Effect of Environment on Plankton Species Diversity in Central Oklahoma Farm Ponds[1]

VERNIE KNUDSON[2] and TROY C. DORRIS

Aquatic Biology Laboratory, Department of Zoology

Oklahoma State University, Stillwater

During the summer of 1963 a study was undertaken of plankton species diversity in seven farm ponds near Stillwater, Oklahoma. The ponds were selected because they drained into one central pond in three series of three or more ponds each. (Fig. 1) Upper ponds in each drainage series tended to collect solid materials washed in from the watershed.

Methods and Equipment

Samples of water were collected from the surface of four sides of each pond at least six feet from the margin. The four samples were mixed to form a composite sample which was taken to the laboratory and examined immediately. Surface temperature was measured with a centigrade thermometer at the time of sampling (8:00 to 9:00 A.M.). The pH of the water was determined with a meter as soon as samples reached the laboratory.

To determine chlorophyll *a* content of the phytoplankton, 100 ml samples were filtered through two Millipore filters, with pore sizes of 5.0 μ and 0.45 μ. Filters were extracted in 10 ml of cold 90% acetone for 24 hours. The solution was centrifuged and the supernatant fluid was read at 664 mu in a Bausch and Lomb Spectronic 20 colorimeter. Conductivity was measured by means of a conductivity bridge. Percentage of transmission at 450 mu in the colorimeter was read to determine the amount of turbidity. Inorganic solids were measured by firing the dried residue from a 50 ml sample at 600°C for one hour. Loss of weight by firing was determined as ash-free dry weight. A 500 ml sample was passed twice through a Foerst plankton centrifuge and the centrifugate was diluted with demineralized water to form a 100X concentrate. The concentrate was transferred with a wide mouth pipette to a Palmer plankton counting slide and examined at 440X. Methyl cellulose was added to slow motile specimens. Numbers of species seen in tallying 10, 100, and 1000 individuals were recorded and plotted on semi-log paper. A diurnal dissolved oxygen study was conducted according to methods described by Odum and Hoskin (1958). Photosynthetic productivity and community respiration were determined.

Results

Mean values of factors determined in each pond are shown in Table I. Although pH fluctuated in most ponds, upper ponds were more variable than lower ponds in each series. The pH values ranged from 7.7 to 10. Although distribution of pH followed no consistent pattern, upper ponds frequently had a higher pH than lower ponds.

Conductivity in upper ponds was less than in lower ponds, and mean conductivity showed a general increase through each series. The range of conductivity was 155 μmho/cm in pond 6 to 331 μmho/cm in pond 4.

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[1]Contribution No. 391, Department of Zoology, Oklahoma State University.

[2]NSF College Teacher Research Participant

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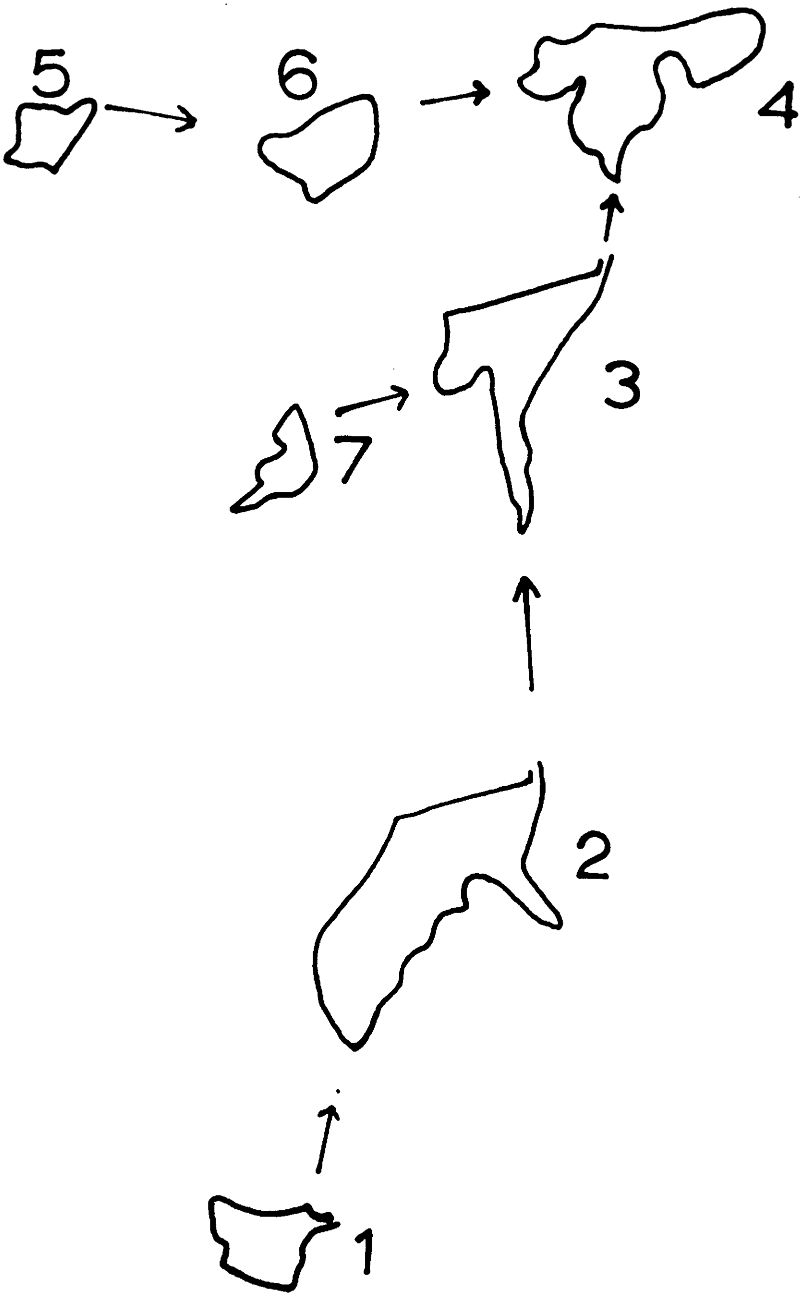

Figure 1

TABLE I

PHYSICAL AND CHEMICAL CHARACTERISTICS OF FARM PONDS NEAR STILLWATER, OKLAHOMA

Pond	Turbidity Units	Conductivity μmhos/cm	pH	Total Solids mg/l	AFDW* mg/l	Chlorophyll *a* mg/l	Species Diversity Sp/1000 Indiv.
1	58	236	8.0	220	140	.420	16
2	21	230	8.5	150	78	.040	19
3	26	279	8.3	280	94	.070	24
4	15	309	7.9	230	140	.005	35
7	20	217	8.0	180	100	.070	27
3	26	279	8.3	280	94	.075	24
4	15	309	7.9	230	140	.005	35
5	14	191	8.6	120	66	.030	34
6	19	218	9.6	160	80	.230	29
4	15	309	7.9	230	140	.005	35

*Ash-free Dry Weight

Turbidity generally decreased downstream in each series. Turbidity appeared to be determined in part by individual pond characteristics, such as depth, pH and watershed.

Mean total solids content tended to increase downstream through each series. The increase was probably due to the organic fraction (ash-free dry weight) which generally increased from upper to lower ponds.

Chlorophyll *a* content ranged from .01 mg/L to .54 mg/L. Pond 1 had the highest mean concentration, possibly because the narrow euphotic zone tended to concentrate phytoplankton at the surface.

Productivity and respiration data are shown in Table II. Since water samples for oxygen analysis were taken at the surface, high photosynthesis and respiration measured in Pond 1 reflects the concentration of phytoplankton in the surface layers of the turbid water. Chlorophyll *a* concentration in Pond 1 was about 2 to 10 times greater than in any other pond. However, Pond 4, with the lowest cholorophyll *a* concentration, exhibited a relatively high productivity.

TABLE II

PRODUCTIVITY MEASUREMENTS FROM DIURNAL CHANGES IN DISSOLVED OXYGEN

	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
Respiration (R) ($g\ O_2/M^2/day$)	21.6	5.8	7.2	5.3	6.7
Gross Productivity (P) ($g\ O_2/M^2/day$)	20.7	5.7	4.2	5.9	5.3
Net Productivity ($g\ O_2/M^2/day$)	6.2	2.5	0.8	1.8	1.2
P/R Ratio	0.95	0.98	0.6	1.1	0.8

The number of species per 10 or 100 individuals did not appear significant and comparisons were made between average number of species per 1000 individuals. Species diversity increased downstream through ponds 1, 2, 3, and 4. (Fig. 2). Although this sequence was not completely duplicated in other series, the tendency was for diversity to be less in upper ponds and greater in lower ponds. Diversity was more variable in upper ponds.

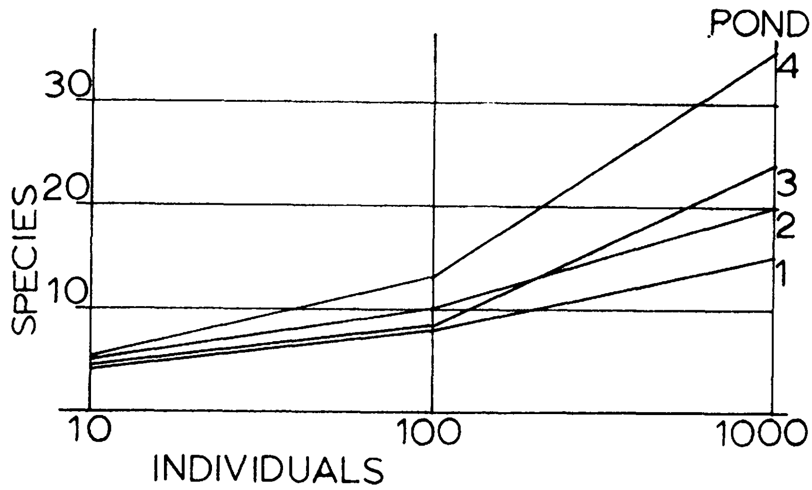

Figure 2

The slope of average species diversity curves increased until 500 individuals had been counted. From counts of 500 to 1000 individuals the increase in number of species was constant. According to Margalef (1958), this would indicate that a count of 500 individuals would be sufficient to determine diversity. Average species per 10 and 100 individuals counted showed little differentiation between ponds. Numbers of species per 1000 individuals counted permitted ranking of ponds. Ponds with a species diversity of 10-17/1000 individuals were usually small, turbid and first in a series, or otherwise immature. Ponds with a species diversity of 18-31/1000 individuals were normally intermediate in a series. They were also intermediate in regard to conductivity, pH, turbidity and total solids. Ponds with a species diversity of 31-45/1000 individuals were clear, at the end of a series, or mature in ecological development.

Lower species diversity in upstream ponds would appear to be due to physical characteristics of the ponds. Certain conditions are probably too harsh or variable for many species. Since these ponds probably contain large amounts of nutrient elements for plankton growth, the species which can live in this habitat multiply enormously. According to Margalef, aquatic ecosystems mature by slightly changing the physical environment. As maturity develops the number of species increases. The increase in species may be due to a less harsh environment which alows other species to compete or it may be due to a paucity of elements when the growth of producers exceeds the cycling of elements by saprophytes.

During this study, quantities of sewage sludge were put into all ponds. In some cases turbidity and diversity were lowered in particular ponds. Some fluctuations in solids may be attributed to the sludge. The total effects of the sludge will require more study to be fully assessed.

Literature Cited

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