AN ECOSYSTEMATIC STUDY OF THE FAUNA AND FLORA OF THE SAVANNAH RIVER[1]

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INTRODUCTION

This program was designed to determine the communities of aquatic organisms living in the Savannah River in the vicinity of the Savannah River plant of the Atomic Energy Commission, and the ecological characteristics of the environment in which they are found. By carrying out such studies before the plant started to operate and by continuing them after operation, any adverse changes due to plant operations could be determined. Although these studies were designed to monitor river changes due to plant operation, many interesting scientific facts of theoretical interest have been obtained. This is largely because all major groups of organisms were collected and chemical and physical analyses were made at the same time. All identifications in the various groups were carried where possible to the specific or subspecific level by qualified systematists. Furthermore, the studies reported here have been made in all except one case (Station 5) in the same areas over nine years, and similar, if not identical, procedures have been used.

This paper sets forth the ecological, faunistic, and floristic results. The results of value to the monitoring program, including the bacteriology studies, have been set forth in various reports submitted to the Atomic Energy Commission and will not be considered in this paper.

The river surveys which are carried out by the Academy of Natural Sciences are based upon the assumption that in natural areas of mesotrophic-to-eutrophic streams such as the Savannah River there is a high diversity of species, and most of them are represented by moderate size populations. The number of species of any group, such as insects or diatoms, does not change much from season to season or area to area if pollution is not present — although the kinds of species vary greatly. (Leonard, 1939; Patrick, 1949, 1963; Gaufin and Tarzwell, 1955; Gaufin, 1958; Hirsch, 1958). The effect of an unfavorable environment, depending on the degree of severity, is to lower the diversity of species, change the kinds of species, and alter the relative sizes of the populations of species (Thienemann, 1939; Patrick, 1949, 1961, 1963; Patrick, *et al.*, 1954; Gaufin and Tarzwell, 1955; Gaufin, 1958; Hirsch, 1958; Cairns, 1965; etc.). Often the structure of populations of in-

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THE INVERTEBRATES

METHODS AND PROCEDURES

Due to the great diversity of form and habitat preference exhibited by the invertebrates, they must be collected in a number of ways. Slow moving and sedentary macroscopic forms are most efficiently collected by hand-picking with the aid of a blunt pair of forceps, a knife, spoon, etc. Most molluscs and bryozoa are collected in this manner. A dip-net is used for collecting swimming forms and those that live on the surface of the substrate. As considerable mud and silt are picked up in this type of collecting, the contents of the net are washed in the river and then placed in a white enamel pan partially filled with clear water for sorting. Large forms can be easily removed and small forms become readily visible against the white background — all specimens are removed to collecting vials by means of forceps or a pipette. A Needham Scraper, a wire mesh basket on a handle which is used much as a rake, is employed for collecting those forms that actually live in the bottom. This method is particularly useful for many worms and molluscs. Sometimes fine mesh screens in the form of a small seine are used in shallow water. Most types of bottom samplers are not very useful in sampling a deep river with a very limited shallow water area.

Some invertebrates are placed in alcohol or formalin in the field. Samples of bottom material and plant material are taken back to the field laboratory for sorting under a dissecting scope — this technique enables one to collect many of the microscopic species.

In addition to the above methods, dredging was employed at all of the river stations. This method reveals the presence or absence of benthic fauna in the deeper water. The benthic fauna of the channel in the Savannah River is insignificant. This is probably because the bed of the river in the deep water areas, which is most of the river, consists for the most part of shifting sand. The method of dredging and the results are discussed in a separate section.

Samples of all specimens collected were preserved in accordance with recognized procedures for specific types of specimens and deposited in the permanent collections of the Academy of Natural Sciences of Philadelphia.

GENERAL REMARKS

The so-called lower invertebrates other than Protozoa and insects include a large number of phyla. As is characteristic of many river areas we have studied, the numbers of species of any of these phyla which were present in the Savannah River are relatively low. The mollusca were usually represented by the largest number of species at a given time of study in the various areas. The Aschelminthes (rotifers, nematodes, etc.) or the Annelida (segmented worms) were represented by the next highest number of species in an area at a given time of study. Probably because of the low

numbers of species and the fact that this grouping is not a natural one, a greater variation was present in the numbers of species at a given time of study.

Description of the Fauna

The numbers of species of lower invertebrates found during the various surveys can be seen in Table 6. During the summer survey in 1951 rotifers were commonly found at all stations as was the worm *Limnodrilus hoffmeisterii* and the snail *Physa heterostropha*. Unionid clams varied in numbers of species at the various stations. The species most commonly found was *Lampsilis dolabraeformis*. Leeches were also commonly found at each of the stations. The sphaerid clams were of spotty occurrence during this survey.

In the fall survey the bdeloid rotifers were commonly found at all stations. The other species of rotifers were of sporadic occurrence. The tubificid worm *Limnodrilus hoffmeisterii* was found at all stations. *Physa heterostropha* was likewise present at all stations in the spring survey. The unionid clams were common at all stations and many species were present at each of these stations. As in the summer survey, the arthropods were of spotty occurrence — that is, no species was generally found throughout all stations, although some species of arthropods were found at all stations.

The number of species found in the winter survey is given in Table 6. The tubificid worm, *L. hoffmeisterii* was again found at all stations. The rotifers were not as common as in the previous two surveys, nor were the unionid clams, but perhaps this was because of greater difficulty in collecting them as the level of the water was much higher during this survey. During this survey *Palaemonetes paludosa* was found at all stations except Station 1. *Spongilla fragilis* was found in the winter time at all stations. *Physa heterostropha*, the gastropod, was collected at all stations.

In the spring of 1952 *Plumatella repens* was found at all the stations except Station 5. *L. hoffmeisterii* was again present at all stations. As in the winter, the unionid clams were much more difficult to collect and therefore probably appeared to be of much more spotty occurrence. Of the unionids, the only one collected at all stations in the spring was *L. dolabraeformis*.

In 1954 the most common species at Station 1 were *P. heterostropha* and *Pseudosuccinea columella*, both of which are pulmonate snails; and the sponge, *Spongilla fragilis*. The oligochaete worm population remained low and formed a very small part of the fauna. Four species of pelecypods were found here. The small glass shrimp *Palaemonetes paludosus* was also found at Station 1. At Station 6A in 1954 there were fewer species of clams present than in 1951. Only *Elliptio hopetonensis* was present in sufficiently large numbers to indicate that a large population was established. As at Station 1 the dominant species of pulmonate snails were *P. heterostropha* and *P. columella*.

In the summer of 1955 at Station 1 the dominant species of invertebrates were the pulmonate snails, *P. heterostropha* and *P. columella*. Sphaerid or finger nail clams (*Musculium* sp.) were present among the riprap. Six species of unionid or freshwater mussels were the major component of the fauna with respect to numbers of species; however, these species were not represented by large populations. The most abundant of the unionid species were *Elliptio hopetonensis* and *L. dolabraeformis*. The populations of sponges, Bryozoa, were small and limited in distribution. They frequently appeared on submerged wood. At Station 3 the dominant invertebrates were the pulmonate snails *P. heterostropha* and *P. columella*. The numbers of species of mussels had been reduced when compared with 1951. Nine species were taken in the summer of 1951 whereas only three were taken in the summer of 1955. Oligochaete worms were fairly common at this station. At Station 5 pulmonate snails were the dominant species. They were the same as those found at Station 3. At Station 6A as at Station 1 the most common species were the pelecypod molluscs *L. dolabraeformis* and *E. hopetonensis*. Occasional limpids, *Ferrissia* and *P. heterostropha*, were found in shallow waters.

In the spring of 1956 at Station 1 the dominant species was the sponge, *Spongilla fragilis*. A total of 17 species of invertebrates was collected at this station in 1956, representing an increase of four over the thirteen recorded in the spring survey of 1952. At Station 3 as at Station 1, the sponge *S. fragilis* was the dominant species on the submerged substrate. The oligochaete worm *Limnodrilus* sp. was also very common in the mud at the bottom. Leeches carrying newborn young were collected fairly commonly at this station. When compared with the spring survey of 1952, there were twelve less species reported at this station than at that time. At Station 5, 9 species of lower invertebrates were found. This represented a decrease of 43 percent from those collected in the spring of 1952. The greatest drop in species numbers were in the oligochaete worms, the crustacea, the gastropods, and the pelecypods. The sponge, which had been common at Stations 1 and 3, was relatively rare in this area. The dominant form taken here was the amphipod *Hyalella azteca*. At Station 6A the sponge, *S. fragilis* was fairly common. Several species of unionid clams were collected at this time in this area. Also present in considerable numbers were *Palaemonetes paludosa* and the amphipod *Hyalella azteca*. This station yielded ten species, a decrease of ten over 1952. These changes in the fauna may be in part due to dredging activities.

As on the other surveys in the spring of 1960, the most protected areas at Station 1 were along the left bank of the river. Rich populations of unionids which were composed of mainly four species were found in among the pilings on this bank. The species forming these large populations were *Elliptio hopetonensis, E. incrassatus, E. fisherianus,* and *L. cariosa*. Tubificid worms were fairly common in the mud bottom close to the shore along the

left bank. The only other invertebrates abundantly present at this station were the two crustacea, the amphipod *H. azteca*, and the crayfish *Procambarus pubescens*. At Station 3 the fauna was much the same as at Station 1. Again the left bank provided the most productive habitats. The ctenobranch gastropod *Amnicola limosa* was only found at this station. At Station 5 a total of 22 species were collected. This was a new area this year, as the old Station 5 no longer lay in the main channel of the river due to the changing of the river channel by dredging. Therefore the results from this area are not strictly comparable with the previous results. Naid worms, crustacea, were common here. Tubificids were also commonly collected at this station. The same four species of unionid clams as reported at Station 1 were found fairly common here. At Station 6 the populations of lower invertebrates were relatively small except for the unionid clams. At this station most of the clams were found in the slough near the lower end of the station. The more common species were *Anodonta hallenbeckii*, *A. couperiana*, and *A. imbecilis*. Also common was the ctenobranch gastropod *Pomatiopsis lapidaria*.

In the fall of 1960 at Station 1, 13 species of lower invertebrates were collected. As in the spring survey, the most conspicuous part of the invertebrate fauna at this station were the four species of unionids listed above. At Station 3 there was a rich fauna of 19 species of lower invertebrates. A large number of mussels were collected between the pilings on the left bank. The four common species were the same as those found at Station 1 — *Elliptio hopetonensis*, *E. incrassatus*, *E. fisherianus*, and *L. cariosa*. There were also two other lampsilid species — *L. splendida* and *Micromya ogeecheensis*. At Station 5 there were extensive sponge colonies which were largely composed of *Trochospongilla horrida*. Associated with this sponge was the unusual bryozoan, *Pottsiella erecta*. Large colonies of another bryozoan, *Fredericella sultana*, were also common. At Station 6A large mussel populations were the most conspicuous part of the invertebrate fauna. These were *E. hopetonensis*, *E. fisherianus*, *E. incrassatus*, and *L. cariosa*. A total of 9 unionid species were taken from this area.

When the spring survey of 1960 is compared with the spring survey of 1956, there is a general increase in species present at all stations. In a similar way there is a similar number or an increase of lower invertebrates in the summer survey at all stations, but this is not so marked as in the spring survey. The only station at which there was a significant decrease in species as compared with the 1955 survey was at Station 6A. Twenty species were reported in 1955 and only 14 in 1960.

Comparison of Faunas on a Given Survey and Over Time in a Given Area

The average number of species was 17. The amount of variation in number of species was much greater than in any other group, being less than one half the mean in some cases (Table 6). This is in part due to the fewer

Somatogyrus virginicus Walker

Occurrence: Apr. 1952 — Station 3.

Ecological distribution: The ecological range of this species covered the range encountered in the river for pH. Otherwise it was as follows: Alk. 20.0-30.0, Cl 1-3, CO_2 5.0-10.0, D.O. 7.0-9.0, Fe 0.07-0.1, Hardness 10-<50, Ca <3-3, Mg <3-3, NH_3-N 0.05-<1.0, NO_2-N 0.001-<0.007, NO_3-N 0.07-0.2, PO_4 >0.01-0.05, SiO_2 >6.0-12.0, SO_4 >1-10, Temp. 17.0-20.0, B.O.D. 0.5-1.0, Turb. 50-100.

Class Pelecypoda
Order Eulamellibranchiata
Family Unionidae
Subfamily Unioninae

Elliptio hopetonensis (Lea)

Occurrence: June 1951 — Stations 3, 6A; Oct. 1951 — Stations 1, 3; Apr. 1952 — Station 5; 1954 — Stations 1, 6A; Sept. 1955 — Stations 1, 3, 5, 6A; May 1956 — Station 6A; June 1960 — Stations 1, 3, 5, 6A; Sept. 1960 — Stations 1, 3, 5, 6A.

Ecological distribution: The ecological range of this species covered the range encountered in the river except for the following: Temp. 18.5-29.0.

Elliptio incrassatus (Lea)

Occurrence: June 1951 — Stations 3, 6A; Oct. 1951 — Stations 1, 3, 5, 6A; Apr. 1952 — Stations 1, 3; Sept. 1955 — Stations 1, 3, 5, 6A; June 1960 — Stations 1, 3, 5, 6A; Sept. 1960 — Stations 1, 3, 5, 6A.

Ecological distribution: The ecological range of this species covered the range encountered in the river except for the following: Cl <1-<10, Temp. 17.0-29.0, B.O.D. 0.1-<5.0.

Elliptio lanceolatus (Lea)

Occurrence: June 1951 — Station 3; Oct. 1951 — Stations 3, 5; Apr. 1952 — Stations 5, 6A; Sept. 1955 — Stations 5, 6A; June 1960 — Stations 1, 3, 5, 6A; Sept. 1960 — Stations 1, 3, 5, 6A.

Ecological distribution: The ecological range of this species covered the range encountered in the river except for the following: Cl 1-<10, D.O. >5.0-9.0, Temp. 18.5-29.0, Turb. 25-500.

Uniomerus obesus (Lea)

Occurrence: Oct. 1951 — Station 3.

Ecological distribution: The ecological range of this species covered the range encountered in the river for pH. Otherwise it was as follows: Alk. 20.0-30.0, Cl 1-3, CO_2 5.0-10.0, D.O. 7.0-9.0, Fe 0.03-0.05, Hardness 10-<50, Ca <3-3, Mg <3-3, NH_3-N 0.009-0.03, NO_2-N 0.001-<0.007, NO_3-N 0.07-0.2, PO_4 0.05-0.1, SiO_2 >6.0-12.0, SO_4 >1-10, Temp. 20.0-23.0, B.O.D. >0.1-0.5, Turb. 50-100.

Subfamily Anodontinae

Anodonta couperiana Lea

Occurrence: June 1960 — Station 6A; Sept. 1960 — Station 6A.

Ecological distribution: The ecological range of this species covered the range encountered in the river except for the following: Alk. >10.0-20.0, Cl 5-<10, CO_2 >3.0-7.5,