AQUATIC PLANT COMMUNITIES OF REELFOOT LAKE[1]

J. HENRY DAVIS, JR.

Professor of Biology, Southwestern, Memphis, Tennessee

INTRODUCTION

Reelfoot Lake is shallow—only in a few places over ten feet deep—and it has wide seasonal fluctuations in the water level. These two conditions are of primary importance and led to the development of the abundant hydrophytic vegetation of the lake and its flood plain. In the sense of the terms employed by Welch (1935) and other limnologists, most of the lake is in reality a pond, for aquatic plants cover and nearly fill a large part of it, particularly in the northern portions near the Biological Station. There is little of the pelagic and none of the abyssal areas. Between the flood plain swamps of willows, silver maples, cypress, and other tree hydrophytes (Hazard, 1933) and the open water of basins seven or more feet deep are broad littoral zones composed of many aquatics. The zonation of these plants is dependent upon the prevailing depth of the water and the amount and character of the accumulated soils beneath them. These aquatic communities are important and convenient categories by which the whole biota of the lake may be correlated. The vegetational concepts of the lake and the recognition of relationships between the plant and animal life are needed to facilitate an adequate study of the whole complex of life in and about the lake. To the first of these propositions this preliminary study is mainly devoted. A fuller study will be completed in time. It is hoped that eventually definite biotic interrelationships can be well established, especially as the plant life influences the fish population. Two of these relationships are stressed here. Aquatic vegetation markedly affects the dissolved oxygen and to some extent carbon dioxide, bicarbonate, normal carbonate, and pH of the water. From data obtained by Baine (1936) certain definite correlations may be drawn. Another influence of vegetation is upon water circulation and temperature changes. Only a little data is available on these latter conditions. Shaver (1933) has given a short account of the aquatics. Further studies are needed.

THE AQUATIC PLANT COMMUNITIES

Vegetational zonation is not as sharply defined in and about the lake as in some bodies of water, yet from an analysis of the plant

[1]Contributions from the Reelfoot Lake Biological Station No. 6. The study here reported on was made possible by a grant from the Reelfoot Lake Biological Station of the Tennessee Academy of Science, to whom the author wishes to express his appreciation.

life, a description can be drawn that will aid in an ecological estimate of life conditions. Five types of aquatics exist in great abundance in the lake. Emergent aquatics are common in the marsh areas that are so prominent in the northern portions of the lake. Floating-leaf attached aquatics are represented by four or five common species that occur mainly in a zone between the marshes and relatively open water. Submerged attached aquatics are very abundant in the deeper portions of the littoral zone beyond the floating leaf lily and lotus areas, thus forming a veritable underwater garden composed mostly of *Potamogetons* and *Zannichellia*. A surface layer of floating unattached plants larger than the microplankton exists in great abundance. Over quiet waters of the lake they form a thick layer in open places in the marsh, among the lilies and lotus, and over the submerged aquatics. Some raft-like masses extend even into the limnetic open water areas when blown by the wind. These plants are well termed the Pleuston (Welch, 1935). A large number of algae and other phytoplankton exist in the surface layers of the water. They with the pleuston and masses of submerged aquatics frequently choke the boat passages through the marshes and lily-lotus zone so thoroughly that passage with a boat by means of oars is nearly impossible.

Besides these true aquatics the drowned valley still supports many cypresses that have survived the flooded condition and accommodated themselves to deeper water than that usually preferring. In places they grow far out into the lake. These live cypress trees, and many dead stumps, form a grove-like forest over the shallower portions of the lake. Their buttressed bases and hollow or rotting stumps aid in holding aquatic plants and decrease the amount of effective wind and wave action that tend to alter the aquatic zones. A number of the stumps support land plants that have taken root upon them. A forest of living and dead cypress trees, growing in four to six feet of water that is literally covered by a yellow-green pleuston mat of duckweed, is a weird and beautiful feature of the lake. This feature makes the lake attractive to natives, naturalists, and sportsmen.

These five types of aquatics may be grouped into the three main vegetational zones mentioned above. From the alluvial swamps out to the open deeper water basins, they are: (1), the marshes; (2), the transition zone, a mixed one with water lilies, lotus, and hornwort predominating; (3), the submerged aquatics. Each of these may have more or less pleuston and phytoplankton on the surface. Therefore, essentially the three zones are composed of three different types of aquatics, namely: (1), emergent aquatics in the marshes; (2), floating leaf and some submerged aquatics in the transition mixed zone; (3), submerged attached aquatics in the submerged aquatics zone. The first classification is preferred here to simplify description.

The Marshes

The many shallow embayments in the northern and middle portions of the lake are filled with marshes that grow out from about the mean water level to an average depth of eighteen inches to two feet. During dry summers the marsh soils are above the water level and at flooded times the water extends beyond them over the swamp areas. This fluctuation in water level, about twenty-two inches (Baker, 1936), helps produce and maintain the marsh conditions. Washed-in sediments and accumulated decaying plants have developed a typical deep marsh muck that in some places is nearly fibrous enough to be a peat. It is often much more acid (pH 6.4) than the prevalently basic water (pH 7.9-8.2) above them. With dry conditions this mucky mud becomes firm and cracked on top and certain weeds and shrubs more typical of swamp and eulittoral areas invade the marshes.

These marshes are composed predominantly of the tall *Zizaniopsis miliacea* variously known as saw-grass, cut-grass, and wild rice. Cut-grass should refer to *Leersia* and wild rice to *Zizania,* so the name saw-grass is here preferred, although it might be confused with the marsh *Mariscus* of more southern regions. Usually over 75 per cent of these marshes are covered by saw-grass. This may grow over ten feet tall. The other herbs are hidden and less important. Only a few shrubs rise above this tall marsh grass. Among the matted rhizomes of the saw-grass and in the more open spaces between the denser regions of the marsh are a number of typical emergent aquatics. The yellow water lily or bonnet (*Nymphaea* sp.) has essentially emergent leaves on stout petioles and is frequent in deeper water portions of the marsh and as a border between it and the transition zone. The water smartweed (*Polygonum muhlenbergii*), the lizard's tail (*Saurarus* sp.), a few locally abundant patches of *Typha latifolia,* and the tall *Scirpus validus* are frequent in the order given. The pickerel weed (*Pontederia cordata*), the large bladderwort (*Ultriculeria biflora*), an aquatic buttercup (*Ranunculus scleratus*), *Cambomba* sp., a *Rumex,* and some species of *Bidens* are not infrequent associates. Species of *Sparganum, Cyperus, Carex, Eleocharis, Juncus,* and other marsh plants have not been found frequently enough to warrant inclusion in this brief list of the typical marsh plants.

Conversations with old residents of the region indicate that marshes are generally more extensive than formerly. The lake seems to be "filling-in" and these marshes do most in extending the shore line out into the lake. It seems probable that swamps invade and succeed the marshes and that marshes gradually encroach upon the transition zone. An exhaustive study of these conditions is warranted. Perhaps a complete flooding, or conversely, a thorough burning of the marsh vegetation and soils, might retard if not eliminate the marsh extension into the lake. The spillway levels could be changed for either purpose. A long time hydrographic study is needed to determine the preferred water levels needed and the efficacy of flushing the lake.

As in most marshes, the accumulated soils and changing water levels are the most important ecological factors. The acidity of the soils in spots, as indicated by pH analyses, and the local occurrence of *Ultricularia* and other plants of acid situations, are indicative. Contrasted to the hard lime-water conditions of the lake as a whole (normal carbonate from 84 to 252 p. p. m., Blaine, 1936), the acidities of marsh areas need special emphasis. How much extreme fluctuations in water level have affected the marshes is not well known.

Photograph by Jesse M. Shaver

Fig. 1. Plant Zonation around Reelfoot Lake. In the foreground is a floating mat of duckweeds. Just back of this is a zone of Yankapin lilies (*Nelumbo*). The marsh is of saw grass (*Zizaniopsis*) and in the background is a willow marsh.

The temperature relations of the prevailing shallow waters over the marsh areas have been measured in the spring. The surface water heats up to above 96° F. at noon when the air above is 80° F. At night the water cools rapidly until after sunrise when it is slightly cooler than the air. The wide temperature range, in some recorded cases over 30° F. in a day, may be significant in biotic estimates. These marshes are homes for amphibia and reptiles and refuges and breeding grounds for fish. Large numbers of migratory birds use the lake, particularly the marsh areas.

The Transition Zone

Beyond the marshes, in water averaging between two and five feet deep, is an abundance of mixed types of aquatic plants. Of these the submerged hornwort (*Ceratophyllun demersum*) is most abundant forming dense sublimnic beds. With the hornwort is a varied assemblage of floating, partly emergent leaf plants. *Nymphaea* not only occurs in the marsh but may be in patches in this zone. The large peltate-leaved lotus or "yankapin" lily (*Nelumbo lutea*) covers large areas near the marsh and extends far out into the transition zone

Photograph by C. L. Baker

Fig. 2. Pleuston supporting the cricket frog. The largest leaves are of *Spirodela,* the smallest *Wolffia,* and groups of leaves *Azolla.* Note the flower of *Cabomba* at the right margin.

(Fig. 1). *Castalia odorata,* the white water lily or mule-foot lily, is less abundant. A small lilypad (*Brassenia peltata*) is of only local occurrence, as at Miller's Landing. *Cabomba caroliniana, Utricularia biflora,* and some of the *Potamogetons* are found here mixed with *Ceratophyllum. Elodea canadensis* and *Vallisneria spiralis* were observed in only a few places in this zone.

The luxuriant growth of submerged aquatics markedly affects the amount of oxygen and carbon dioxide in the water. Six water samples from dense *Ceratophyllum* areas with no duckweed above them gave an average oxygen content of 13.6 p. p. m., which is seven or eight times as much as in the open water areas. The carbon dioxide content is too variable for a definite conclusion but is much less than in dense pleuston so common above the submerged plants. Unlike the open water areas there is no definite increase in carbon dioxide with increase in depth.

This rank vegetation could be decreased, probably without injury to the fish, by the use of sodium arsenite as recommended by Surber (1932). The unusually high oxygen content of the water in this zone and the usual abundance of fish, however, indicates that this zone is one of the best for fish and ought not to be decreased.

In this zone occurs the greatest abundance of phytoplankton. The duckweeds and *Azolla* form most of the pleuston layer. *Algae* and other *Cryptogams* floating and suspended occur abundantly here and in shallower water. Three duckweeds, *Spirodela polyrhiza, Wolffia columbiana,* and *Lemna trisulca,* with the floating fern *Azolla caroliniana,* form a very thick raft over much of the area. In some embayments the liverwort (*Ricciocarpus natans*) occurs abundantly in April and early May. In many places this mass of floating plants is thick enough to support small animals such as the cricket frog, *Acris gryllus* (Fig. 2).

The soupy consistency of this floating layer blankets the vegetation beneath inhibiting current movement and gaseous diffusion as well as preventing some of the light from reaching the submerged vegetation. The water temperatures in this layer are the highest in the lake and are often 20° F. more than in the water two feet below. The oxygen content is much lower than in the *Ceratophyllum* beds and the carbon dioxide is much higher. The water is usually less turbid here than in either the marsh or deeper submerged zone, indicating less current movement and probably some settling of suspended materials.

Algae, particularly *Spirogyra,* in large floating masses abound in and on the surface during April and May. A preliminary study of these algae showed two common *Cyanophyceae* (*Oscillatoria* and *Lyngbya*) fifteen species of diatoms, six species of desmids, six filamentous *Chlorophyceae* (besides *Spirogyra*), with *Zygnema, Mougeotea,* and *Oedogonium* the commonest. The great abundance of *Spirogyra,* forming large greenish yellow air bloated fields in the upper surface of the water, is a striking feature of the northern portions of the lake in May.

Below this mixed type of vegetation is a one- to two-foot accumulation of mud and muck consisting of silted mud and the organic remains of the abundant vegetation. As this accumulates, it is probable that the marsh plants extend out further and take over some of the area once occupied by the transition zone.

The Submerged Aquatics Zone

This is the zone of the deepest water in which attached aquatics live. From about four feet to six or seven feet deep, three or four common aquatic species grow in submerged beds of narrow-leaved, columnar-formed plants that project up to the surface and in some cases flower and fruit above it. The tall submerged plants are mostly members of the pondweed family. The local name of buffalo grass given them is an apt one because the buffalo fish makes its home here. The horned pondweed (*Zannichellia palustris*) is probably the most frequent. *Potamogeton filiformis* and *P. pusillus* with some of the eel-grass pondweed (*P. compressus*) occur in relative abundance in the order named. *Ceratophyllum* and *Elodea* may be found with these, but infrequently, and they are not typical.

These submerged pondweeds occur abundantly in the areas of cypress trees. The live cypress trees are not growing as vigorously as those of shallower-water swamp areas, but the very fact that these cypresses survived the flooding that caused the lake and became adapted to water prevailingly over five feet deep is worthy of note. Water circulates more easily in this zone than in the others and the temperature, oxygen, and carbon dioxide relationships are less striking. When winds disturb the surface, the upper water temperatures are about the same as those of the air. On clear, hot days the bottom temperatures are usually 5° to 7° F. less than at the surface. Baine and Yonts (1936) have obtained chemical data that show that the oxygen content ranges between 11 and 3 p. p. m. and that there is little or no carbon dioxide near the surface. Near the bottom, carbon dioxide increases in some cases to over 5 p. p. m.

North of the middle part of the lake in water over seven feet deep, little or no submerged and rooted vegetation exists. These areas are few and confined to parts of the old river channels such as the Blue Basin.

Summary and Conclusions

This is only a short description and analysis of aquatic plants and phytoecological conditions in the lake. A thorough hydrographic study and map are needed to better present the actual conditions of the entire lake. A detailed quantitative study of the aquatics of the different zones would be of great service.

Six conclusions are instructive:

(1) The aquatic plants occur in three fairly well defined zones that form a littoral belt between the three swamps and the basins that are free of attached plant life.

(2) These zones are: (a), marshes of emergent aquatics, mostly *Zizaniopsis*; (b), a transition zone of mixed aquatics, some few emergent, others floating-leaved and a mass of submerged attached vegetation mostly *Ceratophyllum;* (c), a submerged aquatic zone, dominantly of tall, narrow-leaved members of the pondweed family.

(3) These three zones occur in progressively deeper water with less accumulated soil below each from the inner marsh border outward to vegetation-free basins.

(4) The abundance and kind of aquatic vegetation in some situations markedly affects the water temperature and the oxygen and carbon dioxide content of the water. The photosynthetic and respiratory activities of the aquatics must measurably alter the chemical conditions of the water. The blanketing and damning effects of the vegetation influence insolation and currents, thus affecting the free circulation of the water and diffusion of gases.

(5) The northern part of the lake which is dissected into angular and shallow embayments, supports the greatest mass of vegetation. The southern portions have only a fringe of marsh and other aquatics, for these regions are filling in less and the waters are more violently disturbed by winds and currents.

(6) The shallowness of the lake, its wide seasonal fluctuation in water level, and the forest cypresses, dead and alive, in the lake, all contribute to an increasing abundance of aquatic plant life. It seems fairly justified to suppose that the lake is filling in and largely by the agency of these extensive aquatic zones.

Bibliography

Baine, Ogden, and O. C. Yonts. 1936. Chemical Studies of the Waters of Reelfoot Lake. *Jour. Tenn. Acad. Sci.,* 12: No. 1.

Baker, C. L. 1936. The Commercial, Game, and Rough Fishes of Reelfoot Lake. *Jour. Tenn. Acad. Sci.,* 12: No. 1.

Hazard, J. O. 1933. The Trees of the Reelfoot Lake Region. *Jour. Tenn. Acad. Sci.,* 8: 55-60.

Shaver, Jesse M. 1933. A Preliminary Report on the Plant Ecology of Reelfoot Lake. *Jour. Tenn. Acad. Sci.,* 8: 48-54.

Surber, E. W. 1932. Controlling Vegetation in Fish Ponds with Sodium Arsenite. *U. S. Bur. Fish Investigational Report,* No. 11: 1-39.

Welch, P. S. 1935. *Limnology.* New York: McGraw-Hill.

ATTRACTIVITY OF LIGHT FOR ANOPHELES MOSQUITOES

H. A. JOHNSON
P. A. Sanitary Engineer, United States Public Health Service

The New Jersey Mosquito Extermination Association has devised and used a mosquito sampling trap for the purpose of determining the effectiveness of anti-mosquito campaigns. The insects are attracted to the trap by electric lights and are then blown by a small electric fan into a cyanide jar from which they are later recovered.

In New Jersey pest mosquitoes are the main object of anti-mosquito activities and when operated during the flight time of the pests these traps have proven far superior to ordinary hand catching in measuring the effectiveness of control measures.

Malaria field workers are well aware of the difficulties of sampling the mosquito population by hand catching in the customary daytime

Fig. 1. The Light Traps on Posts at the left and right of the Biological Building. These were the earlier traps used.

resting places. While this has been the most satisfactory method known it entails much effort due to the different habits of various anopheles and does not always give a true picture of anopheles density. It therefore seemed opportune to ascertain whether light traps might be more efficient than hand catching in obtaining a true record of Anopheles prevalence.

This investigation was made at the Reelfoot Lake Biological Station of the Tennessee Academy of Science. The light traps used were similar to those used in New Jersey and consisted of a cylinder approximately one foot in diameter and two feet long. In the center of the cylinder was mounted an electric fan to maintain a current of air through the cylinder. At the suction end was placed an ordinary electric light socket and at the other end arrangements were provided for blowing the insects into a cyanide jar. With slight modifications this type trap could be used in either a horizontal or vertical position.

During the summer of 1933 hand catching was used exclusively. In the usual daytime resting places (tree roots, hollow logs, in and under cow sheds, chicken pens, and inside inhabited buildings) only two species of Anopheles were recovered. *Anopheles quadrimaculatus*, the main malaria carrier of the Southeast, was extremely abundant throughout the summer while *Anopheles punctipennis* was found in small quantities. *A. quadrimaculatus* outnumbered *A. punctipennis* by more than 100 to 1. No other species of Anopheles were observed during the summer.

During the summer of 1934 the mechanical light traps were used and collections were made by them during a period of one-half to three-fourths hours at dusk (flight time for Anopheles). The traps picked up large quantities of *A. quadrimaculatus,* some *A. punctipennis,* and regularly small numbers of *A. crucians.* Hand catches in the daytime resting places were made during the entire period as a check on the trap. *A. quadrimaculatus* and *A. punctipennis* were thus found regularly, but no *A. crucians* were found by hand until two months after the trap had showed them to be actually present. Trap-caught specimens of *A. crucians* were forwarded the Bureau of Entomology at Washington long before their presence would have been noted from hand catches.

During this same summer experiments were carried out to determine the effect of color and intensity of light on its attractiveness for Anopheles. Both factors are apparently involved. An increase in intrinsic brilliancy with a given color resulted in larger catches. The attractiveness of the light also increased with the color as the various colors were tested going down the visible spectrum from red to violet. While infra red and photographic red (ruby) light did not attract Anopheles, ultra violet did possess a small degree of attractiveness. The result of the study showed that an ordinary 100-watt frosted Mazda light gave excellent results and that a 60-watt CX light (ordinary 60-watt light in ultra violet transmitting glass) gave almost as good results. Later studies confirmed the fact that the 100-watt light was most satisfactory.

August and September of 1935 was devoted to a further study of the effectiveness of light traps. Shortly after commencing studies the trap with a 100-watt light picked up specimens of what proved to be *A. walkeri* a rather scarce Anopheles previously reported in a few sections of the United States and Canada. The first *A. walkeri* were caught in the trap on August 14 and by August 27 better than 50 per cent of the entire trap catch was *A. walkeri.* They then diminished slowly until September 8, after which date no more were caught. At this later date cool fall weather had been prevalent for over a week and probably was responsible for the diminution in *A. walkeri.*

An unusually diligent search was made during the time the trap was catching *A. walkeri,* but none were ever found in the customary daytime resting places. A small number of female *A. walkeri* were captured, however, after they had been induced to enter an enclosure by an electric light at night and then the enclosure sealed. It is safe to state that the presence of *A. walkeri* at the Station would not have been recognized had it not been for the light trap. During the period August 14 to September 8, 341 *A. quadrimaculatus,* 8 *A. punctipennis,* 66 *A. crucians,* and 133 *A. walkeri* were caught in the light trap. Very few male Anopheles were ever found in the trap and no *A. walkeri* males were caught during the operation of the device.

There is very little information available relative to the habits of *A. walkeri,* although it is known that they are able to carry malaria. *A. walkeri* resemble *A. quadrimaculatus* very closely in markings, but evidently differ widely from them in habits.

The experimental work on the attractivity of lights for Anopheles at the Reelfoot Biological Station has shown:

First, for indicating the relative prevalence of different species of female Anopheles, the light trap is much more efficient than hand catching.

Second, a 100-watt ordinary frosted Mazda light is a most efficient light source for attracting female Anopheles. Weaker lights attract fewer insects.

Third, a properly operated light trap can be expected to indicate the presence of species of Anopheles that would otherwise be missed altogether.

On the assumption that conditions for Anopheles breeding about the Biological Station are essentially similar each year it is apparent that the genus *Anopheles* is represented in the area by at least four species. *A. quadrimaculatus,* an efficient malaria carrier, is prevalent in great quantities throughout the entire mosquito breeding season. *A. punctipennis* and *A. crucians* are prevalent in small numbers throughout the season. *A. walkeri* is apparently prevalent in moderate numbers only during the hottest summer weather.