entire opening of the oral sucker, the upper lip of which overhangs it. The jaws have the usual triradiate arrangement, but among the leeches of the United States, the form is characteristic. They are compressed and about twice as long as high, and each bears along its ridge a single row of about sixty-five fine, conical, slightly retrorse teeth with bilobed bases. A very short muscular pharynx, with the lining thrown into several longitudinal folds, reaches to about the ninth segment, within which is a still shorter œsophagus scarcely to be distinguished from the crop-like stomach, inasmuch as the sacculations begin immediately. From the tenth to the eighteenth inclusive each segment includes two pairs of lateral gastric cæca, of which those from the thirteenth backward are of large size and branched. The last pair, which originate from the stomach in the



Fig. 4. General conditions near Station 1. View south from Jacob Riis Camp. Station 1 is on the far side of the rocky point, almost in the exact center of the photograph, below the gap through which the main Park road approaches the lake.



Fig. 5. Head of Globe Camp Bay, showing conditions at Station 2, looking southwest. The exact position is at the extreme right of the water shown.



Fig. 6. Conditions at Station 3, head of Brooklyn Industrial Camp Cove, looking north by east.



Fig. 7. View of south shore, looking westward. Station 4 is just beyond the rocky point where a grassy slope reaches to the water's edge. Small pieces of floating islands shown.

latter part of the nineteenth segment, are of very great extent, reaching backward into segment twenty-four or twenty-five and bearing two wide lateral branches in each of the intervening segments. The straight narrow intestine presents no noteworthy features.

While presenting the general features characteristic of the family the reproductive organs (figure 12 B, and 12 C) are in many details peculiar. There are ten pairs of testes situated at the boundaries between contiguous segments from the thirteenth and fourteenth to the twenty-second and twenty-third inclusive. Their delicate ducts, all of which unite in a pair of longitudinal canals, the vasa deferentia, are like the latter covered with minute unicellular glands and follow a somewhat winding course. The glandular coat ceases at the eleventh segment where the vasa appear as smooth very delicate tubes, and at the level of the ganglion of that segment pass abruptly into the pair of massive compact epididymes. From its posterior end each of the latter is continued as a rather wide somewhat folded ejective duct leading to the single median terminal or copulatory organ. Just before entering the outer or glandular layer of the so-called penial bursa, or atrium, the ducts become constricted and then rise as a pair of slightly enlarged sacs which open into the summits of the large inner end of the bursa, to which they stand in the relation of a pair of horns. This median bursa which evaginates to form the penis is in its retracted condition spherical or inverted pyriform in shape, and its thick walls consist of mucous, muscular and glandular coats. Within it the spermatophores or bundles of spermatozoa which are transferred during copulation, are formed.

During life the colors are very rich and showy. On the upper surface the ground varies from a light sage-green to a dark olive-green with obscure dark longitudinal lines or streaks in the median area. Down the median line is a series (sometimes absent) of small but very conspicuous cadmium-orange or light red spots, one to each segment. On each side close to the margins is a similarly arranged series of small black spots. The lower surface is of rich orange varying in shade and intensity, sometimes plain, sometimes spotted to a varying degree with black.

Distribution, Habits and Ecological Relations. The American medicinal leech is widely distributed throughout the northern United States and southern Canada. It extends across the entire width of the continent and has been taken in every state from Maine to Washington. The known north and south range is from Labrador to Kansas and Virginia. In the southern United States it is replaced by other blood-sucking leeches of the genera *Macrobdella*, *Philobdella* and *Limnatis*.

In the Palisades Interstate Park this leech is more plentiful in Carr Pond than elsewhere, though it occurs in smaller numbers in some of the other lakes but not sufficiently to be considered a pest by bathers. Even in Carr Pond it is not nearly so abundant as in many ponds in eastern Pennsylvania and Massachusetts, or in the lakes of Wisconsin and Minnesota. Observations made at the swimming

places (figure 9) when the splashing of twenty to fifty boys or girls in the water stimulated the leeches to great activity, seldom revealed more than two or three swimming at a time. Receptacles placed at the camps with instructions that all leeches caught be placed therein rarely yielded more than three or four as a day's catch at any one camp. By collecting generally along the shores usually fifteen or twenty could be gathered in a morning. I have taken several times that many in the same time in eastern Pennsylvania and elsewhere. By direct observation, especially at marked stations of equal areas, and by the use of the receptacles above mentioned, it was found that the distribution in Carr Pond during the summer of 1919 was not uniform. Few leeches were found in the newer part of the lake near the dam. They were several times as numerous in the body of the lake, and were especially plentiful about the shallows in the vicinity of Globe (figure 5) and Kennedy Camps and in the small cove near Mr. Herbert's shack (figure 8). It seemed evident that the lake had been stocked from a nucleus in the original pond and that the leeches had not yet attained their maximum numbers or moved freely into the new part of the lake.

Ecologically considered *Macrobdella* is a swamp rather than a pond animal. Normally it is an inhabitant of the shallows and the vicinity of the shoreline where land and water meet. It may be found concealed under stones and logs, more especially those that lie partly out of the water. Here when well fed it rests quietly, or when hungry lies in wait for frogs, warm-blooded animals that enter the water, or other prey (figure 13, A, B). Any disturbance of the water such as is caused by a wading animal attracts them, partly because of the mechanical disturbance which stimulates the tactile organs and partly because of the animal emanations that stimulate the organs of chemical sense. Advantage of this peculiarity is taken in collecting them. On stirring up the bottom with one's bare feet any leeches that happen to be in the neighborhood may soon be observed swimming or creeping toward the place, and may be allowed to attach themselves to the skin and be picked off. Anglers quite often find one or more of them attached to catches of fish which have been strung and placed in the water where their lashing and bleeding serve as attractions.

Observations through the summer make it quite evident that the leeches are attracted by the bathers also. They congregate and remain about the docks and beaches, concealing themselves in the crevices of the woodwork or among the stones, and issuing at the bathing hour. Complaints of attacks became somewhat more frequent during the latter half of the summer and there appeared to be a corresponding decrease in their numbers at points elsewhere. Having fed at the bathing places they become quiescent and remain. Consequently they become concentrated at these places and there is a relative decrease in numbers elsewhere, as suggested. This is probably due in part to the fact that they become more active with increasing temperature and consequently move more freely as the water warms. The period of greatest prevalence at the docks cor-

responds with that of maximum temperature of the water in August. While the excursions of the leeches into the open waters are concerned primarily with the quest for food they serve also to extend and alter their distribution. They are strong and rapid swimmers; progressing with easy and graceful dorso-ventral serpentine movements during which the body may be turned either vertically on edge or flatwise.

Every feature of their organization shows that these animals are beautifully adapted to a habit of occasional and temporary parasitism and a sanguinary diet. The acute chemical and mechanical senses, the powerful organs for rapid and varied locomotion, the soft and sinuous body, the concealing coloration, the strongly developed organs of attachment, the finely fashioned instruments for painlessly cutting the skin and capillaries, the haemolysin and powerful pumping apparatus for facilitating the rapid flow of blood, and the great storage capacity and ability to subsist without food to tide over periods of scarcity are among those that appeal especially to students of adaptation.

When biting the leech usually attaches itself firmly to its host by the caudal sucker, the anterior end of the body meanwhile exploring for a suitable place to bite, preference being given to a cut or abraded spot, or, in the absence of such, to a tender vascular area of the skin. To this the oral sucker is then applied intimately and fixed firmly, and the jaws are pushed forcibly against the surface. By a rotary back and forth motion toward and from the center of the radially arranged jaws effected by two sets of oblique muscles, the numerous fine teeth cut three narrow deep slits together having a characteristically trifid pattern. The salivary secretion, containing the haemolysin called hirudin, pours over the jaws directly into the wound and mixing with the blood keeps it fluid and facilitates its flow. By the action of the bulbous pharynx the blood is pumped from the wound into the gastric or crop *cæca* which may become filled in about fifteen or twenty minutes. If the stomach of a feeding leech be cut into from the exterior the blood will flow from the opening in pulsations. The quantity of blood taken by leeches of the size commonly found in Carr Pond is from six to fifteen grammes but may vary between much wider limits depending upon the size of the leech and the nature of the host.

After completing a meal the leech drops off and being then negatively phototropic (that is, tending to move away from the source of light) it seeks the darkness under stones or logs, in crevices, or in burrows in the mud. Ordinarily it does not feed again for several weeks or even months, but is less abstemious than the European medicinal leech, which is said habitually to allow five or six months to elapse between meals. A leech may live indefinitely without food. Two years and more has been recorded for the European leech and I have kept *Macrobdella decora* alive without food for from seven to fifteen months. Under such circumstances they shrink greatly in size. For example, in the experiment covering fifteen months the average weight of five leeches fell from 3.09 grammes to 0.79

grammes. In correspondence with the extreme slowness and completeness of digestion the intestine is short and simple and the anus is minute.

As indicated, the food is typically vertebrate blood derived from men or cattle entering the water, or in their absence from frogs (figure 13, B), tadpoles, fishes or turtles. Frogs' eggs, (figure 13, C) aquatic worms (Tubificidae), and occasionally insect larvae are also eaten. In attacking fishes, favorite points are the gills and isthmus, both highly vascular regions. In the case of frogs the leech will sometimes perforate the skin and insert the cephalic end into the subcutaneous lymph spaces, in which case the large blood vessels may be reached and death result very quickly.

These leeches are extremely sensitive to the presence of food. If, in a vessel containing several, a finger be touched lightly on the bottom, after a short interval the leeches become restless and begin exploratory movements in the course of which the head is passed over the spot touched and immediately arrested, upon which increased excitation follows with more minute and long continued exploration of this spot. It is quite evident from their actions that they detect the presence of the emanations left by the finger. A little blood escaping from a cut is an even greater and farther reaching attraction, and the leeches will gather from considerable distances to the promised feast. This habit may be taken advantage of in collecting the leeches and has been used effectively by the writer in the vicinity of Philadelphia. Movements of the water and the disturbance of the bottom such as results from men or cattle wading or swimming also attract the leeches even when animal odors are eliminated, as is shown by wading in rubber boots or by the use of a pole. After such disturbances the leeches may be seen leaving their places of concealment and crawling or swimming in search of the expected prey, if one may so express the reaction in terms of the consciousness that the animals lack.

Ordinarily *Macrobdeella* is negatively phototropic, remaining concealed in dark places during the day and becoming active at night when presumably frogs and fishes are naturally preyed upon; but if hungry the impulse aroused by the stimuli indicating the presence of food overcomes the impulse toward concealment and they will swim freely during daylight. Otherwise this study would not have had its inception. When well fed they remain quiescent and relaxed under stones and logs near the water's edge, assuming a variety of resting attitudes often partly out of the water. This latter habit is well illustrated when they are kept in the laboratory in aquaria, in which case a favorite position is with one or both suckers attached to the glass above the water's edge, the body being permitted to hang laxly more or less into the water.

Under such circumstances the supply of oxygen is abundant and no respiratory movements take place, but when immersed in water in which the oxygen supply is deficient they exhibit rhythmic undulatory movements that may be quickened or retarded by other stimuli, such as arise from light changes or contacts. This movement varies



Fig. 8. Cove just north of Herbert's, looking down the lake. Station 6 is in the immediate foreground, and conditions here are similar to those at Stations 5 and 7.



Fig. 9. Swimming beach on new extension. Station 11 is just outside of the picture on the right, where shore conditions are similar. The new dam, shown about a third of a mile below, is the location of Stations 9 and 10.



Fig. 10. Cove at Jacob Riis Camp, showing shore conditions at Station 12.



Fig. 11. A swimming dock and boat landing at Carr Pond.

in rate, amplitude, and vigor as determined by a great variety of conditions. It may occur during feeding, when probably it has the additional utility of facilitating the filling of the cæca. Leeches are able, however, to live under nearly or quite anærobic conditions (Putter, '07).

As in most aquatic invertebrates the rate of metabolism, and consequently of the activities of leeches, is a function of the temperature, increasing as the water becomes warmer to an optimum not yet accurately determined, and diminishing as it cools. This is probably another reason why these leeches seek the shallows where the water is warmer during the greater part of the year and especially during the spring. In the autumn as the water cools the leeches remain much of the time quiescent and probably seldom feed. When the water temperature approaches 40°F. they become extremely sluggish and seek winter quarters, and at 39°, the temperature of greatest density of fresh water, they become practically dormant and nearly insensitive but will respond by slow movements if pinched with a forceps, pricked with a needle, or exposed suddenly to a strong light. At this time they appear to be somewhat reduced in size and it may be that, like earthworms and many other animals at low temperatures, they have lost water, but this has not been determined.

In the vicinity of Philadelphia *Macrobdella* may be found throughout the winter on the tidal flats of the Delaware River or on the shores of ponds beneath logs and stones partly buried in the mud and seldom in water more than eighteen inches or two feet deep. In such places they may or may not have burrowed two or three inches into the mud and appear quite dormant until, with even a slight rise in temperature, they are stimulated to show some activity. Leeches of this and other species are frequently found in nature in a lethargic state in the unfrozen mud immediately beneath the ice or in actual contact with or even imbedded in the latter.

That they are quite unharmed by freezing temperatures, I have many times demonstrated in laboratory experiments in which the water in the vessel containing them was wholly or partly frozen; and they have lived thus for several days, showing no indication of injury whatever when gradually thawed out. Further experiments, conducted both during the summer upon active leeches and during the winter upon individuals naturally dormant, have fixed with sufficient accuracy for present purposes the lethal point to cold. It has been found that a temperature of 20° to 22°F. was invariably fatal even when the exposure lasted for only three to eleven hours and the thawing out was very gradual. These experiments were conducted by placing two or three healthy leeches at a time in basins or tight boxes about five inches deep, either with water only or with three or four inches of wet mud, sand, stones, and bits of bark in and beneath which the leeches were buried to varying depths. The vessels were then placed either on ammonia coils in a freezing room, in ice and salt mixtures, or during the winter out of doors. The air temperature and the temperature of the contents of the vessel were determined, the former usually by an ordinary house thermometer and the

latter by a Centigrade chemical thermometer encased in a brass tube. All of the experiments on both dormant and active leeches fixed the lethal temperature at about 20°F. When thawed out slowly and carefully after such freezing the leeches were always found to be completely dead, very much relaxed, somewhat swollen, soft and flaccid, very different from the more or less rigid, turgid state of these leeches when killed by strong mineral or narcotic poisons.

In the spring as the water warms the leeches gradually become active, appearing with the frogs upon which and their eggs they largely feed (figure 13, B, C). At this time, and to a less extent later in the summer, and then only when unfed, they are prone to wander. If kept in an aquarium they will frequently crawl over the sides during the night and occasionally even by day and drop to the floor. I have often found them by following the glistening trail of dried mucous wiped free of all dust and meandering about the floor for perhaps as much as one hundred feet. When found the leech will present a shrunken, more or less dried appearance, and will be covered with adhering dust. If too great a time has not elapsed they may be revived by immersion in water even after shrinking to one-third of their former size and weight. The principal loss has been of water in the form of mucus, and absorption of water takes place rapidly, the animals soon regaining their normal size and activities. This peculiarity is of much value to individuals of the species living in small rain-fed ponds from which the water completely evaporates during dry summers. Under such circumstances these leeches bury themselves in mucus-lined mud cells beneath stones and logs, shrink in size and become dormant. How long they will live under such conditions has not been determined, but they have been found unharmed after such a pond has been dry and the bottom mud hard and cracked for three or four weeks.

When the leeches become active in the spring they are usually voracious and feed eagerly. After being well fed they copulate. In this act the ventral surfaces of two individuals are brought together in the region of the genital pores, the heads being pointed in opposite directions (figure 13, D). The glairy secretion of the copulatory glands aids cohesion, which is further assisted by one or both individuals taking a loop round the other or by attachment of the suckers. The muscles in the genital region contract strongly, often forming a constriction, the penial or copulatory bursa is everted, and the contained spermatophore attached within the vagina of the other individual or at its orifice. The transfer of a spermatophore may be reciprocal or one-way.

The actual formation of the egg-capsules (figure 14) has not been seen in this species, but during June and July they have been found buried in the mud or turf at the water's edge just above or below the water level. They vary from less than one-half to about three-quarters of an inch in length, probably dependent on the size of the producing leech. In shape they are broadly elliptical and in color a pale straw. The structure resembles that of other leeches of the same family, the walls being composed of a cellular spongy layer of

chitinoid material nearly one-eighth of an inch thick, and perforated almost completely at each end by a tubular canal. Lining the spongy layer is a thin membrane of the same material but without spaces or openings. The cavity within is filled with an albuminous mucus similar in appearance and properties to that found within the capsules of earthworms. Imbedded in this are several eggs or young. The exact length of time required for hatching is not known for *Macrobdella*, but is about three weeks and varies with the temperature. Newly emerged young (figure 14) measuring from five-eighths to three-quarters of an inch long in extension are frequently found during July and August. They are easily recognized as they possess the characteristic color markings and the copulatory glands are distinguishable on examples three-quarters of an inch long. According to Rathbun ('84) this species matures in two or three years in the leech farms.

While a great deal has been written about the enemies of the medicinal leeches under cultural conditions fifty years ago, when the matter was of considerable economic importance, little of a specific nature is recorded concerning the enemies of our leeches in the wild state. Doubtless predacious fishes are the principal enemies of the developed animals, though the worm leeches (*Erpobdella*) appear to fall a prey more often than do the jawed leeches. I myself have found them in the stomachs of black bass and sunfish only, and even in these but very rarely. Zoological literature records them among the food of a variety of species. A foreman in the Park, Mr. Herbert, reports that in the late fall of 1917 he examined the stomachs of several yellow perch taken in Carr Pond, and found them to be filled with large dark colored leeches that he thought were *Macrobdella decora*. During July and August, especially the latter, Mr. Fletcher and I caught numbers of yellow perch (together with common and long-eared sunfish and catfish) in Carr Pond in the hope of confirming this statement, but in no case were any leeches found in the stomachs. As this perch is abundant and of large size in Carr Pond any general use by it of *Macrobdella* as food should exert an important repressive influence. That fishes will eat leeches is evidenced by their value as bait. For this purpose their toughness, rendering them difficult to strip from the hook, makes them superior to earthworms and they seem equally attractive, as I have found personally in the cases of sunfish and perch. In many parts of Pennsylvania country boys habitually employ *Erpobdella* and *Hæmopsis* for this purpose, and *Macrobdella* is said to be so used in the lakes of Minnesota and Wisconsin. Professor T. L. Hankinson tells me that he has employed them successfully, and at the writer's suggestion some of the campers on Carr Pond took up their use to a limited extent.

Aquatic birds probably destroy many leeches. I have found them in the stomachs of both wild and domestic ducks. It seems probable that small species, together with the eggs and young even of *Macrobdella*, may often fall a prey to the sandpipers and plovers

that habitually feed among the shingle and shore debris where small leeches especially abound.

Rats, minks, small herons, kingfishers, crows, turtles, snakes, crayfishes and various kinds of predacious insects and their larvae may exert some influence, as they were known to do on the leech farms. Among other leeches, the large *Hæmopsis grandis*, which is plentiful in association with *Macrobdella decora* in Carr Pond, is undoubtedly an important enemy of the latter. This leech habitually feeds upon earthworms, smaller leeches and insect larvae, and has been observed to devour *Macrobdella decora* two inches long. As it lives in the very places where *Macrobdella* deposits its egg-capsules it is probable that it destroys large numbers of the newly hatched young of *Macrobdella*.

METHODS OF CONTROL

In the effort to devise a practical solution of the problem every known aspect of the life history, habits and reactions of this species, of which a general outline has just been given, was passed in review in the hope of finding a weak spot at which it could be successfully attacked. Many methods were considered and experiments tried, the most important of which will be described.

Baiting and Trapping. In my previous experience in collecting blood-sucking leeches frequent use had been made of baits of freshly killed and bleeding small animals and of slaughter-house blood placed in a muslin bag dragged through the water or simply placed in the water and allowed to diffuse. This latter was a method of feeding leeches largely employed in the days of hirudiculture. Both of these methods had been found effective in attracting them, and large numbers of *Macrobdella* and other leeches were often gathered in a short time by simply catching them in a dip-net as they swam toward the baits, or by picking them by hand after a number had attached themselves to the bag or dead animal. It was thought if such baits were placed in a trap easy of entrance but difficult of exit for the leeches that considerable numbers could be gathered automatically and disposed of. Indeed, before visiting the Park this method had appealed to me as likely to meet with success. As soon, however, as I saw the size of Carr Pond and the actual conditions existing there I lost faith in its practicability. Nevertheless a series of experiments with baits and traps, partly in the laboratory, partly in the field, were decided upon.

Three forms of traps were devised and tried. The first (figure 15) was constructed on the well-known principle of the lobster pot. It is a box 24 x 18 x 18 inches built of light, matched partition boards with the top hinged to afford access to the interior. The front has the form of a deep reentering angle (figure 16) running the entire length of the box. The pieces composing this angle fail to meet at the apex, leaving a slit one-fourth inch wide which is continued by two parallel boards as a passage of the same width four inches further into the interior, thus giving the effect of a horizontally extended

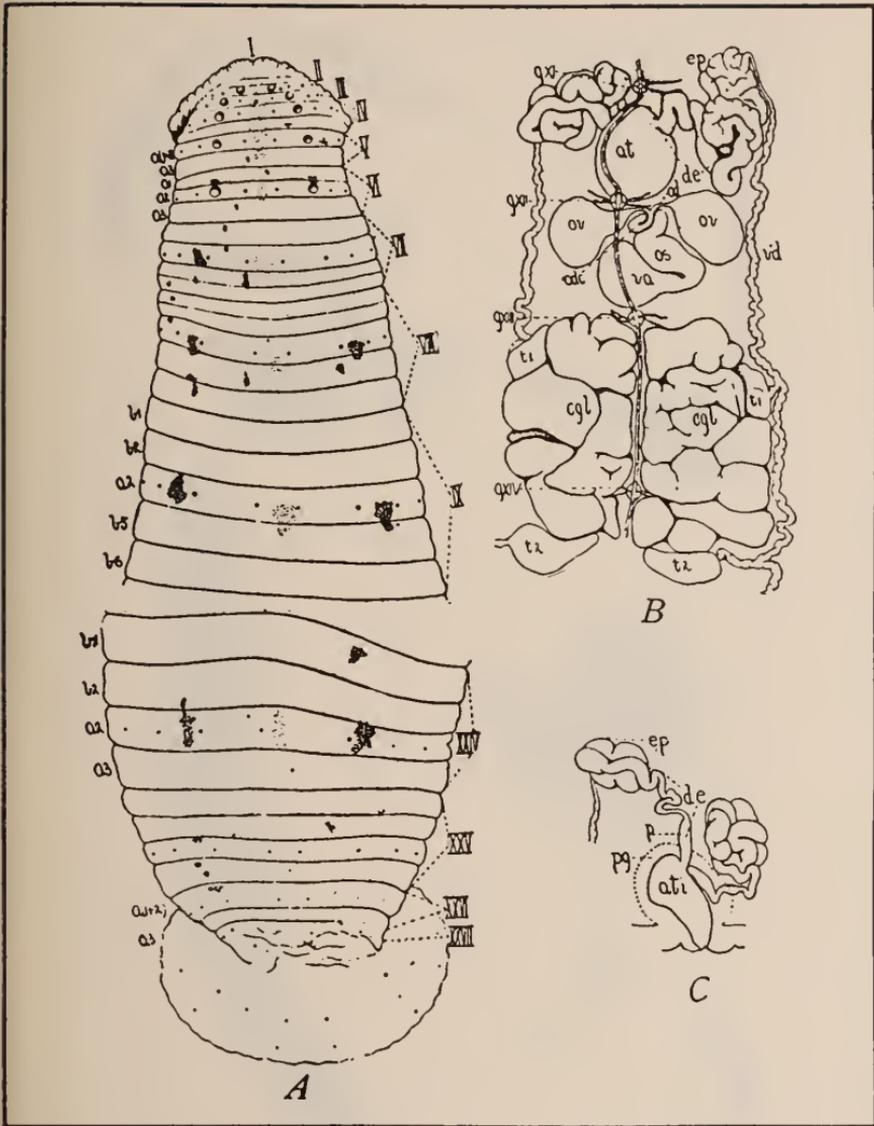


Fig. 12. Characteristics of *Macrobdella decora*. A: Details of exterior of anterior and posterior ends showing arrangement of somites (I to XXVII,—X to XXIII inclusive are omitted), annuli (a^1 – a^3 , b^1 – b^9 , etc.), eyes, segmental sense organs, color markings, suckers, anus, etc. (From Leeches of Minnesota, Nachtrieb et al, '12). B: Dissection of reproductive organs seen from above. *at*, atrium or penis sheath; *cgl*, copulatory glands; *de*, ductus ejaculatorius; *ep*, epididymis; *gXI* to *gXIV*, ganglia of the ventral chain; *os*, ovisac; *ov*, ovary or ovarian sac; *od*, oviduct; *t1*, *t2*, first and second pairs of testes or testicular sacs; *va*, vagina; *vd*, vas deferens. C: Male organs dissected and viewed from the right side. The left sperm-duct retains its natural position; the right is displaced upward, and the dotted line shows the outline of the atrium before the removal of the layer of muscles and prostate glands. *ati*, internal layer of atrium; *de*, ductus ejaculatorius; *ep*, epididymis; *pg*, prostate glands and muscles; *p*, prostate cornua of atrium. (B. and C. from *Hirudinea of Illinois*, Moore, '01).

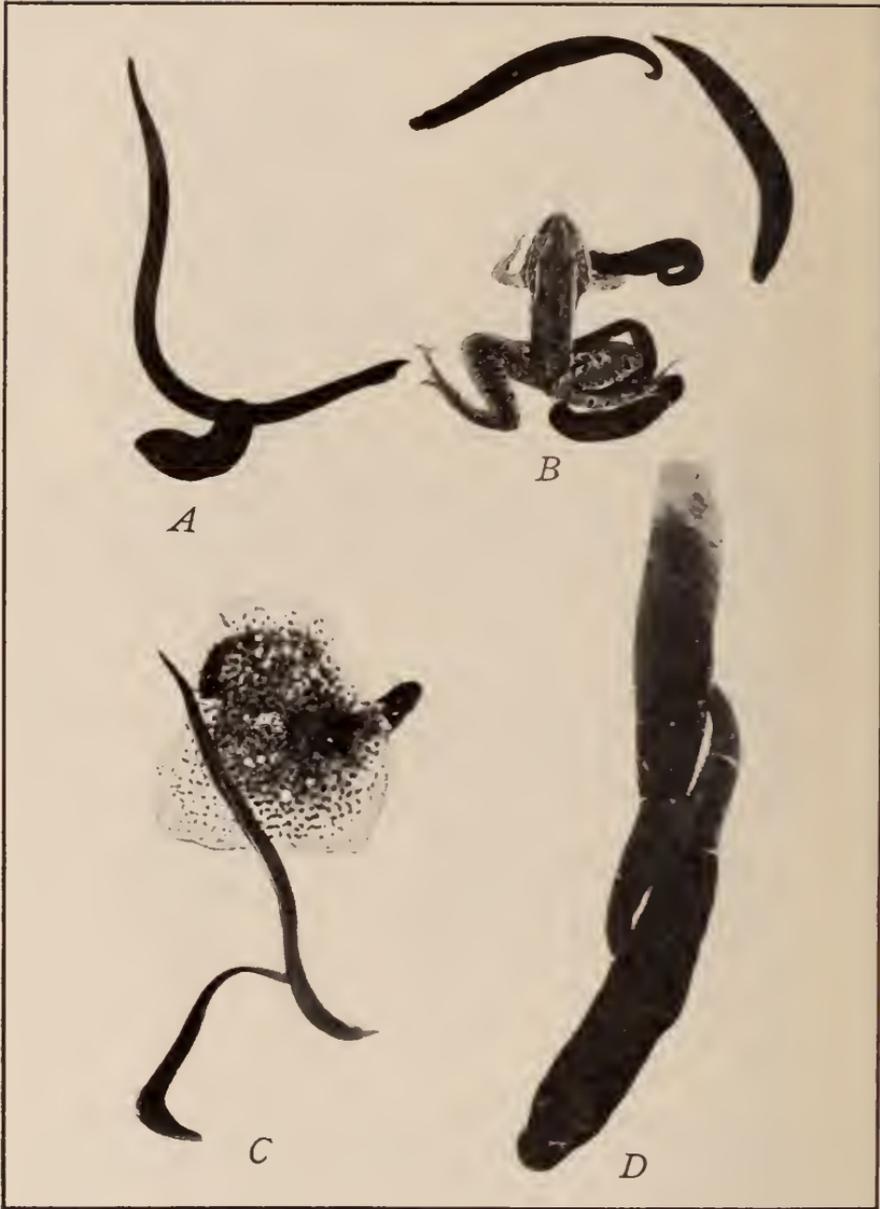


Fig. 13. Activities of *Macrobdella decora*. A: resting and swimming positions (note that the swimming leech is turned on edge). B: attacking and feeding upon a frog which has nearly succumbed to the loss of blood. C: feeding upon frogs' eggs; two leeches have penetrated the mass and are rapidly cutting the eggs from their envelopes and swallowing them; of the remaining two, one is swimming, the other exploring while the caudal sucker remains attached. D: a pair of leeches in copulation; this figure represents *Philobdella*, a southern leech related to *Macrobdella*. A, B and C are reduced. D is nearly natural size.

funnel with the wide opening outward. In the upper sloping face a row of holes was bored and covered with wire mosquito screen. Except for these openings and the slit-like entrance the box was quite tight. In using the trap a bait of freshly killed frogs or more frequently a duck bag filled with fresh blood was suspended inside from the top in such a position that the blood dripped onto the upper sloping side and trickled through the openings above the entrance. The box was then weighted with stones and sunk to the bottom in shallow water close to shore.

The theory of operation of these traps is as follows. The blood flows from the openings above the entrance and diffuses into the surrounding water. Judging from the known habits of the blood-suckers, any in the vicinity might be expected to be stimulated by the scent or taste of the blood to follow the trail to its source where the convergent sides of the funnel would direct them to the entrance through which they would crawl into the interior. Once within the box they would quickly find and attach themselves to the bait and after satisfying their appetites would drop off and seek a dark shelter as is their habit. This would be afforded by the lower chamber of the trap where it was expected they would remain quiescent and satisfied until the trap was examined on the following day. Even should some of them become restless and crawl or swim about there would be little chance of their finding the narrow opening by which they entered, and the more direct openings for the diffusion of blood are in the upper chamber and guarded by a screen.

Three of these traps were made and set at favorable points chiefly in the shallows at the southern end of the lake where the leeches were most common. They were shifted about from time to time in order that as many conditions as possible might be tested. They were baited as often as fresh bait could be procured, that is, two or three times a week for five weeks, and were always examined on the following day. In some cases a bag of blood was dragged over the bottom near the shore in both directions from the trap to establish a better trail. Detailed records of each trap were kept but are not worthy of publication. Suffice it to say that in no case was more than a single leech found in any trap and more frequently there was none. Freshly killed frogs proved a more attractive bait than slaughter-house blood. Concerning the ineffectiveness of the latter see the remarks under the account of laboratory tests of baits.

The second form of trap (figure 15) is a rectangular bag of duck, the mouth of which is supported by a heavy wire frame. From the mouth two duck flaps six inches wide project obliquely into the interior and converge till they nearly meet, their free edges being held in position close together by being stretched on a heavy wire rod. The general effect of this trap is similar to the box trap, but the blood bait diffused into the water through the sides generally as well as through the narrow mouth. It was baited, weighted and sunk at suitable points, usually being suspended above the bottom from an anchored buoy by cords attached to the wire frame so that the open-

ing was above. This trap proved a total failure. Not a single leech was caught by it.

The third form of trap was a little pen four feet across, constructed of four boards driven into the bottom and the banks and fastened by stakes, the whole having the outline shown in figure 17. This was constructed at a shallow point on the south shore where a saw mill had been operated, and where some old boards were lying about to afford shelter for leeches. The bank here is about a foot high, abrupt, and composed of a rich black earth covered with a good growth of grass. The depth of water within the pen varied from ten inches at the outer to four inches at the shore end. Several flat stones and pieces of board were placed within to afford concealment for any leeches that might enter. The trap was baited with blood as were the others, and although used for only one week in the latter part of August proved rather more successful than the other traps. Three visits yielded seven leeches, though it is not certain that some of these may not have been overlooked when the bottom and banks were thoroughly searched for leeches before the trap was baited.

From these experiments the impracticability of trapping, at least by any of the methods adopted, was thought to be sufficiently established. Certainly these traps proved far less effective than human traps in the shape of boys at the swimming docks.

Even had the traps proven several times as effective the expense would have condemned their use. Various experiments and observations would indicate that under ordinary conditions which, of course, vary greatly, the average range of attractiveness of a leech bait does not exceed an extreme limit of fifty feet in any direction. This would give to each trap a maximum effective range of about 100 feet of shore. The shore line of this lake is approximately four miles or 21,180 feet long. Consequently a complete line of traps around the entire lake would require not less than two hundred. The expense of tending the traps would also be heavy. Mr. Fletcher and I working together found that about twenty minutes were required to raise, examine, clean, rebait and set one of the experimental box traps. With an effort directed toward speed, and with improvements in the manner of weighting and for facilitating the escape of air so that they would sink more rapidly this time could be cut in two, making six traps per hour or forty-eight per day of eight hours for two men. The entire time of four to eight men would therefore be required for this work.

There being no local slaughter-house some difficulty was had in arranging for a regular supply of blood. This was finally secured from New York abattoirs through two avenues, Mr. Daschner of the Bear Mountain Inn and the Tuxedo Meat and Provision Company, to both of whom my thanks are due. The blood was shipped on ice in glass jars or tin cans and always reached me in good condition. From the first it was noticed that it remained fluid, was of a remarkably bright red color and would seldom putrefy until the third day, even during the warm weather of midsummer. For this reason it was suspected that it might have been treated with

an artificial preservative, especially as it appeared to be so much less effective than blood previously used at Philadelphia. Inquiry brought the assurance that it was "pure heart blood" of the beef entirely without preservative or treatment of any kind. Some experiments conducted in aquaria in the laboratory showed that the leeches would follow a clear trail of this blood and that they would eat it, though with much less eagerness than the fresh blood of frogs.

Before a supply of fresh blood was arranged for, some laboratory experiments were conducted on several substances in the hope of finding a satisfactory substitute for use as bait. Among the substances tried were dried blood (commercial fertilizer), beef extract (Armour's), musk, urine, and oil of anise. By far the most active response was made to the beef extract, which was readily traced across the aquarium to the finely drawn out end of a tube from which it was slowly diffusing. It was also imbibed to a limited extent. In about half of the experiments with dried blood this also induced a positive reaction but in no case did the leeches appear to eat it. To the musk there was only a very weak response, and to the urine and anise oil there was no appreciable positive reaction.

Gathering the Leeches and their Egg-cases. Up to a half-century ago the use of blood-sucking leeches for medicinal purposes continued of sufficient generality that, in addition to importations from Europe and the product of American leech farms, large numbers of our native wild leeches (*Macrobdella*) were utilized. Especially in the environs of Philadelphia several collectors maintained a considerable and profitable business. The leeches were obtained chiefly from the ponds of Montgomery, Bucks and Berks Counties, and on the tidal flats and marshes on both sides of the Delaware River. After the decline of this business *Macrobdella decora* increased greatly in numbers in this region. During the progress of the World War, with other supplies cut off, there arose a slightly revived demand for native leeches, especially among the foreign population of New York and other large cities, and some inquiries were made by pharmacists and chemists for leeches as a source of supply of hirudin for use in surgery. During my visit to Carr Pond some interest was aroused among a few of the more commercially-minded boys at one of the camps, and they were influenced to gather some of the leeches and dispose of them at a fair price to a dealer in New York City. If it could be done without conflicting with the ideals and discipline of the camps this practice might be largely extended, and in the aggregate a considerable number of leeches got rid of. Probably much more could be accomplished in this way than if men were employed to gather them, and without any expense to the commissioners. No better opportunity for collecting them can be devised than that presented during the swimming periods at the camps, the swimmers themselves serving at the same time as animated baits and traps. Were this plan carried out consistently at all of the camps for a period of years it is certain that a very material reduction in the numbers of the leeches would be witnessed. General

collecting along the shores would be facilitated by placing boards at the edge of the water for the leeches to gather under. As other incentives to gathering the leeches may be suggested the offering of prizes and instruction in their use as bait. Little could be expected from the crudely improvised tackle and haphazard methods of fishing of the smaller boys, but for the older boys and camp leaders with their better tackle and greater expertness, leeches can be recommended as a most effective and a satisfactory bait for bass, yellow perch, the larger sunfishes and similar fishes.

The eggs of *Macrobdella* are encased in spongy capsules (figure 14) deposited for the most part in the mud and turf at the water's edge. Occasionally considerable numbers of these are found in favorable spots. It was hoped that at Carr Pond the leeches might congregate at localized breeding grounds where the egg-cases would be found in large numbers. This hope was disappointed, however, and only a very few widely scattered capsules were found. Under these conditions collection and destruction of these would be futile. It is doubtful if any physical means for destroying the egg capsules in large numbers could be applied successfully, as they are very resistant to drying out and to mechanical and chemical injury.

Use of Natural Enemies. As stated above, very little of a specific nature is known concerning the natural enemies of native American leeches, and particularly of *Macrobdella decora*. It may be safely assumed, however, that the American counterparts of those animals which have been ascertained to prey upon the European medicinal leech will prove to be factors in the restriction of ours also. As many of these are represented in the fauna of Carr Pond, collectively they doubtless exert an important influence in keeping the blood-sucker and other species of leeches within numerical bounds. Probably the most important of such enemies in Carr Pond are certain species of carnivorous fishes (sunfishes, yellow perch, black bass, etc.), the spotted sandpiper, green heron, belted kingfisher and wild ducks, water snakes, frogs and newts, predacious insect larvae, especially *Dytiscus* and some of the larger dragonflies, and the large toothless leech. Nothing is known of the diseases of wild leeches, though in confinement the mortality of the medicinal leech through infection is very considerable. Doubtless little can be done to combat the leeches through the further use of natural enemies, inasmuch as it is probable that a balance between all of the interacting factors has been or soon will be reached and maintained. Some repressive effect might be had by encouraging the increase of certain desirable species of fishes such as those mentioned above, or by introducing crayfishes, of which I saw no examples in Carr Pond; or by destroying their shelters by clearing up the shorelines of boards, logs, etc., as was done among the measures taken against mosquito breeding. However, owing to the activity of the leeches and the ease with which they can adapt themselves to the abundant places of concealment the latter would probably avail little.

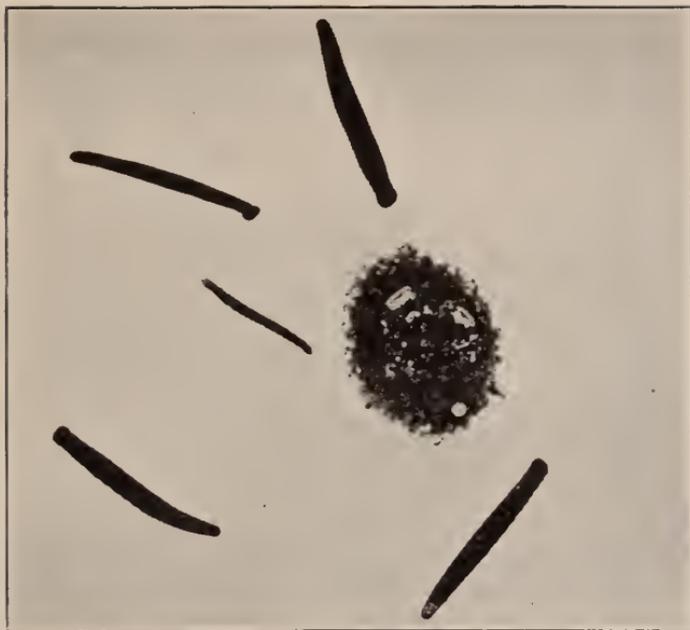


Fig. 14. Egg case and newly emerged young of *Macrob- della decora*; slightly enlarged.



Fig. 15. Leech traps. Three views of box traps; showing from left to right, the top, front and interior from the rear; a canvas bait bag is shown in position above the slit-like entrance. The second type of trap is being held with the entrance forward.

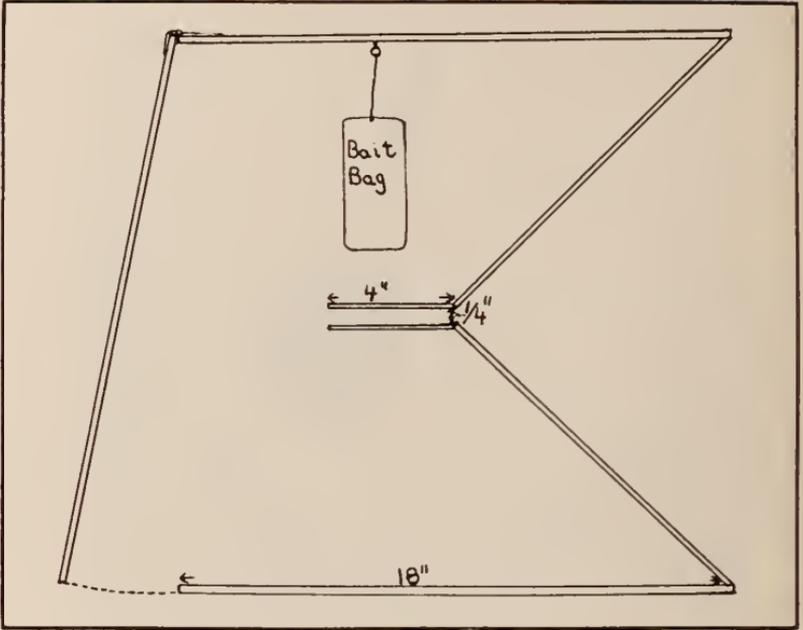


Fig. 16. Sectional diagram of box trap.

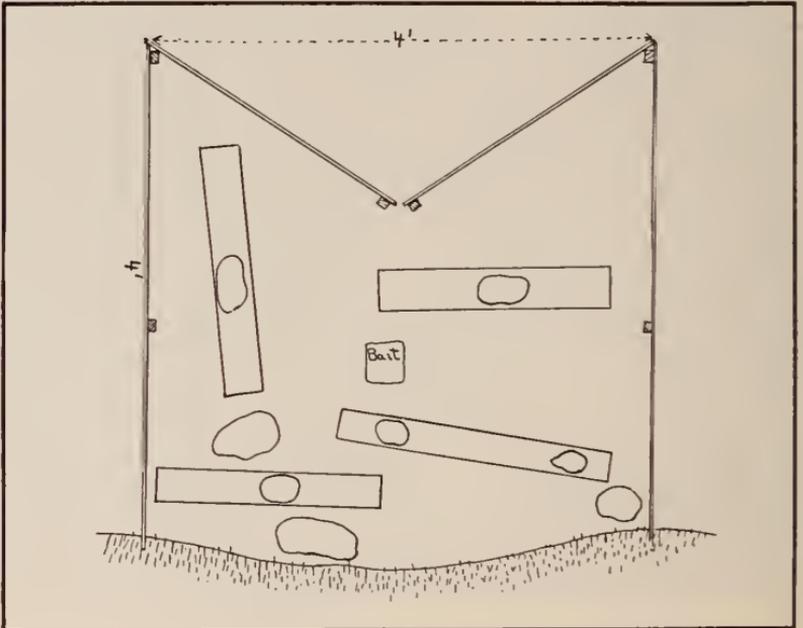


Fig. 17. Diagram of pen trap (third form), showing relation to bank, the entrance, position of bait, and boards and stones to afford concealment.

Use of Poisons and Repellents. That leeches are excessively sensitive to certain poisons is well known. For example, a trace of chloroform or nicotine placed in a vessel in which they are living will cause them almost immediately to fall to the bottom in a rigid moribund condition. The thought naturally arose, therefore, that a poison might be applied to the lake waters in doses lethal to the leeches without injury to the other inhabitants, or that, without killing them, the leeches might be repelled from the swimming places with the same facility with which they are attracted. It is quite probable that such a method could be worked out but there was time to experiment with a few substances only.

For several years it has been customary to treat the waters of Carr Pond and other lakes with copper sulphate to destroy the minute algae (water bloom) that otherwise would form extensive areas of surface scum to the annoyance of bathers. On a few occasions, when the application was made with insufficient care, large numbers of fishes were killed. It could not be learned, however, that there was any deleterious effect upon the leeches.

A series of tests was made to determine the reactions of the leeches to this salt. The experiments were made somewhat crudely as the facilities of the laboratory permitted nothing more refined; but the results are sufficiently accurate for the purposes in view though having no physiological value. A stock solution of one part of copper sulphate to nine hundred and ninety-nine parts of boiled and filtered lake water was prepared. This was diluted for each experiment to the desired strength with raw lake water. In each experiment from one to three freshly caught and active leeches were placed in each of three two-quart (sometimes one-quart) glass preserving jars. One was filled to the top with the fluid to be tested, so that when a cover of cheesecloth was tightly drawn across the top it became impossible for the leeches to avoid the solution. A second was exactly similar except that in place of the copper sulphate solution it was filled with untreated lake water like that in which the leeches normally live. The third was half-filled with the solution being tested, leaving a large air space above into which the leeches could escape from the poisonous solution. The three jars were placed together in a cool dark place and examined at intervals of usually one or two hours, when the condition of the animals, temperature, and other data were recorded. The dilutions ranged from 1 in 1,000,000 to 1 in 5,000,000 of copper sulphate and water and each experiment was repeated several times.

The results were very definite. In the jars containing the copper sulphate the leeches immediately showed signs of irritation and excitement. They swam or less often crawled with great activity, exploring all parts of the jars in their efforts to escape. In the full jars this activity continued for a long time or until the leeches appeared exhausted and fell to the bottom or hung relaxed from the side of the jar. In the half-filled jars they quickly discovered the air-filled upper half and came to rest usually with both suckers attached to the side and the pendant body well above the irritant liquid. In the check jars, after completing their explorations, they soon assumed normal resting attitudes.

Every strength of copper sulphate used proved lethal in time and every leech exposed to its full action died, except in two cases in which a 3,000,000 and a 5,000,000 dilution in which leeches had previously died, were used a second time. These had evidently lost their toxic properties through their previous reaction to organic substances. In the stronger solutions death (determined by the complete relaxation of the leech and its failure to respond at all when pinched with forceps) occurred in from five to twelve and one-half hours, in the one-five-millionth solution in from sixteen to eighty-six hours and in the intermediate strengths in corresponding periods of time. The variation in the time required by any particular strength to kill showed a rough correlation with temperature and amount of organic matter in the form of minute plant life present in the water, being negative to the former and positive to the latter; that is, the toxicity for the leeches increased with increase in temperature and diminished with increase in the quantity of minute algae present. The exact cause of death, whether due to the direct action of the metallic poison or to its indirect action by absorption of the dissolved oxygen in the water with consequent suffocation, was not determined. Inasmuch as leeches are highly resistant to oxygen starvation it is probably not the latter.

In the half-filled jars the leeches continued to live through the period of the experiments. None seemed to be harmed in the least by the solution from contact with which they early escaped. In the check jars they lived normally, not a single one having died during the course of the experiments.

Concerning the effect of copper sulphate upon leeches in the lake itself I was fortunate to be present during two applications for water bloom. Though a very careful inspection of the shore was made not a single dead leech was found, although in one case the mortality among fishes and particularly among catfishes was considerable. Noticing that the water bloom in sheltered places close to shore, especially in shallow water, was often little harmed by the application of copper sulphate, it was thought that the poison might not have reached the leeches. To remove this doubt some of these places were sprayed with a one-five-thousandth solution. No effect on the leeches was noticed except that several were stimulated to activity, which might have been due to the fact that the operator in applying the solution often waded in the water.

It becomes clear, therefore, that copper sulphate cannot be used successfully to kill the leeches. If its use can be recommended at all, it is only as a possible repellent. If applied in considerable strength almost daily at the swimming docks it might drive the leeches away but its value for even this purpose is doubtful.

Because of its large use as a disinfectant for camp latrines, drains, etc., chloride of lime was selected for a similar series of experiments. It proved to be much less toxic than copper sulphate, the weakest solution that was lethal within four days being one-one-millionth and a few leeches survived this. A one-five-hundred-thousandth solution proved invariably fatal in from eighteen to forty hours. Chloride

of lime seemed less irritating than copper sulphate but the leeches when free to do so avoided its effects in the same way.

Common salt was reported to have been used successfully to combat the leeches at one camp from which the most vigorous complaints emanated. Upon investigation it was learned that whenever leeches were caught they were laid on a board and nearly buried in granulated rock salt, which of course proved fatal. The camp directress was encouraged to experiment with placing a quantity of this substance in the crib in the hope of determining if the leeches could be repelled thereby. This was done in a casual manner without any record being kept of the quantity of salt used. I was unable to detect any reduction in the number of leeches.

Laboratory experiments showed that *Macrobdella decora* is highly resistant to sodium chloride solutions. When kept in solutions as strong as one per cent no apparent injury was noticeable after five days. In solutions of from .1 per cent to .02 per cent they exhibited increased activity for a short time (one to three hours) but after that appeared to be perfectly normal. In weaker solutions no effect whatever was apparent, and even in the strongest solution used there was no consistent attempt of the leeches to avoid it, such as was so obvious in the case of copper sulphate and calcium chloride.

Sulphuric acid was experimented with solely as an irritant and repellent. The subjects were placed in a blackened open vessel of water and allowed to assume resting attitudes. Measured quantities of the sulphuric acid solutions were then allowed to flow gently over various regions, generally the head, from the finely drawn out end of a medicine dropper. In each case an equal number of drops of pure water was applied with exactly the same precautions as a check, and the time, amplitude, and nature of the resulting reactions compared. The strengths of the solutions used ranged from 1.0 per cent to 0.1 per cent of concentrated acid (sp.gr. unknown). The leeches proved unpleasantly sensitive to all and exhibited avoiding reactions of varying moderate degrees of intensity. From the stronger solutions they quickly withdrew the head or portion of the body affected, turned directly away from the point of contact and either swam or crawled to the opposite side of the vessel where they remained. Even to these concentrations, however, the complete withdrawal would be characterized as leisurely, requiring from two to four seconds for its completion, though the initial contraction was instantaneous. To solutions of from 0.5 per cent to 0.2 per cent the first part of the response was similar but the leeches merely changed position and only very rarely left the spot. To the weakest solutions they behaved as they do to weak mechanical stimuli, such as a fine jet of water, the part touched being withdrawn without affecting the rest of the body and the original position being resumed after a brief interval.

Experiments with various other substances had been planned but the definiteness of the avoiding reactions of the leeches to the above seemed to sufficiently indicate their ability to escape the effects of any poison that could be safely used. For this reason, and partly because

of the unfavorable weather conditions prevailing during the latter part of the summer, projected field experiments were not carried out. It is anticipated, however, that unless employed daily and in large quantity about the swimming places little practical results could be expected. It is probable that the best results could be had in the autumn when the water becomes cold and the leeches sluggish. The experiments with calcium chloride especially indicate that with lowered temperature the toxicity of the solution decreases less rapidly than the vigor and certainty of the avoiding reaction of the leeches. It seems probable, therefore, that at a temperature approaching that at which the leeches become very sluggish and their senses dull, a point might be reached at which poisons could be applied effectively. Experiments to determine this would be well worth while and if the expectation were justified the method would have the advantage of local applicability if desired.

Freezing in Winter Quarters. After full consideration of all of the possibilities suggested by the known life history and behavior of *Macrobdella decora* the conclusion was reached that under conditions existing at Carr Pond the most promising and practicable method of reducing the population of these leeches was offered by freezing them in their winter quarters. Accordingly the following memorandum of recommendations was prepared and forwarded to Mr. Edward F. Brown, Superintendent of the Camp Department:

"Several species of leeches inhabit the waters of Palisades Interstate Park. The one complained of by the bathers in Carr Pond is *Macrobdella decora*, a true blood-sucking leech. This species is moderately abundant in Carr Pond and less so in some of the other lakes. In considering methods for reducing and controlling its numbers almost every feature of its life history and behavior was passed in review and many experiments and observations made. These will be fully detailed in a complete report to be sent to Doctor Adams. All that is required here is to put in writing in a more formal way the plan for dealing with the leech nuisance in Carr Pond that was outlined verbally to Mr. Welch.

"Strictly speaking, like the frogs with which it so largely associates, this 'blood-sucker' is a swamp animal rather than a pond animal. Its excursions into the open waters are chiefly in quest of food or new living places. Its home is in the shallows and along the shorelines. This fact was recognized in all of the plans for its control that were considered, and is in large part the basis of the one adopted for recommendation.

"Two other facts particularly influenced the formulation of this plan. As is true of many other lower animals the activity of leeches is largely determined by the temperature. As the temperature of the water falls with the onset of winter they become more and more sluggish and finally bury themselves in the mud or beneath stones on the bottom in shallow water. At 39° F., the point of the maximum density of water and the general winter temperature of pond water, they are dormant and nearly insensitive. They therefore hibernate

in the mud until aroused to activity by the rising temperature of spring. In the vicinity of Philadelphia the great majority of them may be found during the winter occupying a zone between the depths of eighteen and thirty inches. Some go beyond these depths, but few or none into deep water. The advantages of this distribution is obvious. As the heavier cold water first accumulates and longest remains in the depths, animals of the physiological type of the leech must enjoy a longer season of activity because their winter quarters lie in the shallows. Because the ponds probably freeze to a somewhat greater depth in the New York Highlands than at Philadelphia we may expect that the leeches will occupy a correspondingly slightly greater depth.

"The remaining fact is that these leeches may be readily killed by exposure to a temperature of 20° F. for a few hours. These determinations were made in a small quantity of water and soft mud and upon leeches shortly before living in a state of activity at higher temperatures. Whether the same temperature would prove fatal to leeches naturally hibernating is not definitely known. They may be more resistant. Here is a source of possible but improbable error that experiment only will determine (1).

"The procedure recommended is as follows: About the beginning of December, when the first thin ice starts to form, when it is certain that the body of water in Carr Pond has attained its minimum temperature and that the leeches have become dormant, the water is to be drawn off as rapidly as possible until the level is lowered four feet. It is to be maintained at this depth continuously for at least five or six weeks during the coldest part of the winter, after which the headgates will be closed in time to impound the melted snow waters when the spring thaw comes. It is believed that a sufficient margin of safety has been provided to cover the two factors of uncertainty referred to above. Lowering the water level four feet should include the greater depth at which the leeches might be expected to winter at the more northern latitude. During the period chosen the occurrence of several spells of zero, or near zero, weather and nightly temperatures very generally below 20° F., may be expected. Under these circumstances the exposed flats should be frozen hard to a considerable depth and temperatures well below the fatal minimum reach the imprisoned leeches.

"The advantages of the plan are its simplicity, inexpensiveness, and the ease with which it can be applied at one operation to the entire lake. According to Mr. Welch it is feasible from the standpoint of operation and open to no objections from that of engineering.

¹ Experiments conducted at my home during the early part of the winter of 1919-20 determined that the minimum temperature lethal point is the same for leeches taken from a condition of dormancy as had been determined previously for active leeches, that is, it is the same whether the temperature has been lowered rather rapidly or very gradually. In either case before dying they become increasingly sluggish, quiescent and dormant and shrink in size, probably through the loss of water chiefly in the form of mucous and nephridial secretion.

Lowering the water level will damage no construction work and only slightly interfere with the winter use of the lake. There will be, of course, still a large surface from which to harvest ice, the cost of which will be only slightly increased by the greater distance over which it will have to be carried. No harm will be done through the loss of water, as the working level of the lake will be easily reestablished by the spring thaws. There are some collateral advantages, especially from the standpoint of mosquito control. The exposure and freezing of the flats should operate to destroy some of the undesirable vegetation. It would almost certainly destroy any larvae of that very troublesome mosquito, *Mansonia perturbans*, living about the lake. It would afford the best of opportunity for clearing up the lake shores and removing obstructions, etc.

"Some biological disadvantages must be noted. Various animals associated with the leeches on the flats would suffer with them. Doubtless large numbers of small frogs which abound in this lake and which winter similarly to the leeches would be killed. However, their lethal point to cold is somewhat lower than that of the leeches and they penetrate the mud to a greater depth, so that the percentage of mortality might be expected to be lower. Other species of leeches not included in the indictment against *Macrobdella decora*, such as the large *Hamopsis grandis*, would be equally affected. Many kinds of aquatic insects, worms, mollusks, etc., which serve as food for fishes would probably be killed. This important aspect of the matter was discussed at length with Dr. Adams, our conclusions being that too little is known of the winter condition of many of these organisms upon which to base a positive decision. Especially do we know little of the powers of resistance to cold of most specific organisms. The only thing to do is to try the experiment, the value of which would be very greatly enhanced were it possible to have a competent biologist on the ground to observe the effects. In general it may be stated that insects in their winter state are highly resistant to cold; that the chironomids, whose larvae constitute perhaps the most important single element in the food of small fishes, largely inhabit the aquatic vegetation and the bottom ooze at greater depths than those affected; and that the small entomostracan crustaceans, so important as food for young fishes and many organisms on which the larger fishes subsist, mostly produce winter eggs especially resistant to great cold and drought.

"It seems desirable to emphasize several considerations upon which the success of the plan will depend, and the ignoring of which may lead to its failure. It is very important that the water be not drawn off before the leeches have become fully dormant. In that case they would probably follow the receding water and take up winter quarters at a new and safe level. For the same reason the level should be reduced as rapidly as possible, and a time when much surface water is draining into the lake should be avoided. It is desirable that the flats should be exposed during a cold snap so that freezing will take place as rapidly as possible. If done during a warm sunny period the leeches may be stimulated to burrow more deeply into the mud,

thus securing additional protection. A heavy fall of snow also might so blanket and protect the flats that the cold would be prevented from penetrating to the desired depth and degree."

("Third Memorandum, September 14, 1919.")

In accordance with the foregoing recommendation the headgate at the lower dam of Carr Pond was opened at the end of November and the new level attained on December 6, 1919, concerning which Mr. W. A. Welch furnished the following data: At that time ice three inches thick completely covered the lake. That same night snow fell to a depth of two inches and on following days there were many successive snowfalls, so that the ground and surface of the lake were continuously covered. Drawing off of the water required about three days, by which time the level had been lowered two feet in the body of the lake and six feet in the lower extension below the old dam. The temporary dam was then blown out and the water level equalized. During the month of December the temperature had been continuously cold and several times had fallen to zero.

On December 30, I personally visited Carr Pond and noted the prevailing conditions. Measurements were taken at the dam, on a tree standing in the water at the extreme head of the lake, and on the docks at Globe, Jacob Riis, and Kennedy camps. At each of these points the level measured from the top of the solid ice was as nearly as could be ascertained two feet nine inches below the normal level of the preceding summer. Nearly all of the little bay or cove near Mr. Herbert's shack, and considerable areas of that at Globe Camp, together with a border of varying width around the shorelines, were drained. All such places were covered with a layer of hard ice about three (2.25 to 3.50) inches thick, evidently that existing at the time the water was drawn off and which settled down as the water level fell. On the lake generally the ice was from seven to eight and one-half inches thick and on this lay a covering of snow from eight to eleven inches thick, the latter at the cove near Herbert's shack and vicinity. The air temperature in the shade just before noon of December 30, a clear and calm day, was -4° C. (25° F.).

Soundings made at various points around the lakeshore showed that in most places the ground beneath the snow and ice covering was frozen to a depth of only about two inches. Immediately beneath this crust the temperature was $+1^{\circ}$ C. (34° F.), at four inches depth it was $+2^{\circ}$ C. (36° F.) and at one foot $+4^{\circ}$ C. (39° F.). That the failure of the cold to penetrate deeper was due chiefly to the protection of the snow blanket is indicated by the fact that the ground under cover of the dock floor at Globe Camp, which was free from snow, was frozen solidly to a depth of six and one-quarter inches. At the drained cove near Herbert's conditions were still less favorable. Here the snow was eleven inches deep, the ice only two and one-quarter inches thick and the underlying mud everywhere unfrozen and very generally of a temperature of $+4^{\circ}$ C. (39° F.) even where in actual contact with the ice. An examination of the lower surface of the ice made it evident that after settling

down into contact with the bottom mud, the higher temperature of the latter had been sufficient to melt it somewhat. This was shown not only by the fact that the ice here was about three-fourths of an inch thinner than on most parts of the drained bottom but also by the spongy texture and the impressions of leaves, twigs, etc., which characterized its lower surface. The bottom here, and to a less degree in other shallow coves and basins, is a nearly black muck filled with organic matter, the slow oxidation of which probably frees a perceptible quantity of heat. It was also determined, especially in the neighborhood of Globe and Brooklyn Industrial Camps that much ground water from both exposed and subaqueous springs was draining into these basins, the effect of which was to maintain a higher temperature of the bottom even after exposure.

Comparing the existing conditions with those postulated in the recommendation of September 14 it will be seen that the temperature of the bottom mud instead of being -6° C. (21° F.) as desired was about 10° C. (18° F.) warmer. While the air temperature had been sufficiently low to effect the desired result under favorable conditions it seems evident that three factors were operating to prevent it. First, the heavy and continuing blanket of snow acted as an insulator against the rapid radiation and conduction of ground heat; second, the effects of the cold were greatly mitigated by the constant and abundant flow of warmer ground water beneath the ice and snow cover; and, third, the slow decomposition of abundant organic matter in certain places freed sufficient heat to somewhat elevate the temperature. The effect of the first two conditions, if realized, were anticipated and referred to in the memorandum; the possibility of the third, though obvious enough, was overlooked.

Concerning possible remedies it is obvious that corrective measures on a scale sufficiently large to be of much value could scarcely be taken against conditions 1 and 3. For experimental purposes it would be practicable to keep limited areas free of snow, especially by the use of a horse plow on the coves at Globe Camp and Herbert's. But the effects of 2 might be mitigated by further lowering the water level. This would expose a larger surface of the bottom to loss of heat, drain off the warmer ground waters from the flats more effectually, and remove the wintering areas of the greater number of the leeches farther from the tempering influence of the body of water of the lake. Accordingly, it was recommended to Mr. Welch that the water be lowered an additional eighteen inches as soon as practicable. This would bring it to a point three inches lower than had been proposed originally.

The search for the leeches in their winter quarters was handicapped by the heavy covering of snow and ice, but thanks to the efforts of two men furnished by Mr. Welch a quantity of the mud from the bottom of the Cove near Herbert's was shoveled on to the ice and examined. Two leeches only were found, one each of *Macrobdella decora* and *Erpobdella punctata*, both alive and dormant.

The winter of 1919-20 proved to be a long and severe one, with

the temperature continuously moderately low. So far conditions were favorable to the success of the experiment. On the other hand the snowfall was remarkably heavy, so heavy, indeed, that it prevented the taking of the supplementary steps recommended. In reply to an inquiry Mr. Welch wrote me under date of March 8, 1920: "Shortly after your visit here we had so much snow that we had to abandon all work in the Park this winter; the roads are all closed and it has been and is still impossible to get around at all. There are approximately seven feet of snow in the mountains now." It is much to be regretted that conditions proved such as to leave the results of the experiment in doubt. The following data were furnished by Mr. Welch from his office records: The ice on the lake attained a thickness of fourteen inches and the snow of twelve inches, both remaining throughout the winter. The temperature frequently reached -5° F. and remained continuously low until the latter part of March. The normal water level in the lake was reached on March twentieth.

Owing to various circumstances I was unable to visit Carr Pond again until August 2, 1920, during which week several days were spent in attempts to determine whether the blood-sucking leeches had been noticeably affected by the conditions existing at the pond during the winter. Two lines of inquiry were carried out, as follows:

First: all of the camp directors and others who were in a position to know were requested to express an opinion concerning the relative abundance and troublesomeness of the leeches during the summer of 1920 compared with that of 1919. Later, Mr. Brown made the same inquiry independently in the form of a questionnaire. The following table shows the results:

NAME OF CAMP	Leeches more or less numerous in 1920 than in 1919	Average number of campers bitten per day in 1920	Remarks
Brooklyn Industrial.....	Less.....	About 2.....	Boys do not mind them. Used for bait.
Globe.....	Less.....	1 or 2.....	Used for bait.
Jacob Riis and Trinity.....	Much less.....	Site occupied by Trinity Camp in 1920.
Kennedy House.....	Much less.....	Not over 1....	During 1919 this camp was always a prolific source of supply.
Big Brother.....	Less.....	About 2 per week.	Many leeches caught by the boys both summers.
Hebrew Orphan Asylum, Boys Branch.	More.....	About 2 or 3..	Used for bait. Two or three times as many and larger than in 1919.
Nathan Hale.....	More.....	Not over 1.	
Martha Barbour.....	Somewhat more.	1 or 2.....	Always troublesome. Girls camp.
Greenwich.....	About the same.	About 5 per week.	Boys catch about 6 or 8 per day.
Ramapo.....	Much more.....	2 or 3.....	Six to twelve caught daily.
Girls Patriotic League and Brooklyn Girls.	More.....	Usually 1 or 2.	About six caught per day.

The first four camps listed are situated on the old part of the lake, the next three are just within the extension and the remaining four are well within the latter. The table includes only those camps concerning which unequivocal data covering both years are available and upon which the information furnished to Mr. Brown and myself agreed. The data from other camps is confirmatory, so far as they go. Mr. Herbert expressed the opinion that there were fewer leeches in 1920 than in 1919, and in 1919 than in 1918. In reply to an inquiry Mr. Welch wrote on November 30: "From all appearances there were as many leeches in Carr Pond during the summer of 1920 as there were during the summer of 1919," and on December eleventh: "All of the information which I have been able to gather seems to show that last year the leeches had certainly moved from their former locations and were more prevalent in new sections of the lake and it had occurred to me that this might be due to the fact that when we drew down the waters of this lake the new emptied very much more rapidly than the old and the leeches left in the mud in this section were able to get out and down to the water before the final freeze up."

Second: a personal examination similar to that conducted last summer to determine the abundance and distribution of the leeches was made. While this, of course, does not furnish an accurate census it does give a basis for rough quantitative comparison. In 1919, twelve stations, representing a variety of conditions and different parts of the lake shore, were selected for careful examination. So far as practicable these were of approximately equal size, that is, each was a section of the shore about fifteen feet long and three feet wide, one foot of the width being landward and two feet in the water. The several areas were not accurately measured but only paced off. The general physical and biological conditions were noted. All pieces of timber, sticks, stones or other objects affording places of concealment were lifted and scrutinized and the mud and turf more or less probed and superficially examined.

All leeches taken within the marked areas were counted, but the figures for *Macrobdella* only are given in the table. The attempt was not to make the determination quite exhaustive of all the leeches present in each area as this would have involved washing and screening the soil to a depth of three or four inches, but nearly all were secured by the method adopted. In 1919 each station was examined several times during the summer and the figures given show that later examinations invariably yielded a much smaller number of the larger leeches. In 1920 the time was sufficient to examine only six of these stations with the same thoroughness as in 1919. The others were examined much more hastily but so far as they go the figures are confirmatory.

TABLE showing number of *Macrobdella decora* collected or seen at selected stations (figure 3). Numbers 8 to 11 are on the new part, the others on the old part of the lake. Note that in 1919 the number decreases with the progress of the season at every station but number 11, though this is less marked at stations close to swimming docks, as numbers 3, 7 and 12. X, means no or incomplete collections made.

NUMBER AND LOCATION OF STATION	DATES OF COLLECTIONS IN 1919						Average 1919	Aug. 4 and 5 1920
	July 5	July 8	July 14 and 15	Aug. 1 and 2	Aug. 9 and 11	Aug. 21 and 23		
1. Island opposite Globe Camp.....	*23	x	13	18	11	9	14.8	8
2. Head of cove north of Globe Camp.....	x	8	7	8	7	4	6.8	x
3. Head of cove south of Brooklyn Industrial Camp.....	6	x	7	4	2	5	4.8	x
4. Site of former sawmill, south end.....	18	x	10	11	8	8	11.	7
5. Head of cove south of Herbert's shack...	12	x	9	7	8	9	9.	8
6. Point north of Herbert's shack.....	4	x	5	6	3	3	4.2	x
7. Shallow at Kennedy House Camp.....	19	x	14	14	11	13	14.2	6
8. Shallow between the Negro (Ideal) and Ramapo Camps....	x	8	8	8	5	4	6.6	x
9. West shore near dam. This area was practically all water...	6	x	4	1	3	0	2.4	7
10. Pool at foot of dam...	x	2	4	0	x	x	2.	x
11. Foot of Nathan Hale Camp. Proximity of bathing beach.....	x	6	7	7	6	8	6.8	12
12. North of Jacob Riis Camp. Trinity Camp 1920, near crib.....	x	7	9	9	8	3	7.2	x

* Some boys from Globe Camp assisted in making this collection.

Stations (especially Nos. 1, 4 and 7) on the old part of the lake all show a very marked diminution in the number of *Macrobdella* collected. These also are the points where this species was most abundant in the summer of 1919. Possibly the fact that the first collections recorded for 1919 were made between two and three weeks earlier in the season may have exaggerated the divergence but later collections made early in August (either the first or second) of 1919, within two or three days of the 1920 dates, give figures still in excess of the latter (except for station 7), namely, 18, 11, 7 and 14 respectively for these same stations. Stations 9 and 11 are representative of conditions on the new part of the lake and both exhibit marked increases.

Less thorough examinations and collections were made at many other points and generally in the old part, and in nearly every case in the newer part of the lake the results proved consistent with the above figures, namely, they indicate that these leeches have diminished in numbers in the old lake and increased in the extension. In this

connection it should be recalled that all of the observations made during the summer of 1919 demonstrated just the reverse, the leeches being much more plentiful in the body of the lake above the old dam than below it. This was attributed to their not having yet migrated in large numbers into the newly filled lower end of the lake. Sometime during the interval between the two examinations this redistribution has taken place. Nevertheless, in 1920 they had failed to attain in the new part of the lake their abundance of the preceding year in the old part. Their distribution had become much more uniform but the population was nowhere so dense as in the most populous places in 1919.

If these rather meagre though consistent data can be relied upon it appears clear that the total population of *Macrobdella* in Carr Pond has been considerably reduced, for not only do the figures indicate that the ratio of decrease in the old part exceeds that of increase in the new part of the lake but it must be remembered that the area involved in the former is about four and one-third times that involved in the latter condition. How much of this decrease may rightly be attributed to the effects of the experiment and how much to other conditions it is impossible to know, inasmuch as, unfortunately, no definite checks could be made available. It may be pointed out, however, that the differences in hydrography of the two parts of the lake is consistent with a greater destructive effect of freezing in the old than in the new section. In the former is found more of gently shelving beach and large areas of shallow. The lowering of the water level exposed some fairly extensive flats upon which the wintering leeches must have found it difficult to escape the effects of the cold. On the other hand most of the new part of the lake has a trough-like form with the bottom in most places sloping rapidly into deep water. Not only would this conformation retard the chilling process but it would facilitate the escape of the leeches from its effects. The removal of the old dam, permitting of a freer circulation of the water and doubtless of a freer interchange of life also, doubtless facilitated the migration and equalization of the leeches in the two parts of the lake.

The time was insufficient for any careful determination of the relative abundance of other life associated with the leeches during the two summers. But I was strongly impressed that frogs were much less plentiful in 1920 than in 1919. This seemed especially so on the shallows near Globe and Brooklyn Industrial Camps. At all points around the shore except one area near the dam the marginal vegetation was obviously less luxuriant than in 1919.

In view of the facts and opinions recorded in the foregoing account it was very desirable that the experiment be repeated. Consequently in a letter to Mr. Welch, under date of August 18, the following paragraph was written: "It seems to me that the results are sufficiently encouraging to warrant a continuance of the experiment and I recommend that the water be again lowered during the coming winter with the same precautions emphasized in my memorandum of last year, and in addition that the degree of lower-

ing be made six feet instead of four. This will have the effect of draining off the warm ground waters more completely and at the same time make it more difficult for leeches wintering on the borders of the area to escape."

Owing to the mildness of the winter of 1920-21 and especially to the paucity of the snowfall Major Welch declined to draw off the water, fearing that the spring run-off might prove insufficient to reestablish the old level.

During 1921-22 conditions proved much more favorable for a repetition of the experiment and under date of May 29, 1922, Major Welch wrote: "When the first freeze [of the preceding winter] came the lake was full and we immediately drew it down. Within two or three days the water had lowered about four feet and just after this we had a period of very severe weather which froze the ground very thoroughly before the snow came. Of course, it is too early in the season to say what the result has been and as soon as we have an opportunity to observe, I will be very glad to give you all the facts."

On September 14, 1922, Major Welch wrote further: "I am very glad to be able to inform you that the leeches have not been in evidence at Lake Stahahe this year. I am not sure that they have all been destroyed although I have been unable to find any nor can I get any reports from the camp directors on this lake which lead me to believe that they have found any. If we have a good opportunity this winter to again lower Lake Stahahe and freeze the mud over its shallow areas we shall do so in an endeavor to entirely eliminate these leeches."

This statement of Major Welch is confirmed by Miss R. M. Joliffe, Mr. E. F. Brown's successor as Superintendent of the Camp Department who writes (Nov. 3, 1922): "We had no trouble so far as I know with leeches in Lake Stahahe last summer;" and by the direct testimony of camp directors, twelve out of fifteen of whom replied to a questionnaire.

Two directors report leeches more numerous in 1922 than in 1921, one adding that they had decreased in number from 1919 to 1921, four that they were less numerous and five much less numerous in 1922, while one fails to answer this question. Answering the question how many campers were known to have been bitten during the season, six reply none, three one, one two, and two eight or ten. It is rather interesting that both of those directors who reported leeches as more numerous in 1922 also state that none of their campers were bitten during the season and one adds that very few were seen all summer. Most of the directors state that few or even no leeches were seen and the two highest estimates of the number seen are about five daily and twenty-five for all summer.

These camps are located all around the lake and more than half of them are very near to census stations at which the leech population was counted in 1919 and 1920. The two camps where an increase was reported are both located at the south end of the lake. One of the most significant statements is that of Mr. Wm. Demerest, of

Kennedy House Camp, who has been on the lake for many seasons and is very familiar with conditions. He says: "We seemed to be absolutely free of leeches at our place." My station 7 was located at this camp and blood-sucking leeches were more plentiful there than at any other point on the lake. At every visit during the summer of 1919 leeches were found and the campers almost always had a large number that they had captured for me.

The evidence seems unequivocal, therefore, that there has been a great decrease in the number of these leeches since the summer of 1919 during the progress of these freezing experiments. While it cannot be said that the relation of cause and effect have been fully established this probability seems sufficiently great to warrant the recommendation of the method for the control of blood-sucking leeches under conditions similar to those in Palisades Park: namely, in bodies of water the level of which can be rapidly lowered, in which there are shallow areas, and which are located in regions climatically favorable. Just how far the method may be successfully applied remains to be determined experimentally.

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PRELIMINARY REPORT ON THE PARASITIC WORMS OF ONEIDA LAKE, NEW YORK.

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INTRODUCTION

The author of this preliminary report, assisted by Mr. Frank C. Baker, at that time zoological investigator at the State College of Forestry and at present Curator of the Natural History Museum of the University of Illinois, began on August 21, 1917, a study of the parasitic worms infesting the fish and other aquatic vertebrates and the mollusks of Oneida Lake, New York. This study was conducted under the auspices of The New York State College of Forestry at Syracuse and the United States Bureau of Fisheries, and under the immediate direction of Dr. Charles C. Adams of the College of Forestry, as a part of a general ecological and fish cultural survey of the inland waters of the State. The general plan of the work is as follows. First, as complete collections as possible are to be made of the parasitic worms infesting the aquatic animals in the lake; and second, an intensive study of the parasitic worms of the different species of the important fishes of the lake is to be made, with a view to learning as much as possible of the life history of these parasites. The present paper gives an account of the first collections made in accordance with this plan, in the late summer of 1917. The further collections being made from time to time will doubtless add to the number of species of fish and other animals, and to the list of parasitic forms harbored by these creatures.

NATURE OF AQUATIC PARASITIC WORMS

The parasitic worms that infest fishes and other more or less aquatic vertebrates, as well as fresh-water mollusks, belong to four general groups: the Trematodes or flukes, the Cestodes or tapeworms, the Nematodes or threadworms, and the Acanthocephala or spiny-headed worms. All of these worms, with the exception of a few species of flukes, are internal parasites, living in the various

internal organs of the host — as the animal is called which harbors a parasite. When they occur in large numbers in a vital organ they may seriously affect the health of the host, and either cause its death or form such a brake on its locomotor activities that it falls an easy prey to its natural enemies.

As a rule parasitic worms are in a high degree selective in their choice of the host and also of the particular organ in which they shall pass their existence. A species of parasite which lives and breeds in a fish could not pass the same stage of its life history in a frog or in any of the land vertebrates, and usually a parasite that is found in a given species of fish would be found only in that species, or at least in some closely allied one. Also, a species of worm that normally inhabits some particular organ of its host will usually not be found in any other organ. If it lives in the mouth, for instance, it will not, as a rule, occur in the intestine, and a worm which may be looked for in the duodenum will not be found in the rectum. A worm that attaches itself to the gills and sucks the blood of the host in that favored locality will never be found in the interior of the body.

It is not intended, however, to give the impression that a worm consciously seeks the particular host and organ in which it will flourish best. In the course of the evolutionary history of these worms, as indeed in that of all animals, each species has, as the result of the operation of natural selection, become adapted to a certain more or less definite environment where it finds the conditions of existence favorable. Internal parasites are bound to a specific environment more rigidly than perhaps any other animals, because, living as they do within the body of their host and confined to a narrow space, they are constantly immersed in its body fluids. The chemical and physiological action of these fluids, to which the entire organization of the parasite is thus adapted, varies radically in different localities of the host's body, and a species of worm whose relation to its host would fit it for a prosperous existence in one organ might not be able to exist at all in some other, or perhaps in any other. A parasite, for instance, which clings to the mucous membrane of the mouth or pharynx of a bird, where the reaction of the salivary juices is an alkaline one, would not survive if it should be carried into the stomach, where the reaction is an acid one, but would be digested like any other particle of organic matter.

It is, in fact, hardly possible to exaggerate the extreme delicacy of the adjustment of an internal parasite to its environment, which binds the parasite in most cases to a certain organ of a certain host-animal. It is thus important in studying internal parasites to observe carefully the localities in the host's body in which the parasites are found, and all the accompanying circumstances of their life and surroundings. Quantitative studies of these points are also important, since the greater the number of observations the truer will be the generalizations based upon them. One of the main objects of this whole study is to determine these conditions and thus to throw light upon the life history of the parasites under investigation.

The life history of most internal parasites, however, includes much

more than their life in the hosts in which they pass their adult existence. There are in most cases two distinct periods in the life of such animals, (1) the adult period, and (2) the larval period. In the first period the parasite lives in some one of the open organs of the host, which has direct communication with the outer world, such as the digestive tract or the lungs. Here the parasite reproduces itself, and from its seat its eggs or young find their way to the outside, usually with the dejecta of the host. In the larval period the young animal, having thus been carried to the outer world, lives for a while a free, non-parasitic life, and is later transferred either directly to a host similar to the parental host, in which it is destined to pass its adult, parasitic existence, or to a host very different from the parental host, in which it passes into a second larval stage. In the latter case the young worm leads a more or less inactive life, often enclosed in a cyst, until this host is finally eaten by an animal of the same, or in some cases of a nearly related species, as the parental host. The young worm is thus mechanically transferred to the stomach of this animal and in the course of time makes its way into that particular organ in which nature has intended it shall live and breed.

It will be seen from this statement how complex is the life history of parasitic worms, and how necessary are intensive studies of them and their several hosts. It is not sufficient to collect the adult worms and to study their relation to their hosts, the larval worms and their hosts must also be studied in order to complete the life-cycle; and until the life-cycle is understood it is often impossible to suggest a means of controlling the ravages of the parasite. It is just for this reason that field studies like those being made on the shores of Oneida Lake are important, where the conditions are unusually favorable for investigating every phase of the life history of the parasites under consideration.

The organs of the host animal which are most liable to be infested by parasitic worms are the different portions and appendages of the digestive tract, and all the divisions of this tract from the mouth to the vent may harbor them. It is unusual to find a fish or other aquatic vertebrate that does not have these worms in some or every part of this tract. In most cases, however, the number of worms in a single intestine is not large, but occasionally cases of heavy infestation are found. One large water snake was found on the shores of Oneida Lake the stomach of which was literally packed with large Nematode worms, so that it was difficult to see where there would be room for the animal's food. Two eels, also, were found with their intestines so distended by the tapeworms they contained that the vitality of the fish must have been seriously lowered. The practical reason why the digestive tract is a usual place of infection of adult parasites is that they are usually brought into the body of the host with its food.

After the digestive tract, perhaps the most frequently infected organs are the respiratory organs. In fish the gills are a favorable location for numerous species of flukes, which attach themselves to

the gill-filaments and suck the blood of the fish through their delicate walls. A heavy infection of this sort might easily result in such a serious loss of blood by the fish that it would languish and die. The lungs of frogs almost always contain flukes that sometimes quite fill them. The air-passages and lungs of birds, turtles, snakes, and other aquatic vertebrates are also often infected.

All parasitic worms have very great reproductive powers, and when the conditions accompanying their embryonic and larval development are unusually favorable, as occasionally happens, they may increase in number to such an extent that a parasitic epidemic follows and thousands of animals of the species affected may die. Such epidemics occur among fish from time to time, and are sometimes familiar to fishermen because of the large number of dead fish they find strewn along the beach. Where the fish which are thus destroyed belong to species having commercial importance it is evident that the economic loss may be great.

Where an animal is but slightly infected with animal parasites they may not apparently affect its health or general well-being, but it is probable that any considerable infection, while not perhaps sufficient to affect the activities of the host, would reduce its reproductive powers and prevent it from bringing into the world the normal number of young. Parasitic castration, more or less complete, is a matter of considerable importance in the animal world, and has been frequently observed among Crustacea and other invertebrates. The parasitized animal may be affected either by the destruction of the tissue of the sex glands by the parasites, or by being so weakened by them during its developmental period of life that the sex glands fail to develop or to function normally, and the animal's mating instincts remain inactive. It is probable that in the case of fish and other vertebrates the effect of parasitism on reproduction is similar. Definite information, however, is lacking, and observations directed to the matter would be of great value.

Parasites sometimes affect the commercial value of food fishes even when apparently they have no influence upon their health or their ordinary habits of life. Perch, rock bass, sunfish and other food fish in Oneida Lake are frequently caught, especially in the late summer and fall, in which good sized cysts are found imbedded in the muscles, often just beneath the skin, in the gills, fins or in other parts usually more or less superficial. Each of these cysts contains a Trematode worm ranging from 4 to 10 mm. in length, and is usually very noticeable. Although the worms are entirely harmless to man, and would simply be digested with the flesh of the fish if eaten, wormy fish are usually thrown away by fishermen and cannot be sold in the market. A popular account of the relation of the worm parasites to fishes and the influence of these parasites on their food value has been published as a part of the present study, as: *Parasites of Fresh-water Fishes*, U. S. Bur. Fisheries, Econ. Cir. No. 42, pp. 1-8, 1919.

Many other species of fish also may harbor cysts containing larval Trematodes, Cestodes or Nematodes in their muscles and thus lose a part or all of their commercial value.

Of the four classes of vermian parasites that infest fish and other aquatic vertebrates perhaps the most important from an economic standpoint are the Nematodes and the Acanthocephala. These worms are slender, cylindrical animals, ranging from microscopic size to several centimeters in length, which sometimes infest their hosts in such large numbers that they either kill them outright or reduce their strength and vitality sufficiently to place them at a fatal disadvantage in the struggle for existence. The Nematodes, or threadworms, are usually found either in the digestive tract or in cysts embedded in the muscles or fat or attached to the peritoneum or to a mesentery. In the former case the worms are active adults, which usually range more or less freely in the portion of the digestive tract in which they live, sucking the blood or absorbing the vital fluids of the host and producing their eggs or young. They undoubtedly often injure the host by lacerating the intestinal wall and draining its vitality, and perhaps also by enabling bacterial or protozoan parasites to gain a foothold in its tissues and blood. The hookworm, which has in the past few years obtained such an unpleasant notoriety in the Southern States of this country, belongs to this group of parasitic worms.

Encysted threadworms are in their larval stage of development, and in this condition they lie dormant and inactive in their hosts without apparently doing them any harm. The cysts, however, like those of the flukes already mentioned, often affect the market value and sale of food fish, as purchasers of fish in a fish market will not usually buy fish which they see to be wormy, even when the worms are harmless, as they always are, and do not decrease the food value of the fish.

The Acanthocephala or spiny-headed worms live in the intestines of their hosts and are often very numerous in aquatic vertebrates. They resemble threadworms in appearance but differ from them, among other things, in possessing a prominent, more or less retractile projection, the so-called proboscis, at the anterior end of the body, which is covered with recurved hooks by means of which they attach themselves to the intestinal wall of the host. When they infect an intestine in large numbers, as they frequently do, the laceration of the intestinal wall by their spiny proboscides undoubtedly causes a severe injury to the host and may cause its death.

The Cestodes or tapeworms are very important parasites of aquatic vertebrates. The adult worm lives in the intestines of its host; the larval worm may be found in almost any organ of the body and in the body cavity, usually enclosed in a cyst, but in the case of certain species not encysted. Tapeworms are much the largest vermian parasites of aquatic vertebrates, some of them measuring 30 cm. or more in length, and are often fatal to fish containing them. The cysts are sometimes very common objects in the flesh of many of the smaller food fishes.

The Trematodes or flukes are probably the least harmful of the internal vermian parasites of aquatic vertebrates. The worms are of small size, usually measuring a few millimeters in length, and in most cases are not found in large numbers in a single organ of the host.

Occasionally, however, as already stated, they may infect the gills of a fish in large enough numbers to injure the animal. Not long ago such a species of fluke was discovered on the gills of the rainbow trout in the State Fish Hatchery at Cold Spring Harbor, Long Island. Practically all the trout a year or more old were infected, in many instances in such large numbers that the gills were shrivelled and functionless.

The larval stage of the Trematodes of fish and other aquatic vertebrates is passed very generally in snails, but also, in the case of certain species, in small fish, in crustaceans, and in other small animals that are the natural prey of the host of the adult worms. It is thus necessary in endeavoring to elucidate the life history of these worms to investigate these animals, especially the fresh-water snails. The study of larval Trematodes has been neglected in this country and observations made on their structure, habits of life, and their relation to their hosts, such as can be made with great advantage at Oneida Lake, will be of great value.

None of the worms that parasitize fishes and other aquatic vertebrates will live in the human body, with a single exception, which is, however, of such rare occurrence in America as to be practically negligible. There need be no alarm, consequently, about the possibility of an infection of parasitic worms as the result of eating the flesh of any fishes, frogs, wild ducks or other similar animals. The exception just mentioned is the broad tapeworm *Diphyllobothrium latum*, which in its adult stage is a common human parasite among the Scandinavian peoples and other fish-eating populations of Europe, and in its larval stage lives in many species of food fishes.

TABULATED RESULTS

The following tables show the names of the species of fish, birds, reptiles, amphibians and mollusks that have been examined in the course of this study, the number of individuals of each species examined, and the number of parasites obtained from each species. Where the parasites were found in large numbers in an organ the number given in the table is usually an estimate, as it was often impossible to count them. This was especially true in the case of the Trematode and tapeworm cysts imbedded in the liver and the fat of the mesenteries of certain fish, such as the common bullhead, the bluegill, and the sunfish. In the case of the eels mentioned, but two complete fish were examined. Only the viscera of the others were examined, obtained from a fish dealer. The lists are not complete, as they record the results of but four weeks' work, and will be added to by future collections. They do, however, indicate the distribution of vermian parasites in Oneida Lake animals.

The animals were collected at or near the town of Brewerton at the western end of the lake, both in the lake itself and in the Oneida River, which is the outlet of the lake. A laboratory equipped with the necessary apparatus and instruments from the zoological laboratory of the College of Forestry was established at this place. The fish and other vertebrates examined were identified by Frank C. Baker and T. L. Hankinson; the mollusks by Frank C. Baker.

FISH EXAMINED		PARASITES COLLECTED					
SCIENTIFIC NAME	Common name	Number examined	Number infected	Nema- todes	Acan- thocephala	Ces- todes	Trema- todes
<i>Abramis chrysoleucas</i> (Mitchill).....	Golden Shiner.	2	1	0	12	0	0
<i>Ambloplites rupestris</i> (Raf.)..	Rock Bass....	4	4	8	9	0	1
<i>Ameiurus natalis</i> (Le Sueur)..	Yellow Bull-head.....	3	3	8	2	2 and many cysts	0
<i>Ameiurus nebulosus</i> (Le Sueur).....	Common Bull-head.....	6	6	6	5	20 and many cysts.	17
<i>Anguilla rostrata</i> (Le Sueur)..	Eel.....	39	39	7	20	36	40
<i>Cyprinus carpio</i> Linn.....	Carp.....	3	1	4	0	0	0
<i>Esox reticulatus</i> Le Sueur....	Chain Pickerel	4	3	0	6	18	2
<i>Eupomotis gibbosus</i> (Linn.)...	Common Sunfish.....	5	5	6	0	Many cysts.	9
<i>Lepomis incisor</i> (Cuv. et Val.)..	Bluegill.....	2	2	0	0	0	Many cysts.
<i>Micropterus salmoides</i> (Lacépède).....	Large-mouthed Black Bass..	1	1	0	5	0	10
<i>Micropterus dolomieu</i> Lacépède.....	Small-mouthed Black Bass..	4	4	0	22	Many cysts.	50
<i>Erimyzon sucetta oblongus</i> (Mitchill).....	Chub Sucker..	1	1	0	1	1	0
<i>Perca flavescens</i> (Mitchill)....	Perch.....	8	8	13	0	0	5 and a few cysts.
<i>Pomoxis sparoides</i> (Lacépède)	Calico Bass....	2	1	0	1	0	0
<i>Stizostedion vitreum</i> (Mitchill)	Wall-eyed Pike	9	8	0	70	27	1

BIRDS, REPTILES AND FROGS EXAMINED		PARASITES COLLECTED					
SCIENTIFIC NAME	Common name	Number examined	Number infected	Nema- todes	Acan- thocephala	Ces- todes	Trema- todes
<i>Ardea herodias</i> Linn.....	Great Blue Heron.....	4	4	0	0	Many	Many
<i>Ardea virescens</i> (Linn.).....	Green Heron..	2	2	13	0	1	0
<i>Ceryle alcyon</i> (Linn.).....	Kingfisher....	2	0	0	0	0	0
<i>Larus argentatus</i> Brünnich...	Herring Gull..	2	1	0	0	0	20
<i>Chrysemys marginata</i> (Agassiz).....	Painted Turtle	1	1	20	0	0	0
<i>Natrix sipedon</i> (Linn.).....	Water Snake..	9	7	Many	6	20	12
<i>Rana pipiens</i> Schreber.....	Leopard Frog.	12	11	Many	0	0	90

MOLLUSKS EXAMINED	PARASITES COLLECTED				
	Number examined	Number infected	Annelida (Chaetogaster)	Larval Trematodes	Hydrachnids
<i>Anodonta cataracta</i> Say.....	3	0	0	0	0
<i>Anodonta implicata</i> Say.....	1	0	0	0	0
<i>Lampsilis luteola</i> (Lamarck).....	4	4	0	0	Few
<i>Lampsilis radiata</i> (Gmelin).....	2	0	0	0	0
<i>Sphaerium vermontanum</i> Prime.....	2	0	0	0	0
<i>Unio complanatus</i> (Dillwyn).....	2	0	0	0	0
<i>Amnicola limosa</i> (Say).....	20	0	0	0	0
<i>Ancylus parallelus</i> Haldeman.....	1	0	0	0	0
<i>Bythinia tentaculata</i> (Linn.).....	17	0	0	0	0
<i>Campelema integrum</i> (Say).....	3	2	0	Few	0
<i>Goniobasis livescens</i> (Menke).....	23	6	0	Many	0
<i>Lymnaea catascopium</i> Say.....	10	6	0	Many	0
<i>Lymnaea columella</i> Say.....	1	0	0	0	0
<i>Lymnaea emarginata</i> Say.....	5	3	0	Many	0
<i>Lymnaea haldermani</i> Binney.....	10	0	0	0	0
<i>Lymnaea palustris</i> (O. F. Müller).....	10	6	Few	Many	0
<i>Lymnaea stagnalis lilliana</i> Baker.....	18	10	15	0	0
<i>Physa warreniana</i> Lea.....	13	6	8	Many	0
<i>Planorbis antrosus</i> Conrad.....	13	2	1	Many	0
<i>Planorbis campanulatus</i> Say.....	25	6	6	Many	0
<i>Planorbis hirsutus</i> Gould.....	10	0	0	0	0
<i>Planorbis parvus</i> Say.....	3	0	0	0	0
<i>Planorbis trivolvis</i> Say.....	9	3	8	0	0
<i>Valvata tricarinata</i> (Say).....	35	0	0	0	0
<i>Vivipera conlectoides</i> Binney.....	3	0	0	0	0

DETAILED RESULTS OF THE INVESTIGATION

The following notes give in detail the results of the examination of the internal parasites found in (1) the fish, (2) the birds, reptiles and frogs, and (3) the mollusks mentioned in these tables.

Parasites of Fishes. *Abramis chrysoleucas* (Mitchill): Golden Shiner. Two fish were examined, in one of which no parasites were found. In the intestines of the other (No. 1219) were taken many *Acanthocephala* (Vial 31) belonging to the genus *Pomphorhynchus*. The worms were about 8 mm. long and were light brown or orange in color. But one species of this genus has been described from American fishes; two species are known in Europe which infect several species of fresh-water fishes. No Nematodes, Cestodes or Trematodes were taken.

Ambloplites rupestris (Raf.): Rock Bass. All of the four individuals examined (No. 1205f) were relatively little infected with internal parasites. A single Trematode belonging to the species *Crepidastomum cornutum* (Osborn) was found in the stomach of one of them. This worm has been taken before in the rock bass and several other species of common fresh-water fish in Canada and the eastern United States, and is undoubtedly a widely distributed parasite. Crayfish and may-fly nymphs (*Hexagenia*) are believed to be its intermediate hosts and numbers of both these animals were found in the stomachs of the rock bass examined (Nos. 1201, 1202, 1232). The same species of Trematode was also taken, and in large numbers, in the small-mouthed black bass from Oneida Lake.

Two of the rock bass examined contained Nematodes, belonging to two species. In one of them, three slender worms measuring each about 30 mm. in length were taken from the hinder portion of the rectum. These worms possess the oral armature which characterizes the genus *Camallanus* and are to be referred to the species *C. oxycephalus* (Ward and Magath). They were all females and the uterus contained young worms. The blood of this species is bright red and surges regularly between the two ends of the body, the blood-wave passing from the anterior to the posterior end and back again about six times in a minute.

The intestines of another fish contained five specimens of another species of Nematode, the largest of which was about 20 mm. long and the smallest about half that length. They belong to the family Cucullanidae and are to be referred to the genus *Dactinoides*. A species of this genus has been described from the perch and the wall-eyed pike in Lake St. Clair and also has been found in the perch in Oneida Lake.

The intestine of one of the rock bass examined contained nine Acanthocephala (Vial 79). The worms ranged from 6 to 12 mm. in length and belong to the genus *Echinorhynchus*, a genus containing many species parasitic in fresh-water fish.

No Cestodes were taken in the rock bass examined.

Ameiurus natalis (Le Sueur): Yellow Bullhead. Three fish (No. 1240, *1247A) were examined and but few parasitic worms were found, although all the fish were infected. In the intestines of one bullhead two Cestodes belonging to the genus *Corallobothrium* were obtained, and in the livers of two of them numerous cysts of an undetermined species of Cestode. In the intestines of two also were found a few small Nematodes about 5 mm. long belonging to the genus *Cucullanus*, while in the intestines of two fish two Acanthocephala (Vial No. 15) of the genus *Echinorhynchus* were taken. No Trematodes were present.

Ameiurus nebulosus (Le Sueur): Common Bullhead. Six fish (Nos. 1205b, 1213, 1217) were examined, all of which were infected with parasitic worms, two of them heavily. Two of the fish contained Nematodes, three contained Acanthocephala, four contained Cestodes and three contained Trematodes.

Six specimens of a single species of Nematode were taken from two bullheads. They were small slender worms about 5 mm. in length which belong to the genus *Spinitectus*. Worms belonging to this genus have also been taken from the perch, the carp and the common sunfish in Oneida Lake. But one species has been described as yet in America.

The Cestodes from the bullhead belong to two species. From the middle of the intestines of one fish many small worms belonging to the genus *Corallobothrium* were obtained, being probably the same species as that taken from the yellow bullhead. But one record

* Determination doubtful.

has heretofore been made in this country of this genus, and that was in Wisconsin where it also occurred in the common bullhead. In the liver of three fish were found numerous encysted plerocercoids belonging to some species of tapeworm of the genus *Proteocephalus*.

Two species of minute Trematodes were taken in the bullhead. In the stomach of three fish many individuals about half a millimeter in length were found that belong to an undescribed genus allied to *Plagiorchus*. In the intestine of one fish also were obtained many slender Trematodes about one millimeter in length, compressed and mounted, belonging to an undescribed genus allied to *Allocreadium*.

Three of the six bullheads examined contained a few Acanthocephala (Vial 15) belonging to the genus *Echinorhynchus*.

Anguilla rostrata (Le Sueur): Eel. Two eels (Nos. 1216e, 1251) were examined, and also the viscera from about forty others which were obtained from a fish dealer in Brewerton. They were found to be extensively infected with parasitic worms — Cestodes, Trematodes, Nematodes and Acanthocephala being all represented. Half of the viscera contained Cestodes belonging to two different species. The most numerous species was a tapeworm belonging to the genus *Proteocephalus*, and probably to the species *P. macrocephalus* (Creplin), the length of which was about 200 mm. In most cases but one or two worms were taken from a single intestine, but in two cases the intestine contained a large number of the worms. The other Cestode was also a species of the genus *Proteocephalus*, but much smaller than the one just mentioned. It is a slender worm, measuring from 10 to 15 mm. in length, ten individuals of which were taken from the intestine of a single eel. This genus of tapeworm contains many species common in fresh-water fishes.

Two species of Trematode were taken. In the stomachs of about three-fourths of the fish examined from one to three large distomes belonging to the genus *Azygia* were found. One fish harbored fourteen in its stomach. The worms measured from 18 to 25 mm. in length, compressed and preserved. Species of this genus are common in fresh-water fish and have been taken also in the chain pickerel and the wall-eyed pike in Oneida Lake. Another species of Trematode, belonging to the genus *Crepidastomum*, was found in the intestine of a single eel, nine individuals being taken. The length of the worms was 2 mm., preserved.

But few Nematodes were taken, and these were all of one species. This was a slender worm about 10 mm. in length belonging to the genus *Ascaris*, which was found in small numbers in the intestines of a few eels. The male of this species has two pairs of postanal papillae.

The Acanthocephala were better represented. A single species belonging to the genus *Acanthocephalus* and measuring from 5 to 10 mm. in length was obtained in several intestines.

Cyprinus carpio (Linn.): Carp. Three fish (Nos. 1205c, 1216g) were examined, but one of which was found to be infected with internal parasites. In this fish four Nematodes belonging to the genus *Spinitectus* were taken. Cestodes, Trematodes and Acanthocephala were not found.

Esox reticulatus (Le Sueur): Chain Pickerel. Four fish (No. 1233b) were examined and but few parasitic worms were found. One fish was entirely free from them. In two fish many small Cestodes belonging to the family Proteocephalidae were found in the intestine and in one fish in the rectum, the worms being present in small numbers and all belonging to the same species.

In the stomach of each of two fish was found a single Trematode, both belonging to the genus *Azygia* but to two different species. One of these is a long slender worm with parallel sides and 20 mm. long by 1.25 mm. wide, compressed and preserved; the other is more or less lenticular in shape and 4 mm. long by 8 mm. wide, also compressed and preserved.

In the intestine of one fish a small number of two species of small Acanthocephala (Vial 99) were found. One of these species belongs to the genus *Neoechinorhynchus* and is about 5 mm. in length; the other species belongs to the genus *Acanthocephalus* and has a length of about 6 mm.

No Nematodes were taken in the chain pickerel.

Eupomotis gibbosus (Linn.): Common Sunfish. Five sunfish (Nos. 1233d, 1247c) were examined. One of these fish was infected with cysts of the Trematode *Clinostomum marginatum* (Rudolphi), which was also found in the perch in Oneida Lake, two cysts occurring on the gills and seven at the base of the tail. In the stomach of one fish were found several slender Nematodes about 12 mm. in length belonging to the genus *Spinitectus*. Worms belonging to this genus were also found in the common bullhead, the carp and the perch in Oneida Lake. In the livers of three sunfish were found a small number of large cysts containing immature Cestodes of undetermined affinities. No Acanthocephala were taken.

Lepomis incisor (Cuv. and Val.): Bluegill. Two fish (No. 1205) were examined and the only parasites taken were encysted Trematodes belonging to the genus *Hemistomum*, which were found in the livers of their hosts. When taken from their cysts and extended the worms measured about 1.5 mm. in length. The livers of the fish were quite filled with them. The bluegill is the intermediate host of these worms, the adult host being some species of gull or other fish-eating bird.

Micropterus salmoides (Lacépède): Large-mouthed Black Bass. One fish (No. 1247G) was examined and only Acanthocephala and Trematodes were discovered. Belonging to the first group were a small number of worms of the genus *Neoechinorhynchus* (Vial 120), about 5 mm. in length, which were taken in the intestine. Belonging

to the second were a large number of minute distomes of the species *Caecicola parvulus* (Marshall and Gilbert), which were found in the pyloric caeca and the duodenum and which measured about half a millimeter in length. This distome has also been obtained in the same fish in Wisconsin.

Micropterus dolomieu (Lacépède): Small-mouthed Black Bass. Four fish (Nos. 1227a, 1228, 1233h, 1268a) were examined which were found to be rather heavily infected with Trematodes, Cestodes and Acanthocephala. No Nematodes were found.

One species of Trematode was taken. The duodenum and pyloric caeca of all the fish were thickly infected with a minute distome belonging to the species *Crepidastomum cornutum* (Osborn), the length of which, compressed and mounted, averaged one millimeter. This worm was also found in the rock bass in Oneida Lake.

One species of Cestode was found. The liver and the fatty tissue surrounding the pyloric caeca of all the bass examined contained a large number of large cysts of a proteocephaloid tapeworm. The worm taken from its cyst and extended measured about 8 mm.

Two species of Acanthocephala were taken from the intestines of three of the bass examined. One of these belongs to the genus *Neoechinorhynchus* (Vials 72, 75, 182, 183), from one to a dozen worms being found in each fish. Associated with these were also a few worms belonging to the genus *Echinorhynchus* (Vials 73, 75, 77, 182, 183).

Erimyzon sucetta oblongus (Mitchill): Chub Sucker. One fish was examined (No. 1263) and the only internal parasites found were a single Acanthocephalan belonging to the genus *Echinorhynchus* and a single Cestode belonging to an undetermined genus.

Perca flavescens (Mitchill): Perch. Eight fish were examined and were not found to be badly infested with parasites. Five of them contained Trematodes and four contained Nematodes. No Cestodes or Acanthocephala were taken.

Two species of Trematodes were found. One of these is *Clinostomum marginatum* (Rudophi), which was taken from two perch (No. 1225), encysted just beneath the skin on the pectoral fins and at the base of the tail. These worms were immature individuals, the fish being their intermediate host. The adult worms live in the oesophagus and pharynx of herons and other fish-eating birds which become infected with the parasites by eating the fish. The presence of the conspicuous cysts or "grubs," as they are called by fishermen, usually renders the fish unsalable in the markets and grubby fish are thrown away by amateur fishermen, notwithstanding the fact that they are entirely harmless and could not injure anyone eating them with the flesh of the fish. *Clinostomum* is thus of economic significance, especially throughout the summer and early fall when it is most numerous.

The second species of Trematode was found in the stomach of three of the perch examined, but one or two being found in each fish. It is a worm about 8 mm. long when compressed and mounted, which belongs to an undescribed genus allied to *Azygia*.

Of the Nematodes taken in the perch one fish (No. 1249) contained in its stomach several worms of the same species of *Spinitectus* found in the bullhead. Three fish contained each a few individuals in its intestine of a species belonging to the genus *Dacnitoides*. The worms averaged 5 mm. in length.

Pomoxis sparoides (Lacépède): Calico Bass. Two fish were examined, in the intestine of one of which (No. 1220) was found a single Acanthocephalan (Vial 32) belonging to the genus *Pomphorhynchus* and probably of the same species as those found in the golden shiner. No other parasites were taken.

Stizostedion vitreum (Mitchill): Wall-eyed Pike. Nine fish were examined, in one of which no parasites were found. Of the other eight, seven contained Acanthocephala (Vials 5, 84), seven contained Cestodes, and one contained a single Trematode. No Nematodes were taken.

The Trematode was a distome which was obtained from the stomach of its host. It measures, compressed and preserved, 10 mm. long and 1.5 mm. wide and belongs to the genus *Azygia*. Worms of this genus have been described from the stomach of many fresh-water fish in America and Europe but have not been found heretofore in the wall-eyed pike.

Three species of Cestodes were taken from the pike. In five of the fish numerous small worms belonging to the genus *Bothrioccephalus* were found, the largest of which was 25 mm. long. The location of these worms was the duodenum and pyloric caeca, from the mouth of which they were sometimes found projecting. In the intestines of two fish a few immature worms belonging to the family Proteocephalidae were found, and in two others a few immature Cestodes of unknown affinities.

One species of Acanthocephala was found. The intestine of seven of the pike (Nos. 1233a, 1247e, 1252) contained many worms belonging to the genus *Neoechinorhynchus*, in one fish the worms occurring the entire length of the intestine. This primitive genus has also been found in the chain pickerel, the large-mouth black bass, the small-mouth black bass, and the eel in Oneida Lake, and it is a matter of interest that it is so common in these collections.

Parasites of Birds, Reptiles and Frogs. *Ardea herodias* (Linn.): Great Blue Heron. Four birds were examined and two species of Trematodes and two of Cestodes were found. No Nematodes or Acanthocephala were taken.

In the mouth and upper portion of the oesophagus of all the birds Trematodes belonging to the species *Clinostomum marginatum* (Rudolphi) were obtained, the number of worms in each bird vary-

ing from thirteen to twenty-four. The length of the worms ranged from 4 to 10 mm. This Trematode also occurs in cysts under the skin of the perch and sunfish, as already set forth in this report, these fish acting as the intermediate host of the worm. The heron is its final host and harbors the mature, egg-laying worms, which it acquires by feeding on the fish. The eggs of the parasite, falling into the water with the excrement of the bird, give rise to the young worms, which make their way by some unknown means into the fish, and their life-cycle is thus completed.

The second species of Trematode taken was a minute holostome belonging to the genus *Strigea*. Numerous specimens of this worm, which measured about one millimeter in length, were found in the intestine of one of the birds examined. Another species of this genus was also taken in the herring gull on Oneida Lake.

Of the two species of Cestodes taken in the heron one was a very small worm, measuring 10 to 15 mm. in length, which was found in large numbers in the duodenum of one of the birds. It belongs to the genus *Hymenolepis*, a genus which contains many species of small tapeworms parasitic in water birds. The other species was represented by a single specimen, 120 mm. in length, taken from the intestine, and belonging to the family Tetrabothridae.

Ardea virescens (Linn.): Green Heron. Two birds were examined. *Clinostomum* and *Strigea*, both of which were found in large numbers in the great blue heron, were not found. One Cestode belonging to the same species in the family Tetrabothridae as that taken in the great blue heron was obtained in the intestine. Several Nematodes belonging to the genus *Ascaris* were taken in the intestine of one of the birds. No Trematodes or Acanthocephala were found.

Ceryle alcyon (Linn.): Kingfisher. Two birds were examined and no internal parasites were taken in either.

Larus argentatus Brünnich: Herring Gull. Two young birds were examined and the rectum and cloacal bursa of one of them was found to be infected with a holostomid Trematode of the genus *Strigea*. The length of the worms varied from 2 to 8 mm. and about twenty were present. Another species of the same genus was also taken from the intestine of the great blue heron. The larvae of these worms are known as tetracotyle forms and have been found in the liver of *Lymnaea catascopium* Say and *L. emarginata* Say in Oneida Lake. It is not likely that the gulls are infected with these parasites by eating the snails but rather that some small snail-eating fish upon which the gulls feed acts as the intermediate host of the worm. No Cestodes, Nematodes or Acanthocephala were found in the herring gulls examined.

Chrysemys marginata (Agassiz): Painted Turtle. Four large turtles were examined, in only one of which parasitic worms were found. The stomach of one turtle contained a tangled mass of Nematode worms averaging 25 mm. in length, belonging to the genus

Strongylus. Worms of this genus have not been found in any other animals in this collection.

Natrix sipedon (Linn.): Water Snake. Nine large snakes were examined and seven were found to be badly infested with parasitic worms. Two snakes contained no parasites.

Six of the snakes contained large Nematodes in their stomachs belonging to the genus *Ascaris*, the length of which was from 50 to 150 mm. In five of these snakes from two to thirty worms were present in each one and the sixth snake contained an extraordinary number of them, its stomach being packed full. Some of the worms had pierced the stomach wall, the head and tail of the worm projecting into the stomach while its middle portion was imbedded in the tissue of the wall.

From the stomach of one of the snakes which contained none of the Nematodes just mentioned were obtained five Acanthocephala, (Vial No. 136) belonging to the genus *Pomphorhynchus*. The length of the worms was about 5 mm. Worms of this genus were also taken in the golden shiner and the calico bass in Oneida Lake.

Two species of Trematodes were obtained. One of these species was taken in the anterior portion of the oesophagus of two of the snakes, four being taken from one and eight from the other. They are elongate worms, measuring about 12 mm. long and 1.5 mm. broad, when compressed and preserved, and belong to an undescribed genus of the subfamily Reniferinae. One of these same snakes also harbored in its stomach a single distome, 5 mm. long and .75 mm. wide when preserved, belonging to an undescribed genus of the family Azygidae.

Two species of Cestodes were found in three snakes: in two snakes they occurred in the intestine and in another snake in the rectum.

Rana pipiens (Scherber): Leopard Frog. Twelve frogs were examined, in one of which, a half-grown animal, no internal parasites were found. All of the others but one contained Trematodes in the lungs, belonging to the genera *Pneumonoccs* and *Tneumobitics*, the number of worms in the lungs of any one frog varying from one to nineteen, the average being eight. Six frogs contained Trematodes in the urinary bladder belonging to the genus *Gorgoderina*, the number in a single frog being one or two, with the exception of one frog in which eight were found.

Seven frogs contained Nematodes. In one frog the worms were in the body cavity; in four frogs they were in the lungs; in one frog in the intestine and in one frog in the rectum. These worms were of three different species, all belonging to the family Ascaridae.

No Cestodes or Acanthocephala were taken in the frogs examined.

Parasites of Mollusks. Six species of Pelecypoda, including 14 individuals were examined, and no internal parasites were found in any of them. In *Lampsilis lutcola* (Lamarck) from one to four Hydrachnids, belonging to the species *Unionicola aculeata* (Koenike) were found between the gills of each individual examined.

Nineteen species of Gastropoda, including 221 individuals, were examined and of these the following species yielded no internal parasites: *Amnicola limosa* (Say), 20 individuals examined; *Ancylus parallelus* Haldeman, 1 individual examined; *Bythinia tentaculata* (Linn.), 17 individuals examined; *Lymnaea columella* Say, 1 individual examined; *Lymnaea haldermani* Binney, 10 individuals examined; *Planorbis hirsutus* Gould, 10 individuals examined; *Planorbis parvus* Say, 3 individuals examined; *Valvata tricarinata* Say, 35 individuals examined; *Vivipera contectoides* Binney, 3 individuals examined.

The following Gastropoda contained parasites:

Campomela integrum (Say). Three snails were examined, of which the livers of two were infected with a tailless Trematode larva belonging to the genus *Agamodistomum*. The worm is fusiform in shape and about 1.25 mm. long by 5 mm. wide. The worms were not numerous.

Goniobasis livescens (Menke). Twenty-three snails were examined, the livers of six of which were infested with a small number of sporocysts and cystocercous cercariae of large size and similar to *Cercaria anchoroides* Ward. The sporocysts are rather regularly fusiform in shape and from one to two millimeters in length, and contained three or four cercariae each. The free cercariae are about 3 mm. in length, of which the body measures 1 mm. The tail is flat with the anterior half covered with large papillae, and terminates in a pair of flat blades, each .5 mm. in length, which project at right angles. Similar cercariae have been taken previously in four localities in the eastern and central part of this country, in three of which places it was found free-swimming, moving about actively with the tail in advance. It was not found free-swimming in Oneida Lake and when taken from the livers of the snails appeared very sluggish and without definite swimming motions.

Lymnaea catascopium Say. Ten snails were examined, the livers of six of which were infested with two species of larval Trematodes. One of these species is a xiphidiocercaria about .2 mm. long, with a slender tail considerably shorter than the body. The other species is a holostomid belonging to the larval genus *Tetracotyle* and similar to that taken from *Lymnaea emarginata*.

Lymnaea emarginata Say. Five snails were examined, the livers of three of which were heavily infected with holostomids of the larval genus *Tetracotyle*, similar to those found in *Lymnaea catascopium*. These larvae belong to some species of the genus *Strigea* which parasitize fish-eating water birds. Adult worms of this genus have been taken in the herring gull and the great blue heron on Oneida Lake. These interesting larvae are pear-shaped and measure .26 mm. by .19 mm., the oral sucker and sucker-like depressions being at the larger end. Two growth sizes were observed, the smaller being the one just described. The larger one has a large circular forward por-

tion and a tail-like hinder part and measures .49 mm. in length and .41 mm. in width, in the widest place.

Lymnaea palustris (O. F. Müller). Ten snails were examined, of which the livers of six were infested with minute gymnocephalous cercariae. The snails which were not infested were all of small size. In all of these snails one or two oligochaetous Annelids belonging to the genus *Chaetogaster* were found in the mantle cavity.

Lymnaea stagnalis lilliana Baker. Eighteen snails were examined, of which ten contained each one or two Annelids of the genus *Chaetogaster*. No other worms were found.

Physa warreniana Lea. Thirteen snails were examined, the livers of five of which contained numerous rediae and gymnocephalous cercariae. The rediae have a length of 1 mm. The cercariae are about .5 mm. long and have a long slender tail which is about twice the length of the body. Six of the snails had each one or two Annelids of the genus *Chaetogaster* in the mantle cavity.

Planorbis antrosus Conrad. Thirteen snails were examined, the livers of two of which were heavily infected with sporocysts and xiphidiocercariae. One snail had a *Chaetogaster* in the mantle cavity.

Planorbis companulatus Say. Twenty-five snails were examined, of which the livers of six contained numerous sporocysts of undetermined affinities. One or two *Chaetogasters* were taken from each of three snails.

Planorbis trivolvis Say. Nine snails were examined and no internal parasites found. Three snails contained *Chaetogasters* in the mantle cavity.

ACANTHOCEPHALA FROM THE FISHES OF ONEIDA LAKE, NEW YORK *

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INTRODUCTION

Through the courtesy of Dr. Charles C. Adams, the writer has been granted the opportunity of examining a collection of Acanthocephala from Oneida Lake, New York. The specimens were collected by Mr. Frank C. Baker and Dr. Henry S. Pratt, between August 23 and September 15, 1917, in the course of investigations of the parasitic worms of Oneida Lake conducted under the direction of The New York State College of Forestry, with the cooperation of the United States Bureau of Fisheries. While only three species of Acanthocephala were encountered during the investigation, the meagerness of biological data concerning these forms makes it appear desirable to present the results in this paper.

The acanthocephalan fauna has been intensively studied for but few localities in North America. Linton made noteworthy contributions ('89, '91, '01, '05) to the knowledge concerning the marine hosts in the vicinity of Woods Hole, Mass., and of Beaufort, N. C. In addition he published the first results ('93) of the intensive study of these parasites from a fresh-water habitat for this continent in his work on the "Fish Entozoa from Yellowstone National Park." More recently the present writer has published the results of extensive investigations upon the occurrence of Acanthocephala in hosts from the Illinois River (Van Cleave, '19) and from Douglas Lake, Michigan ('19a). Most of the remaining records of Acanthocephala on this continent are incidental to studies in taxonomy and morphology, and therefore give only fragmentary bits of evidence of the biological aspects and the distribution of the various species.

Because of the intricacy of the relationship existing between

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parasites and their hosts, it becomes a matter of considerable interest to compare the lists of species of parasites found in similar habitats. Only after this has been done carefully for a considerable number of regions will it be possible to offer any very reliable data concerning the distribution of individual species.

HABITS OF ACANTHOCEPHALA

The Acanthocephala constitute a group of parasitic worms the individuals of which have become so thoroughly adapted to the parasitic life that they spend their entire existence within the bodies of other animals. They render no known service to the organisms which they parasitize, but on the contrary inflict damage by appropriating food materials from the host for their growth and development, and by doing violence to the tissues of the host through the action of the spine-covered proboscis or hold-fast organ. Beyond the simple observation that animals heavily infested with these parasites are usually much thinner than those free from infestation, nothing has been done to determine the actual effect of Acanthocephala upon their hosts. As has been pointed out in an earlier paper (Van Cleave, '19, p. 227), it is probable that because of lacerations and punctures of the wall of the intestine, due to the action of the proboscis, these parasites facilitate the entrance of disease-producing organisms into the body of a host.

THE LIFE CYCLE

Relatively little is known concerning the development of North American species of Acanthocephala, but they belong for the most part to the genera that include other species for which the life cycle has been determined wholly or in part. In every species that has been studied two or more hosts have been found essential for the completion of the life cycle. Of these the animal that shelters the sexually mature parasite is called the *definitive host*, while the first organism that harbors the parasite during its larval existence is termed the *primary host*. The definitive host of an acanthocephalan is invariably a vertebrate, while the primary host is usually a crustacean, though insects and insect larvae frequently serve some species in that capacity. Intermediate hosts, though apparently not essential to the development of these worms, are interposed between the primary and definitive hosts in some species. So far as known the acanthocephalans enter the final or definitive host only through the introduction of organisms sheltering the larval worms into the digestive tract of the definitive host. Since these parasites are thus acquired in feeding, their study becomes a matter of considerable importance if we are to understand the full significance of the relationship between hosts of economic importance and their food supply.

The significance of intermediate hosts in the life cycle of the Acanthocephala is apparently not great, for, at least in some instances, they do not seem to be essential links in the chain of development.

Even in species for which intermediate hosts have been discovered it seems fairly clearly demonstrated that infestation of the definitive host may occur directly through the primary host. Adaptation to an intermediate host seems in these forms to be more strictly a facultative adaption to prevent extermination of the individual parasite. If a primary host carried very young larvae these insufficiently developed worms would not be able to establish themselves as intestinal parasites even if the primary host were eaten by a vertebrate which is suitable as a definitive host. Such insufficiently developed larvae, freed in the digestive tract of the vertebrate, must either pass out of the body because of their inability to maintain their position or must penetrate the wall of the digestive tract of the new host. The early appearance of the proboscis hooks would make this latter possibility entirely plausible. Once outside the lumen of the digestive tract the larvae find conditions where they might become encysted and continue the larval development temporarily interrupted by the destruction of the sheltering primary host. It accordingly happens occasionally that a fish serves in the capacities of both definitive and intermediate hosts to the same species of acanthocephalan.

In some instances invertebrates have been reported as intermediate hosts of some species of *Acanthocephala*. If a primary host bearing larval *Acanthocephala* were eaten by an invertebrate, the larvae of any stage which escaped destruction might be able to continue their interrupted course of development in their new environment, having acquired thereby a new, though non-essential, link in their developmental cycle.

FACTORS IN DISTRIBUTION

Numerous factors influence the geographical distribution of parasitic organisms having an alternation of hosts. I have previously called attention ('19, p. 229) to the absurdity of assuming that the distribution of such parasites is coextensive with the range of their hosts. Individuals of a given host species may be heavily infested with a given parasite in one part of their range, and entirely free from the same species in other localities. Correlated with this is the fact that a given endoparasitic species may be the dominant parasite of entirely different host species in different regions within its range. Factors controlling these changes are but little understood. Dissimilarity in the food habits of the hosts in various parts of their range might result in the hosts of one locality being heavily infested with parasites while those of another locality would be relatively, if not entirely, free from the same parasites.

It is known that the distribution of some parasitic worms is broader than that of any single species that serves it as host during its larval period. Thus it is possible that in part of its range a species of endoparasite and one of its normal final hosts might occur side by side in the same locality without having their usual intimate interrelationship. Such a condition would be possible if the parasite

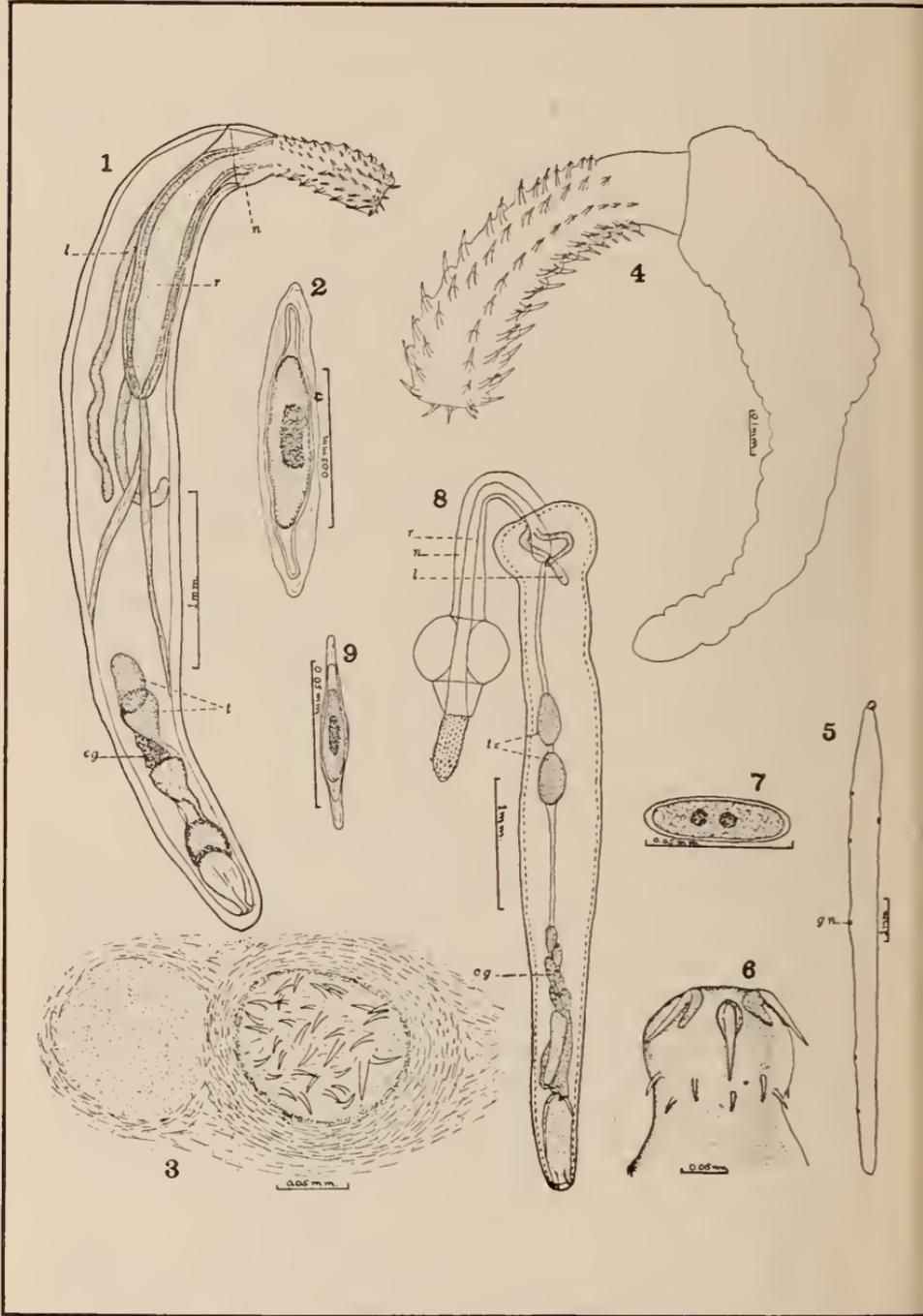


PLATE 2. ONEIDA LAKE ACANTHOCEPHALA.

EXPLANATION OF PLATE 2

All figures were drawn from stained permanent mounts in damar, by the aid of a camera lucida.

Symbols: *c g*, cement gland; *g n*, giant nucleus of subcuticula; *l*, lemniscus; *n*, neck; *r*, receptacle of proboscis; *t*, testis.

Echinorhynchus thecatus (Linton)

Fig. 1. A young male, showing general arrangement of internal organs.

Fig. 2. Hard-shelled embryo from body cavity of a gravid female. Three protective membranes of varying thickness surround the group of cells that have been derived from the fertilized egg cell by cleavage. Embryos are discharged into the water at this stage.

Fig. 3. Larval cyst from peritoneum of yellow perch (from Wisconsin). Fishes may serve this parasite as intermediate hosts. If the amphipod which swallows the hard shelled embryo is unmolested the larva attains its full larval development in the primary host. In case a fish devours a primary host containing slightly developed larvae it seems probable that the larvae become encysted in the tissues of the fish, which thereby becomes an intermediate host, sheltering the larvae until they reach the infecting stage.

Fig. 4. Juvenile form from intestine of fish. This individual is in the same stage of development and is of the same size as the encysted larvae from primary or intermediate hosts.

Neoechinorhynchus cylindratus (Van Cleave)

Fig. 5. Outline drawing showing general body form and the distinctive swellings that indicate the location of the giant nuclei of the body wall.

Fig. 6. Proboscis, showing typical spheroidal form and the number and arrangement of hooks.

Fig. 7. Embryo from body cavity of gravid female.

Pomphorhynchus bulbocolli Linkins

Fig. 8. Young male, showing general arrangement of organs. This species is readily distinguishable by means of the very long neck, which bears an inflated enlargement just behind its attachment to the proboscis.

Fig. 9. Embryo from body cavity of gravid female.

has acquired entirely new hosts through its larvae becoming established in unusual primary hosts that do not enter into the food supply of the host of the mature worm. If the parasite were carried by the migration of its usual normal definitive host into a locality where the larvae failed to find their accustomed primary hosts, the larvae might become adapted to entirely new species of animals in that capacity. If these new species of primary hosts do not enter into the food supply of the unusual definitive host the latter would thereby become freed of the parasite in the newly invaded territory, and the parasite might at the same time acquire as definitive hosts other species which feed upon the newly gained primary host.

DISCUSSION OF SPECIES

But three species of Acanthocephala were encountered in the collections from Oneida Lake, yet in the case of each of these distinctly new biological data have been added. New host species are added to those previously recorded for each of the three species: *Echinorhynchus thecatus* Linton, *Neoechinorhynchus cylindratus* (Van C.), and *Pomphorhynchus bulbocolli* Linkins (in Van Cleave, '19). For the last mentioned species an unusual host, due probably to an accidental infestation, is also recorded.

Echinorhynchus thecatus Linton, 1891.

Length: females 11 to 26 mm.; males 7 to 12 mm. Proboscis usually about 1 mm. long. Neck about one-fourth the length of the proboscis. Proboscis receptacle long and slender, about 1.5 times the length of proboscis. Central nervous system near center of receptacle. Proboscis hooks arranged in 12 longitudinal rows of 12 or 13 hooks each, adjacent rows alternating. Each hook ensheathed in a cuticular collar. Embryos within body cavity of gravid female 80 to 110 μ long by 24 to 30 μ wide.

This species was by far the most abundantly represented of the acanthocephalans in the fishes of Oneida Lake, having been taken from the digestive tract of six of the nine species which were found parasitized with these worms; for three of these hosts there is no previously published record of the occurrence of this parasite. These new hosts for *E. thecatus* are: the eel (*Anguilla rostrata*), pike perch (*Stizostedion vitreum*), and the chain pickerel (*Esox reticulatus*). The obvious lack of specificity of hosts of this species renders it capable of existence in numerous species of fresh-water and migratory fishes. Many of the records of its occurrence are doubtless due to accidental introduction into unusual hosts where it maintains itself for a time without being able to reach sexual maturity.

In the report on the Acanthocephala from fishes of Douglas Lake, Michigan, I called attention ('19a, p. 6) to the fact that the small-mouthed black bass (*Micropterus dolomieu*) is preeminently the definitive host of *E. thecatus* in that region. The same intimate

relationship between this particular host and its parasite is just as clearly demonstrated in the records from Oneida Lake. Most of the fishes of this species examined were infested with *E. thecatus*. Though the infestation was quite general the number of individual parasites removed from the digestive tract of a single host was much smaller than has been observed in other localities. From Oneida Lake fifty-four specimens is the greatest number taken from a single specimen of *M. dolomieu*, while I have frequently taken more than two hundred specimens from a single small-mouthed bass from Lake Pepin, Minnesota.

One of the most interesting records of the occurrence of *E. thecatus* is that of its appearance in relatively large numbers in the digestive tract of *Anguilla rostrata*. This is the first record of the occurrence of this species in the American eel.* Conditions for infestation must have been especially favorable, because each of the four specimens of eel that carried an acanthocephalan infestation yielded *E. thecatus* in numbers ranging from nine to forty-nine. The extent of the infestation and the number of parasites from each host is fully as great as that for small-mouthed black bass of the same locality, though the latter has been generally recognized as the normal host of *E. thecatus*. For this reason it does not seem probable that the infestation of *Anguilla rostrata* in Oneida Lake could be considered as accidental.

The writer has discovered *E. thecatus* in the intestine of the pike-perch from other localities, but this is the first published record of its occurrence in this host.

The number of specimens of each fish examined was in each instance too small to justify any statements regarding percentages of infestation. Since, however, the available data are of interest in showing the relative extent of infestation, the results of the examinations for this and the following species are arranged in tabular form.

TABLE I.

Analysis of the occurrence of *E. thecatus* in Oneida Lake hosts

HOST SPECIES	Number infested with Acanthocephala	Vial numbers	Number infested with <i>E. thecatus</i>	Specimens in individual hosts
<i>Anguilla rostrata</i>	4	36, 54, 56, 125	4	9-49
<i>Micropterus dolomieu</i>	7	73, 75, 77, 182, 183	5	1-54
<i>Ameturus nebulosus</i> **	3	15	1	2
<i>Stizostedion vitreum</i>	4	84	1	3
<i>Ambloplites rupestris</i>	1	79	1	7
<i>Esox reticulatus</i>	1	99	1	2

*Van Cleave, 1920a, published after this report went to press.

** Determination doubtful, as careful distinction was not always made between *A. natalis* and *A. nebulosus*.

In a recent paper (Van Cleave, '20) the writer has outlined the trend of development of this species. Larvae of *E. thecatus* have been found undergoing their development in the amphipod crustacean *Hyalella knickerbockeri*. Evidence already cited in this paper seems to prove that infestation of the definitive host may occur directly through this primary host. On the other hand, encysted larvae of this species have been taken from the mesenteries of *Perca flavescens*, *Micropterus salmoides*, *Ambloplites rupestris*, and *Percina caprodes*, thus demonstrating that these species may serve as intermediate hosts of *E. thecatus*. Since *Hyalella* is included in the fauna of Oneida Lake, it is entirely probable that it serves as primary host of *E. thecatus* though no actual demonstration of this fact is at hand.

Neoechinorhynchus cylindricus (Van Cleave, 1913).

Body large, almost cylindrical, except in young forms, in which the posterior extremity is gradually narrowed. Females 10 to 15 mm. long, with a maximum diameter of 0.7 mm. Males 4.5 to 8.5 mm. long and 0.5 to 0.7 in diameter. Proboscis slightly broader than long (0.172 by 0.150 mm.). Proboscis hooks arranged in three circles of six hooks each. Embryos within gravid female 49 to 51 μ long by 15 to 21 μ broad.

Neoechinorhynchus cylindricus is the only representative of the family Neoechinorhynchidae encountered in the collections from Oneida Lake. Five of the nine species of fish carrying Acanthocephala harbored this species. As hosts for this species, *Esox reticulatus* and *Stizostedion vitreum* are made a matter of record for the first time. The writer has encountered *N. cylindricus* in the pike-perch from the upper Mississippi River, and from Lake Erie at Sandusky, Ohio, but there is no previously published record of the occurrence in this host.

TABLE II.

Analysis of the occurrence of *N. cylindricus* in Oneida Lake hosts

HOST SPECIES	Number infested with Acanthocephala	Vial numbers	Number infested with <i>N. cylindricus</i>	Specimens in individual hosts
<i>Stizostedion vitreum</i>	4	5, 84	4	1-32
<i>Micropterus dolomieu</i>	7	72, 74, 75, 182, 183	5	1-10
<i>Micropterus salmoides</i>	1	120	1	3
<i>Esox reticulatus</i>	1	99	1	3
<i>Anguilla rostrata</i>	4	125	1	6

From the above table it is obvious that *Stizostedion vitreum* is the most generally utilized host of *N. cylindricus* in Oneida Lake. The six specimens taken from one individual of *A. rostrata* were all

immature, though gravid females of this parasite have been taken from the eel at Woods Hole, Mass., (Van Cleave, '13, p. 188), thus indicating that the eel is not an accidental host but serves as a normal definitive host in which *N. cylindricus* may complete its developmental cycle.

The large-mouthed black bass (*Micropterus salmoides*) is the host from which the type material of this species was taken in Pelican Lake, Minn., (Van Cleave, '13, p. 187), yet the single specimen of this species found infested in the Oneida Lake investigations carried an extremely light infestation by this parasite. Thus it becomes evident that a parasite may in different parts of its geographical range infest the same host species in widely varying degrees. Not only is there no necessary correlation between the distribution of a parasite and that of its type host, but even when the range of the two are coextensive the parasite may be the dominant parasitic guest of entirely different hosts in different localities.

Nothing is known regarding the development of *N. cylindricus*. Villot ('84) worked upon the development of a European representative (*N. rutili*) of the same genus, and found that the larval development occurs in the aquatic larvae of *Sialis*. It is entirely probable that some aquatic insect larva shelters the developing young of *N. cylindricus*.

Pomphorhynchus bulbocolli Linkins, 1919.

Body elongate, tapering toward posterior end. Neck prominent, measuring 2.6 to 4 mm. in length; diameter 0.15 to 0.4 mm. in posterior region and 0.8 to 1.5 mm. in region of spherical enlargement. Proboscis cylindrical, 0.5 to 0.6 mm. long by 0.7 to 0.2 mm. in diameter, armed with 24 to 28 circular rows of hooks. Basal circle with 12 hooks, remaining circles with 6 each. Embryos within body cavity of gravid female 53 to 83 μ long by 8 to 13 μ broad.

In so far as known, fishes are the only normal hosts of the adult parasite belonging to the genus *Pomphorhynchus*. Many hosts throughout the United States have been found to harbor this species though there have been few published records of its occurrence, owing to the fact that many of the early workers recorded the finding of the European species in this country without giving descriptions sufficient to verify or disprove their claims. It seems probable that all of the early records of *Echinorhynchus proteus* (= *P. laevis*) from North America should be referred to the distinctively American species *P. bulbocolli*. Only three species of fishes from Oneida Lake were found to harbor *P. bulbocolli*, but in addition a very unusual instance of its occurrence in the water snake (*Natrix sipedon*) was discovered. One specimen of *N. sipedon* contained five small individuals of this species in the stomach. The presence in this host was, without doubt, accidental, the worms having been taken into the stomach of the snake incidentally with one of their

normal hosts which was devoured by the snake for food. It is extremely doubtful if the parasites could have become permanently established in this strange environment. Such unusual occurrences are occasionally met with in general collecting, and are likely to lead to confusion if not correctly interpreted. The accidental appearance of an organism in the digestive tract of a given animal does not necessarily demonstrate that it has become established there as a parasite. The only true criterion for the determination of what constitutes a normal definitive host is the ability of the parasite to perfect its sexual development.

TABLE III.

Analysis of the occurrence of *P. bulbocolli* in Oneida Lake hosts

HOST SPECIES	Number infested with Acanthocephala	Vial nos.	Number infested with <i>P. bulbocolli</i>	Specimens in individual hosts
<i>Ameiurus nebulosus</i> *	3	20, 27	2	2-3
<i>Abramis crysoleucas</i>	1	31	1	11
<i>Pomoxis sparoides</i>	1	32	1	1
<i>Natrix sipedon</i>	1	136	1	5

* Determination doubtful, as careful distinction was not always made between *A. natalis* and *A. nebulosus*.

One species of fish is added to the hosts previously recorded for *P. bulbocolli* in the record of its occurrence in the intestine of the golden shiner (*Abramis crysoleucas*).

Nothing is known regarding the development of *P. bulbocolli*. In 1872 R. Leuckart described the larva of a European representative of this genus from the body of the amphipod *Gammarus pulex*. Since that time several fishes have been reported as intermediate hosts of the European species *P. laevis* (= *E. proteus*).

CONCLUSIONS

But three species of Acanthocephala have been encountered in the fishes of Oneida Lake. All of these are of broad distribution in freshwater habitats in North America. It is noteworthy that no species distinctive for the locality were discovered. This stands in rather sharp contrast with the conditions encountered in two other freshwater habitats studied intensively by me, in each of which species of apparently restricted distribution were found. From the fishes of Douglas Lake, Michigan (Van Cleave '19a), two of the four species of Acanthocephala encountered were new, and collections from the surrounding states seem to indicate that each of these is rather sharply limited in its distribution. Similarly, from the fishes of the Illinois River (Van Cleave, '19) two species of Acanthocephala distinctively local in distribution were taken. In spite of the fact that *Gracilisentis gracilisentis* and *Tanaorhamphus longirostris* were

locally abundant in *Dorosoma cepedianum* from regions about Peoria and Havana, Illinois, extensive collections from other parts of the continent have never produced them from any other localities.

Pond and lake conditions furnish by far the most favorable environment for development of excessive infestations by Acanthocephala, yet on the whole the infestations of individual hosts from Oneida Lake were relatively light.

In the region under consideration the influence of migratory fishes, such as the eels, in the dispersal of various species of Acanthocephala seems to be negligible. In some localities migratory fishes are reported to have caused a mixing of fresh-water and marine species of Acanthocephala. Many species of Acanthocephala lack definite restrictions as to specific hosts. As a consequence they are facultative parasites of many diverse kinds of fish. Thus the eels from Oneida Lake have been found to harbor the two species of Acanthocephala most abundantly represented in that local fauna. Apparently the fresh-water acanthocephalan fauna has not been enriched by the addition of species recently introduced from the ocean by migratory fishes.

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CURRENT STATION NOTES

THE INTENSIVE USE OF FOREST PARKS

In the last number of the *Bulletin* reference was made to the intensive recreational use of forests by great crowds of people from the large cities, and attention was called to the new problems arising as a result of this new situation. On the shores of Carr Pond, in the Palisades Interstate Park on the Hudson River, numerous permanent camps have been located for children, most of whom come from the crowded sections of New York City. The opportunities for bathing in this Pond are one of the chief attractions of these camps. The various camp leaders and the Park authorities, in 1919, became greatly concerned with complaints about the abundance of large leeches which disturbed the bathers. This problem became so serious and was of so much practical importance, that, through Mr. Edward F. Brown, at that time Superintendent of the Camp Department of the Park, the Commissioners sought the cooperation and assistance of the Roosevelt Wild Life Station to find a means of abating this nuisance. Dr. J. Percy Moore, of the University of Pennsylvania at Philadelphia, our leading authority on leeches in America, was called upon to assist in this matter. As he was already working on the problem of mosquito control by means of fishes, for the United States Bureau of Fisheries, a general cooperative plan was made between these three agencies, the Commissioners, the Bureau and the Station. Dr. Moore thus began his study of devising methods of controlling leeches, and secondarily, extended his studies of mosquito control. His report in this number of the *Bulletin*, is the first published investigation of this character.

At first sight it might seem that a study of leeches would have but little practical significance, until it is recalled that control of the leeches was originally a practical administrative difficulty, demanding attention, and that this led to the investigation. We are thus reminded how intensive use of these great forest parks is destined to present problems wholly new and calling for technical study. Looking to the future we anticipate many similar problems awaiting attention in large forest parks now being developed for recreational purposes.

THE SICKNESS OF WILD ANIMALS

All are familiar with the fact that when domestic animals become sick it is possible to call upon professionally trained men to assist in their care. But whose concern is it to look after wild animals when they are sick? We have not yet evolved a profession occupied solely with this responsibility. The Roosevelt Station, recognizing this need, is making an effort to supply in part the deficiency. As wild life belongs to the State and Nation, and therefore to the public, there has been very little of the personal concern for its welfare that accom-

panies private ownership. In looking forward towards constructive measures for the proper maintenance of the wild life of our forests, the time is fast approaching when adequate provision should be made for a study of its diseases.

Fishermen and anglers frequently meet with diseased fish, but at present we know so little about the habits and life histories of disease-producing organisms that we are generally unable to protect our food and game fish. With a view towards making an inventory of the worm-caused diseases of Oneida Lake fish a cooperative survey was arranged between the United States Bureau of Fisheries and the College of Forestry, and Dr. Henry S. Pratt of Haverford College, Pennsylvania, and Mr. Frank C. Baker, then of the College, made a study of the parasitic worms of this lake. The paper by Dr. H. J. Van Cleave is based upon specimens collected by Messrs. Pratt and Baker. Other reports extending these investigations are in preparation.

THE ROOSEVELT WILD LIFE MEMORIAL

As a State Memorial

The State of New York is the trustee of this wild life Memorial to Theodore Roosevelt. The New York State College of Forestry at Syracuse is a State institution supported solely by State funds, and the Roosevelt Wild Life Forest Experiment Station is a part of this institution. The Trustees are State officials. A legislative mandate instructed them as follows :

“To establish and conduct an experimental station to be known as ‘Roosevelt Wild Life Forest Experiment Station,’ in which there shall be maintained records of the results of the experiments and investigations made and research work accomplished; also a library of works, publications, papers and data having to do with wild life, together with means for practical illustration and demonstration, which library shall, at all reasonable hours, be open to the public.” [Laws of New York, chapter 536. Became a law May 10, 1919.]

As a General Memorial

While this Memorial Station was founded by New York State, its functions are not limited solely to the State. The Trustees are further authorized to cooperate with other agencies, so that the work is by no means limited to the boundaries of the State or by State funds. Provision for this has been made by the law as follows :

“To enter into any contract necessary or appropriate for carrying out any of the purposes or objects of the College, including such as shall involve cooperation with any person, corporation or association or any department of the government of the State of New York or of the United States in laboratory, experimental, investigative or research work, and the acceptance from such person, corporation, association, or department of the State or Federal government of gifts or contributions of money, expert service, labor, materials, apparatus, appliances or other property in connection therewith.” [Laws of New York, chapter 42. Became a law March 7, 1918.]

By these laws the Empire State has made provision to conduct forest wild life research upon a comprehensive basis, and on a plan as broad as that approved by Theodore Roosevelt himself.

Form of Bequest to the Roosevelt Wild Life Memorial

I hereby give and bequeath to the Roosevelt Wild Life Forest Experiment Station of The New York State College of Forestry at Syracuse, for wild life research, library, and for publication, the sum of, or the following books, lands, etc.

