SOME EFFECTS OF TURBIDITY ON BOTTOM FAUNA

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By

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INTRODUCTION

The bottom fauna from Oklahoma has recieved limited attention (Burris, 1949, unpublished thesis) and the effect of turbidity on bottom organisms is practically unknown. Thousands of ponds have been constructed in the southwest during the last few years. A major portion of these ponds are exceedingly turbid. Since the animals from the bottom play an important role in the productivity of the pond (Welch, 1936), it is important to discover the limiting effects that turbidity has upon the activities of these animals. The limnologists agree on many of the physical, chemical, and biological effects that turbidity has on bodies of water, but there are some aspects of the problem about which various workers have disagreed.

The temperature of water is affected by turbidity. It has been considered that turbid water was warmer than clear water (Welch, 1935; Munns, 1948). Wallen (1952), after an intensive study of several ponds, has shown that turbid ponds were often cooler than clear ponds.

Most authors agreed that turbidity interfered with the penetration of light rays (Ellis 1936, 1937, 1944; Corfitzen, 1939; Chandler, 1942). It has been said that the rate of light absorption by any silt suspensions in water increased as the wave length of light decreased (Corfitzen, 1939). Ellis (1936) states that colloidal clays in water decreased the penetration of light. A turbidity of 115 ppm. in Lake Erie (Chandler, 1942) removed 40 per cent of the light in the first 10 cm. of water and 99 per cent was absorbed at a depth of one meter.

Turbidity has some relationship to the range of pH of water. Clear ponds in Oklahoma have a wide range of pH. Variations from 5.6 to 10.6+ have been found (Wallen, unpublished data). The ponds with turbidities due to soil particles are less varied and pH readings of 7.6 to 8.6 represent the recorded extremes for turbid waters in this area (Wallen, unpublished data).

It was generally stated that turbidity decreased the total plankton population (Chandler, 1942; Doan, 1942; Berner, 1951). Zooplankters were more abundant than phytoplankters in muddy water of the Mississippi River (Berner, 1951). Increased turbidities resulted in a higher concentration of zooplankton near the surface than at greater depths (Doan, 1942). Diatoms composed a greater percentage of the total phytoplankton when the average turbidity exceeded 25 ppm. (Chandler, 1942).

The relationships of natural turbidities to the production of fishes are poorly understood. Smith (1939) indicated that young fishes may be protected from predators by the turbidity of water. Gordon Hall, Oklahoma Game and Fish Department Technician, has learned that channel catfishes do not commonly reproduce in clear ponds in Oklahoma but do reproduce in otherwise similar turbid ponds (Hall, personal correspondence, 1952). Decreases in turbidity were accompanied by increases in production of fishes in Kansas except when turbidity was below 100 ppm. at which time there was no relationship (Schneberger and Jewell, 1928). Doan (1942) in studies of the abundance of fishes said that "Increased spring turbidities were associated with lower Ohio catches in the same year, had no direct effect on the perch fishing, but was followed by increased sauger catches three years later". The turbidities in the present study were due to suspensions of silt and montmorillonite clay similar to those found nonpoisonous to fishes at turbidity concentrations of natural ponds (Wallen, 1951).

Many workers have been aware of the importance of bottom fauna as a source of fish food (Izaak Walton, 1653; Forbes, 1888; Wagner, 1908). Neess (1949) contended that under certain conditions the bottom fauna was a direct source of food for fishes. The bottom organisms have been important in food-habit studies of most fishes (Evermann and Clark, 1920). Welch (1936) states that bottom fauna is one of the most influential features in biological productivity.

The present discussion referes to a turbid pond as one with more than 25 ppm. of montmorillonite clay and silt suspensions and a clear pond is one whose water contains less than 25 ppm. of silt-clay suspensions.

METHODS AND PROCEDURE

The evaluation of the effect of turbidity on bottom fauna included two main phases with studies of 18 different ponds. Table Number I is a list of the ponds from which collections were made with the general features of each, and their location from the intersection of Main and McElroy streets in Stillwater, Oklahoma.

The first phase of the study consisted of weekly collections made during the spring to discover the cyclic relationship of the organisms in a clear pond versus the organisms of a turbid pond. Two ponds, located two miles apart and having comparable morphological features, were selected for this part of the study. Each pond was about one acre in size, had pasture drainage, exhibited a similar type of mud bottom, and contained an undetermined population of fishes. One was a turbid pond (Pond Number 1, Table I) which had been constructed for about fourteen years. Pond Number 1 had been turbid since the time of its construction. The primary factor that contributed to its turbidity was runoff-water containing montmorillonite clay from an adjoining unsurfaced farm road. The other was a clear pond (Pond Number 2, Table I) of about the same age as the turbid one. The main factors contributing to its lack of turbidity were a settling basin located in its drainage and an abundant growth of vegetation in the water.

The second phase of the study involved the selection of seven additional clear ponds and nine other turbid ponds and the determination of the summer population of bottom fauna in each. Single collections were made from these ponds during the summer. The ponds varied in size (0.1 acre to 1 acre) and location (within 12 miles of Stillwater) as well as in many other morphological features. The series represented typical farm ponds of Central Oklahoma and were investigated from the standpoint of total summer

TABLE I

A LIST OF THE PONDS FROM WHICH COLLECTIONS WERE MADE WITH THE GENERAL FEATURES OF EACH, AND THEIR LOCATION FROM THE INTERSECTION OF MAIN AND McELROY STREETS IN STILLWATER, OKLAHOMA

POND No.	TURBIDITY ppm.	SIZE ACRES	LOCATION MILES	TYPE OF DRAINAGE	AMOUNT OF VEG.
1	Turbid	1.00	3 West	Pasture & Road	None
2	Clear	1.00	.8W - .2S	Pasture & Road	Lots
3	Turbid	.50	1 East	Pasture	None
4	Clear	.75	1.5W - .2N	Pasture	Lots
5	Turbid	.25	Near No. 2	Pasture & Road	Little
6	Turbid	.33	3.4 West	Pasture & Road	None
7	Clear	.33	6.8W - .8N	Pasture & Road	Lots
8	Clear	.50	10W - 2N	Pasture	Little
9	Turbid	.50	11W - 1N	Pasture	None
10	Turbid	.33	12W - 2.3N	Pasture	None
11	Turbid	.50	Near No. 10	Pasture	None
12	Turbid	.50	1.9 North	Pasture & Road	Some
13	Clear	.10	12.5W - 2.7N	Pasture	Some
14	Turbid	.50	3.5W - 1N	Field	Some
15	Clear	.50	3.7W - 1.3N	Pasture	Some
16	Clear	1.00	3.5W - 2.7N	Pasture	Some
17	Clear	.75	3.7W - 1.8N	Pasture	Some
18	Turbid	.75	3.6W - 1.8N	Pasture & Road	Some

populations of comparable bottom faunas.

The methods used in the experiment were those recommended by Welch (1948). The bottom samples were taken with a Peterson dredge 100 square inches in area. A sample consisted of three dredgefulls; one each from depths of 10, 20, and 30 inches. All measurements of turbidity were made with a Jackson turbidimeter. The collections were made while wading in the shallow water, which usually limited the operations to an area near the shore. Samples were taken from the same station whenever collections were gathered more than once from the same pond. The date, time of day, location of the pond, size of the pond, turbidity of the water, type of watershed, and the site of collection were recorded at the time of each collection.

The three samples from each pond were emptied into a tub and screened with a No. 30 mesh sieve having openings 0.0198 inch square. The material that remained in the sieve was deposited into half gallon jars and enough water added to keep the organisms alive.

The containers were then taken to the laboratory and emptied into a white porcelain pan. The contents of the pan were washed by agitating the material with a stream of tap water. All water escaping from the pan was again strained through a No. 30 mesh sieve to prevent the loss of any organisms. Thorough washing of the samples was required to prevent the remaining water from becoming muddy when the material was searched for organisms.

The pan and its contents were then placed beneath a bright light. An adjustable desk lamp was found to be ideal for this purpose. It was necessary to leave some water on the specimens to encourage them to move and be selected, however, more than the minimun amount to cover the material on the bottom hindered visibility.

The writer found it easier to sort the organisms from the debris by first clearing a small area at one end of the pan. A pair of forceps was then used to spread each small bit of material across the previously cleared area. Many of the animals were not observed unless they moved, thus every care was taken to sort the organisms from the debris while the animals were still alive. A small pipette was used in capturing water-mites and other tiny, active organisms. Some of the animals usually escaped discovery during the first examination of the material. Each collection was carefully searched at least twice, as a precaution against overlooking some of the animals. The debris was then discarded. All organisms were preserved in 10 per cent formaldehyde for future identification and study.

The next part of the procedure consisted of measuring the total volume of organisms. The organisms and preservative were placed in a centrifuge tube (graduated to 0.1 ml.) and the volume, estimated to 0.05 ml., was listed. The surplus liquid was then drained into a second tube and its volume was determined. The second reading was subtracted from the first and the results recorded as the total volume of the sample. The per cent of the volume that each type of organism contributed to that collection was then computed.

The organisms were then identified. The identification keys used were those of Ward and Whipple (1918), Johannsen (1934) (1935) (1937), Pratt (1935), Jaques (1947, 1951), Chu (1949), Needham and Needham (1951) and Peterson (1951). The writer is indebted to the following people for their help in identification of the material: Dr. I. E. Wallen for the Molluska; Dr. D. E. Howell for some of the insects; Mr. Bergstrom and Mr. Mitchell for the water-mites; Dr. C. F. W. Muesebeck and the following men of the

United States National Museum, Dr. Burks for identification of the immature mayflies, Dr. Gurney for the dragonfly nymphs, Dr. Wirth and Dr. Stone for the immature diptera.

PRESENTATION OF DATA

Fifty-five types of animals were collected from the 18 ponds visited during the study. A list of organisms found in all ponds during the investigation and a comparison of the total numbers from clear versus turbid ponds is included as Table II. The more important taxonomic groups are considered in the following discussion in order to present special features of the populations.

Oligochaeta

Oligochaetes were present in the clear pond throughout the spring. These annelids composed from 23 to 95 per cent (an average of 55 per cent) of the total volume of organisms collected from Pond Number 2 (Table III). Nearly 2400 segmented worms were found in clear Pond Number 2, while only 58 were taken from turbid Pond Number 1 during the same period of study. Nais was the most abundant annelid in the clear pond, and the number found was in proportion to the amount of vegetation collected. Nais is included in a list of annelids that normally occupy vegetated habitats (Ward and Whipple, 1918). A few Nais were also found in an additional clear pond and one other turbid pond during the summer.

Ophidonais were collected from most clear ponds as well as from several of the turbid ponds. Members of this genus were very abundant in one turbid pond which had many sticks and leaves on the bottom. Ophidonais were always more abundant in ponds containing a large amount of organic material on the bottom. The association is probably due to their utilization of the plant material as food. Budding adult Ophidonais and many immature ones were collected during June which indicates that this is an active period of reproduction.

Naidium was abundant in one clear and one turbid pond during the latter

TABLE II

A LIST OF ORGANISMS FOUND IN ALL PONDS DURING THE STUDY GIVING A COMPARISON OF THE TOTAL NUMBERS FROM CLEAR VERSUS TURBID PONDS

	CLEAR	TURBID
I. Annelida		
A. Hirudinea		
1. Glossiphonidae		
a. Placobdella parasitica (Say)	1	
B. Oligochaeta		
1. Naididae		
a. Naidium	17	107
b. Nais	1872	17
c. Ophidonais	1154	527
II. Arthropoda		
A. Amphipoda		
1. Gammaridae		
a. Gammarus	23	1
B. Coleoptera		
1. Dytiscidae		
a. Adult		1
b. Hydroporus (larva)	1	
2. Haliplidae		
a. Haliplus	1	
3. Hydrophilidae		
a. Berosus	1	
C. Diptera		
1. Heleidae (Ceratopogonidae)		
a. Palpomyia	247	207
2. Tabanidae		
a. Chrysops	30	
3. Tendipedidae		
a. Chaoborus	46	204
b. Clinotanypus	174	21
c. Glyptotendipes	5	
d. Pelopia	21	
e. Pentaneura	39	136
f. Procladius	5	6
g. Tanytarous	340	138
h. Tendipes	607	603
4. Tipulidae	1	
D. Ephemeroptera		
1. Baetidae		
a. Callibaetis	1	

TABLE II (CONTINUED)

	CLEAR	TURBID
2. Caenidae		
a. Caenis	291	35
3. Ephemeridae		
a. Hexagenia limbata (Serville)	9	1369
E. Hemiptera		
1. Corixidae		1
2. Mesovellidae		
a. Mesovelia	1	
3. Notonectidae		
a. Plea	3	
F. Hydracarina		
1. Arrenuridae		
a. Arrenurus	168	1
2. Axonopsidae		
a. Albia	2	1
3. Krendowskiidae		
a. Geayia	1	7
4. Lebertiidae		
a. Oxus	116	16
5. Limnesiidae		
a. Limnesia	43	2
6. Pionidae		
a. Forelia	1	
b. Piona	23	
7. Unionicolidae		
a. Koenikea	102	18
b. Neumania	72	61
G. Megaloptera		
1. Sialidae		
a. Sialis (larva)	1	
H. Odonata (Anisoptera)		
1. Coenagrionidae		
a. Amphiagrion		15
b. Chromagrion		42
c. Enallagma	2	25
d. Ischura		1
Odonata (Zygoptera)		
1. Aeschinidae		
a. Anax	1	
b. Gomphus	9	39
2. Libellulidae		
a. Epicordulia	1	
b. Libellula	34	
c. Macromia		1

TABLE II (CONTINUED)

	CLEAR	TURBID
d. Mesothemis	12	
e. Perithemis	5	
I. Trichoptera		
1. Beracidae (Probably)	1	
2. Calamoceratidae (Probably)		1
III. Molluska		
A. Eulamellibranchia		
1. Sphaeriidae		
a. Musculium		2
2. Unionidae		
a. Uniomerus tetralasmus Say		6
B. Pulmonata		
1. Planorbidae		
a. Gyraulus parvus (Say)	58	1
b. Helisoma trivolvis (Say)	9	1
2. Physidae		
a. Physa hawnii (Lea)	14	
IV. Nemathelminthes		
A. ————		
1. Nematoda		1
Grand total	5565	3613
Average number per collection	265	157

TABLE III

THE VOLUME OF ORGANISMS AND THE PERCENTAGES OF THE TOTAL VOLUME REPRESENTED BY NAIDS OF HEXAGENIA AND ADULT ANNELIDS FROM CLEAR POND NUMBER 2

COLLECTION DATE	TURBIDITY ppm.	TOTAL VOL. 300 sq.in.	HEXAGENIA % Vol.	ANNELIDS % Vol.
Feb. 21	-25	4.05 ml	0	27
28	-25	3.85	>1	95
March 6	-25	1.30	>1	50
20	-25	3.25	0	83
27	-25	.55	0	40
April 2	-25	2.95	>1	65
17	-25	1.45	0	55
27	-25	2.10	>1	50
May 3	-25	.80	0	40
8	-25	.35	0	90
15	-25	.45	0	70
24	-25	.80	>1	40
June 7	-25	.85	0	23
20	-25	.55	0	50
Total		23.30		
Average		1.66		

part of August. The annelids were fringed with daughter worms on the posterior two-thirds of their bodies. The intensive action of reproduction was interesting but lack of time prevented further investigation.

Ephemeroptera naiads

The Ephemeroptera populations of the turbid and clear ponds were vastly different. Immature mayflies were found in large numbers during the spring, but a different genus was abundant in each of the two ponds. A total of 291 specimens of Caenis were collected from all clear ponds but only 35 specimens were found in the turbid ponds. This nymph had a high affinity for vegetated areas and most organisms collected were found clinging to living plant material.

Hexagenia limbata (Serville) naiads were abundant in all collections from turbid Pond Number 1 representing 65 to 94 per cent of the total population of bottom fauna from this pond (Table IV). The immature burrowing mayflies averaged nearly 80 per cent of the total volume of bottom fauna from this turbid pond, as compared with less than one per cent of the total volume of fauna from clear Pond Number 2. During the entire period of study 1369 Hexagenia limbata were collected from all turbid ponds while 9 specimens were found in all of the clear ponds. Hexagenia limbata composed 65 per cent or more, by volume, of the bottom fauna from all ponds that had a turbidity above 250 ppm.

Odonata (Zygoptera)

Seven genera of Zygoptera nymphs were found of which two were taken consistently. Gomphus was often collected from the turbid ponds during both spring and summer phases of the study, and was occasionally found in some clear ponds but only during the summer. Libellula was not found in any turbid pond. This genus was abundant in the clear pond during the

TABLE IV

THE VOLUME OF ORGANISMS AND THE PERCENTAGES OF THE TOTAL VOLUME REPRESENTED BY NAIADS OF *HEXAGENIA* AND ADULT ANNELIDS FROM TURBID POND NUMBER 1

COLLECTION DATE		TURBIDITY ppm.	TOTAL VOL. 300 sq.in.	HEXAGENIA % Vol.	ANNELIDS % Vol.
Feb.	21	111	.95 ml	92	>1
	28	133	1.50	75	>1
March	6	185	1.20	67	>1
	20	305	1.75	75	>1
	27	215	1.80	87	>1
April	2	220	.80	72	0
	17	275	1.05	65	5
	27	167	1.05	75	>1
May	3	110	1.15	65	>1
	8	68	1.30	86	0
	15	106	1.65	85	2
	24	139	1.50	91	>1
June	7	180	1.30	92	>1
	20	132	1.65	94	>1
Total			18.95		
Average			1.58		

spring and was represented in moderate numbers in several clear ponds during the summer. Anax, Epicordulia, Mesothemis and Perithemis were found only on one date, February 21, and were collected from clear Pond Number 1. Their presence is probably related to the large amount of vegetation taken on that date.

Odonata (Anisoptera)

Three genera of Anisoptera were found: Amphiagrion, Chromagrion and Enallagma. Damselfly naiads were limited, with few exceptions, to collections from the clear pond during the spring. They were usually found clinging to vegetation and were much more numerous in collections containing that material. Such would be expected as vegetation is their natural habitat (Ward and Whipple, 1918) and provides shelter as well as food.

Hemiptera

Very few specimens of Hemiptera were found during the experiment. One Mesovelia and three Plea were collected from the clear pond during the spring. One immature specimen of the family Corixidae was taken from one turbid pond during the summer.

Coleoptera

Representatives of Coleoptera were seldom collected from any of the ponds. One specimen each of Berosus and Hydroporus, in larval form were found in the clear pond during the spring. A Haliplus larva was found in a clear pond, and adult Dytiscidae were collected from one clear and one turbid pond during the summer.

Diptera

Diptera larvae were abundant in both the clear and the turbid ponds during the spring. Eight genera were found in the clear pond and six genera were taken from the turbid pond. Most of the diptera reached their highest populations in the clear pond during April followed by a rapid decline in early May. The populations in the turbid pond were fairly constant throughout the period of study. Pentaneura, an exception, showed a slight population rise in the turbid pond on two occasions, once on March 20 and again five weeks later. Tendipes was the most abundant dipterous organism in both ponds. It is of interest to note that this midge larva was found in every collection made from turbid ponds, and was found almost as consistently in collections from the clear ponds. The total number found in clear ponds and the total number from the turbid ponds were practically the same throughout the entire study (Table II). Tendipes was found in higher numbers in collections that contained vegetation. The material may have served either as food or refuge, or perhaps, as a combination of both.

Many specimens of Chrysops were found during both spring and summer in the clear ponds. Chrysops was not found in any of the turbid ponds. Clinotanypus was abundant in clear Pond Number 1 and was found in one clear and one turbid pond during the summer. Procladius was rarely collected from both clear and turbid ponds. Tanytarsus and Pentaneura were represented in collections from a majority of both clear and turbid ponds throughout the investigation. Palpomyia was collected quite consistently from both the turbid and the clear ponds during the spring and was present in many ponds during the summer. Glyptotendipes was found in one small, clear pond during the latter part of August. The length of these organisms was more than 3 cm. and they were a brilliant red in color. The writer did not have the opportunity to learn whether or not fish were present that might feed on this large dipterous larva.

A comparison of the total numbers of Diptera with the populations of the other major groups of organisms in all ponds is presented in Table V. The per cent of the population represented by each group is given in the table.

Amphipoda

Twenty-three specimens of *Gammarus* were collected from clear Pond Number 2 and only one individual was taken from any turbid pond during the study. Vegetation is believed to be the most important factor in accounting for this difference since amphipods are associated with aquatic plants (Ward and Whipple, 1918).

Hydracarina

The Hydracarina are a poorly known group. Little work has been done on the taxonomy of water-mites from the southwest. Information about the ecological factors that might determine their existence is equally scarce. More than 600 aquatic mites were collected during the course of the present study. A greater portion of the animals were found in clear ponds but a surprising number were taken from the turbid waters. Table VI is presented for a comparison of species and numbers of water-mites found in clear ponds and turbid ponds.

Nine genera of water-mites were found in the clear pond during the spring and six of these genera were present in the corresponding turbid pond. *Arrenurus* was the most abundant water-mite collected and was limited almost entirely to clear Pond Number 2. Only one specimen, of the 169 found, was taken from a turbid pond (Number 1). Members of the genus *Arrenurus* were most abundant during April and May. *Thas* was the second most abundant in the clear ponds and showed an increase in population during April and again in May. The genus was represented in several collections

TABLE V

A COMPARISON OF THE POPULATION OF DIPTERA IN ALL CLEAR AND TURBID PONDS WITH THE NUMBERS OF OTHER MAJOR GROUPS OF ORGANISMS PRESENT AND PER CENT OF THE TOTAL POPULATION REPRESENTED BY EACH GROUP

	Clear Ponds		Turbid Ponds	
	Numbers	% of Total	Numbers	% of Total
Diptera	1515	27	1315	36
Hexagenia	9	1	1369	38
Annelida	3043	55	651	18
Hydracarina	526	9	107	3
Other Organisms	472	8	171	5
Total	5565	100	3613	100

TABLE VI

A LIST OF THE NUMBERS OF WATER-MITES COLLECTED FROM ALL PONDS DURING THE STUDY

	Turbid Ponds	Clear Ponds
Arrenurus	1	168
Oxus	16	116
Neumania	62	70
Koenikea	18	102
Limnesia	2	43
Piona		23
Geayia	7	1
Albia	1	2
Forelia		1
Total	107	526

from the turbid pond.

Neumania was taken in about equal numbers from both ponds. They were more plentiful in the turbid pond during February and March and less abundant later on. Specimens from the clear pond were rarely collected during February and March but were more abundant in mid-April. Koenikea was taken regularly from the turbid pond until the last week in April, after which time it was not found in any turbid pond. The genus was absent from the clear pond until the first week in April. Following this date the population increased rapidly to a peak on April 17, then began declining and was seldom collected in clear ponds after the first of May.

One specimen of Limnesia was found in the turbid pond and 43 were collected from the clear pond. Water-mites of this genus were collected quite consistently and showed a small increase in numbers in mid-April. A few members of the genus Piona were collected from the clear pond. Geayia was the only genus that was more abundant in the turbid pond than in the clear pond and the numbers here are so small as to not be conclusive. Of the eight specimens of this genus that were collected, seven were found in the muddy pond. Two specimens of Albia were collected from the clear pond and one was taken from the turbid pond. Only one specimen of Forelia was collected and this one came from the clear Pond Number 2.

Scattered collections of few individuals of seven of the genera were collected during the summer, mostly from clear ponds. The dates of the population peaks were earlier in the year than those peaks mentioned by workers farther north (Baker and Wharton, 1952). The difference in time of reproductive activities is probably related to the earlier seasons of this area.

Pulmonata

Snails were more abundant in the clear ponds but an occasional specimen was taken from a turbid pond. Gyraulus parvus was found only in the spring. Fifty-eight specimens were taken from the clear pond and one specimen was found in the turbid pond. Helisoma trivolvis was collected from the clear ponds during both spring and summer, and one individual was found in the turbid pond during the spring. Physa hawnii was taken only from clear Pond Number 2 during the spring.

Other Animals Seldom Represented

The order Eulamellibranchia was represented by two genera. Musculium and Uniomerus were found in turbid Pond Number 1. Hirudinea was represented by Placobdella parasitica collected once from clear Pond Number 2. A larval form of Sialis, of the order Megaloptera, was taken from a clear pond in mid-August. One Nematoda was found in turbid Pond Number 1. The writer believes that the size of sieve used in screening the collections of mud may have allowed many other Nematodes to be lost. None of these animals were collected in significant numbers for a true comparison of their preferences with regards to turbidity.

DISCUSSION

A review of literature reveals that little work has been done to clarify the relationship of turbidity to bottom fauna. The bottoms of streams and impounded waters constitute an important source of fish-food organisms, and every effort should be made to expand our knowledge of this ecological realm.

The writer began a study of the bottom organisms of several local impoundments in February, 1952. A total of 47 collections were made from the bottoms of 18 farm ponds typical of Central Oklahoma (Table I). Ten of the ponds were turbid and the remaining eight were clear. Collections were made weekly from one turbid and one clear pond during the spring. The other 16 ponds were visited occasionally during the summer.

Factors contributing to the variance of the populations from the different sets of ponds are not entirely understood. But it is possible to eliminate some of the items that are associated with the limnology of the experiment.

The water temperature was not an important factor in the current study. Although there are usually some differences in temperatures of turbid and clear waters, the depths to which the collections were limited would make this difference negligible.

The penetration of light effects some bottom dwelling animals (Welch, 1935), and the absence or presence of light may have been an important factor here, although most of the organisms that were found abundantly in turbid ponds of this study have also been found in clear ponds of other regions.

The chemical conditions usually vary in both turbid and clear ponds. But the range of chemical variation in turbid ponds is near the middle of the range of chemical variation in the clear ponds. Therefore, it is unlikely that the chemical conditions were a limiting factor in the ponds studied.

Many of the impoundments visited during the present study contained aquatic vegetation in varying amounts. Some of the ponds supported a very small quantity of plants, while other ponds were practically choked with vegetation. Vegetation was sometimes unavoidably included in the samples collected from the bottom. It became important to learn if there was an association between the aquatic plants and the organisms being collected. An attempt was made to solve the problem by taking special collections from Pond Number 2. One collection contained a large amount of vegetation, while the other collection, taken a few feet from the first and at about the same time, contained no vegetation. Table VII is a comparison of the numbers of organisms found when collections were taken with vegetation and without vegetation from clear Pond Number 2. The difference in the total number of organisms found in each collection is significant. A total of 813 animals were taken from the collection which contained vegetation, as compared to 514 found in the samples taken without plant material.

Some genera of organisms showed a definite association with vegetation, these include *Nais*, *Tendipes*, *Caenis*, *Pentaneura*, *Enallagma*, *Amphiagrion*, and *Chromagrion*. There were four genera of animals that were more abundant in the collection made without vegetation. They are *Ophidonais*, *Clinotanypus*, *Tanytarsus*, and *Hexagenia*. The writer believes it is worthy of note that the two genera of annelids were not abundant in the same type of habitat. Also of interest is the fact that the single specimen of *Hexagenia* was found in the collection that did not contain vegetation. Although, the presence of vegetation effects the numbers of animals collected it was not

TABLE VII

A COMPARISON OF THE NUMBERS OF ORGANISMS FOUND WHEN COLLECTIONS WERE TAKEN WITH VEGETATION AND WITHOUT VEGETATION FROM POND NUMBER 2

	With Vegetation	Without Vegetation
Ophidonais	3	210
Nais	193	65
Tendipes	290	81
Palpomyia	7	5
Libellula	11	3
Chrysops	12	5
Procladius	2	
Caenis	219	28
Pentaneura	12	
Chaoborus	1	
Beraeidae	1	
Coenagrionidae	36	3
Amphipoda	9	3
Clinotanypus	6	65
Plea	2	
Gyraulus	7	6
Physa	2	6
Tanytarsus		33
Hexagenia		1
Total	813	514

the major factor in causing the dissimilarity of the populations studied, since areas were selected with low vegetation for all collections.

The presence or absence of soil produced turbidities divided the populations of Diptera larvae into three ecological groups. The first group, which included the genera *Palpomyia*, *Procladius*, and *Tendipes*, was not visibly affected by turbidities and were found in about equal numbers in both clear and turbid ponds. The second group, composed of *Tanytarsus* and *Clinotanypus*, was decidedly more abundant in clear waters. The last group, containing *Pelopia*, *Glyptotendipes*, and *Chrysops*, was entirely limited to the clear ponds.

Annelids were more abundant in the clear ponds with two exceptions. Samples taken from a turbid pond (Pond Number 3, Table VIII) during March showed a high percentage of *Nais* in the collection. Another turbid pond sampled during the summer contained an abundance of *Naidium* (Pond Number 5, Table VIII).

Two genera of dragonfly nymphs showed a relationship between the numbers collected and the turbidity of the water. *Gomphus* was found in large numbers only in turbid ponds, and *Libellula* was collected only from clear ponds.

Mollusks were also affected by the amount of turbidity in the water. Snails were seldom found except in clear ponds. Such would be expected as the association of snails with vegetation is well known. *Musculium* was found only in turbid ponds. The fingernail clam is a burrowing form in the bottom and its appearance in muddy waters can probably be expected. *Uniomerous* was also collected only in turbid ponds however this is believed to be incidental to its true distribution.

Mayfly nymphs from the clear and turbid ponds exhibited a sharp contrast

TABLE VIII

A LIST OF THE VOLUMES AND COMPARISON OF PERCENTAGE COMPOSITIONS OF *HEXAGENIA* AND ANNELIDS BY VOLUME FROM THE PONDS VISITED DURING THE SUMMER

COLLECTION DATE		POND NO.	TURBIDITY ppm.	TOTAL VOL. 300 sq.in.	HEXAGENIA % Vol.	ANNELIDS % Vol.
March	6	3	225	1.40 ml	>1	90
June	27	4	-25	.08	0	12
	28	5	205	.95	35	60
Aug.	11	6	375	2.20	90	0
	12	7	-25	.45	0	10
	13	8	-25	1.00	60	7
	13	9	330	2.50	95	>1
	18	10	385	4.95	96	0
	18	11	1350	2.05	98	0
	20	12	50	2.95	96	0
	21	13	-25	1.45	>1	8
	25	14	162	2.55	85	0
	26	15	-25	.90	0	65
	26	16	-25	.08	0	0
	27	17	-25	3.05	0	>1
	27	18	50	3.00	55	35

in numbers collected. Some authors, including Welch (1952), state that Caenis nymphs are adapted for life in very turbid waters, which would imply that they should be found in higher, or at least equal, numbers in turbid ponds. High populations of Caenis were found in the clear ponds, but Caenis was seldom present in noticeable numbers in the turbid ponds. Hexagenia limbata was the most abundant organism found in the turbid ponds. The genus was seldom represented in any of the clear ponds.

There has been considerable material written about the nymphs of Hexagenia, and a number of accounts have been given of the ecological associations of various species. Spieth (1941) in his discussion of Hexagenia limbata (Serville) states, "Ecologically it is highly adaptable being found in many different types of water. It seems equally at home in lakes and streams. Whether the lake is large or small, whether the stream is sluggish and silt-laden or rapid and clear appears to be immaterial".

The writer has not found any article stating that Hexagenia limbata (Serville) is affected by turbidity of the water. It would seem, however, that this species is restricted to muddy ponds in this area.

Fifty-five genera of animals were represented in the total collections from all ponds (Table II). Forty-three types of animals were found in clear ponds and 29 kinds of organisms were found in turbid ponds. Twenty-two genera of animals were represented in clear ponds that were not found in turbid ponds. Conversely, seven genera of organisms were present in turbid ponds that were not found in clear ponds. Table II is a list of the organisms collected only in clear or only in turbid ponds.

The bottom-fauna populations were seasonal in the clear ponds. A greater number of individuals as well as a larger variety of species were represented during the spring. The numbers of organisms were much more

TABLE IX

A LIST OF THE ORGANISMS COLLECTED ONLY IN CLEAR OR ONLY IN TURBID PONDS

Organisms From Clear Ponds	Organisms From Turbid Ponds
Anax	Calamoceratidae
Beraeidae	Corixidae
Berosus	Dytiscidae
Callibaetis	*Macromia*
Chrysops	*Musculium*
Epicordulia	Nematoda
Forelia	*Uniomerus*
Glyptotendipes	
Haliplus	
Hydroporus	
Libellula	
Mesothemis	
Mesovelia	
Parameletus	
Pelopia	
Perithemis	
Physa	
Pionia	
Placobdella	
Plea	
Sialis	
Tipulidae	

uniformly distributed in the turbid ponds throughout the study. The average volume of bottom fauna collected from the clear pond slightly exceeded the average volume of organisms collected from the turbid pond during the spring, the figures being 1.66 ml. (Table III) and 1.58 ml. (Table IV). The collections made during the summer revealed an average of two and one-half times as much fauna in the turbid ponds as was present in the clear ponds, the figures being 2.51 ml. and 1.0 ml. respectively (Table X).

A comparison of the average volume of organisms collected from the clear ponds with the average volume of animals taken from the turbid ponds is interesting. The average volume of fauna collected from the clear ponds decreased from 1.66 ml. in the spring to 1.0 ml. during the summer, which represents a decline of 40 per cent; while the average volume of organisms increased in the turbid ponds from 1.58 ml. in the spring to 2.51 ml. during the summer, representing a 37 per cent increase. It should be indicated that the total volume of organisms (2.51 ml.) collected during the summer from turbid ponds was greater than that of the average of clear ponds at any time. A possible explanation of this may be in the continued abundance of large Hexagenia naiads in the turbid ponds during the period of study, while the population of immature insects is believed to have been reduced in clear ponds by emergence during early summer.

The present article is the second investigation of bottom fauna made in this area. It is hoped that the series will be continued until an adequate guide to bottom fauna development in southwestern impoundments has been established.

TABLE X

A COMPARISON OF THE VOLUME OF ORGANISMS FOUND IN THE CLEAR AND TURBID PONDS COLLECTED FROM DURING THE SUMMER, WITH THE TOTALS AND THE AVERAGE GIVEN FOR EACH SET

		Clear Ponds	Turbid Ponds
COLLECTION DATE	POND No	TOTAL VOLUME 300/ sq. in.	TOTAL VOLUME 300/ sq. in.
March 6	3		1.40 ml.
June 27	4	.08 ml.	
28	5		.95
Aug. 11	6		2.20
12	7	.45	
13	8	1.00	
13	9		2.50
18	10		4.95
18	11		2.05
20	12		2.95
21	13	1.45	
25	14		2.55
26	15	.90	
26	16	.08	
27	17	3.05	
27	18		3.00
Total		7.01	22.55
Average		1.00	2.51

SUMMARY

1. A quantitative and qualitative analysis of bottom fauna was made from ten turbid and eight clear ponds.
2. The fauna from one turbid pond is compared with the fauna from one clear pond throughout the spring.
3. Nine other turbid ponds and seven clear ponds were visited occasionally during the summer.
4. The phyla, Annelida, Nemathelminthes, Molluska, and Arthropoda were represented in the bottom organisms collected.
5. Annelids were the most abundant organism found in the clear ponds.
6. Hexagenia limbata (Serville) was the most abundant organism found in the turbid ponds.
7. Twenty-one genera were represented in the clear ponds that were not found in turbid ponds.
8. Seven genera were represented in turbid ponds that were not found in clear ponds.
9. Annelids composed the major portion of the bottom fauna in numbers with immature Diptera next, however Hexagenia limbata was the most abundant organism by volume.
10. Seven genera of water-mites were collected of which five were present in both clear and turbid ponds.
11. The populations of organisms were less changeable in the turbid ponds than they were in the clear ponds.
12. A greater volume of bottom fauna was collected from the turbid ponds than was found in the clear ponds.

LITERATURE CITED

Baker, Edward W. and G. W. Wharton. 1952. An Introduction to Acarology. New York: The Macmillan Company.

Berner, Lester M. 1951. Limnology of the Lower Missouri River. Ecology, Vol. 32 (1): 1-12.

Burris, William E. 1949. The Development of Bottom Fauna in a Newly Constructed Impoundment. Thesis, Oklahoma A & M College.

Chandler, David C. 1942. Limnological Studies of Western Lake Erie. II. Light Penetration and its Relation to Turbidity. Ecol., Vol. 23: 41-52.

Chu, H. F. 1949. How to Know the Immature Insects. Dubuque, Iowa: William C. Brown Company.

Corfitzen, W. E. and C. P. Vetter. 1939. A Study of the Effect of Silt on Absorbing Light Which Promotes the Growth of Algae and Moss in Canals. United States Dept. Interior Bureau of Reclamation. 14 pp.

Doan, Kenneth H. 1942. Some Meteorological and Limnological Conditions as Factors in the Abundance of Certain Fishes in Lake Erie. Ecol. Monographs, 12: 293-314.

Ellis, M. M. 1936. Erosion Silt as a Factor in Aquatic Environments. Ecology, 17: 29-42.

———, 1937. Detection and Measurement of Stream Pollution. Bull. U. S. Bur. Fish., 48: 365-437.

———, 1944. Water Purity Standards for Fresh-Water Fishes. U. S. Fish and Wildlife Service, Special Scientific Report No. 2: 16 pp.

Evermann, B. W. and H. W. Clark. 1920. "Lake Maxinkuckee." The Department of Conservation State of Indiana. Publication 7, 2 Vols.

Forbes, S. A. 1888. Studies of the Food of Fresh-Water Fishes. Bulletin, Illinois State Laboratory of Natural History. Vol. II, Art. VII, 433-473.

Jaques, H. E. 1947. How to Know the Insects. Dubuque, Iowa: William C. Brown Company.

———, 1951. How to Know the Beetles. Dubuque, Iowa: William C. Brown Company.

Johannsen, O. A. 1934. "Aquatic Diptera Part I." Cornell University Agriculture Experiment Station, Memoir 164, 71 pp.

———, 1935. "Aquatic Diptera Part II." Cornell University Agriculture Experiment Station, Memoir 177, 62 pp.

LITERATURE CITED (CONTINUED)

Johannsen, O. A. 1937. "Aquatic Diptera Part III." Cornell University Agriculture Experiment Station, Memoir 205, 84 pp.

Johannsen, O. A. and L. C. Thomsen. 1937. "Aquatic Diptera Parts IV and V." Cornell University Agriculture Experiment Station, Memoir 210, 80 pp.

Layman, Earle F. 1945. Reaction of Certain Nympha of Steonema (Ephemeroptera) to Light as Related to Habitat Preference. Annals of the Entomological Society of America Vol. 38, No. 2, June, 1945: 234-236.

Munns, Edward N. 1948. Our Forests and Watersheds. The Scientific Monthly, 67: 346-354.

Needham, J. G. and P. R. Needham. 1951. A Guide to the Study of Fresh-Water Biology. Ithaca: Comstock Publishing Company, Inc.

Neess, J. C. 1949. Development and Status of Pond Fertilization in Central Europe. Trans. Am. Fish. Soc. Vol. 76: 335-358.

Peterson, Alvah. 1951. Larvae of Insects. Part I and II. Ann Arbor, Michigan: Edwatds Brothers, Inc.

Pratt, Henry Sherring. 1935. A Manual to the Common Invertebrate Animals. Philadelphia: P. Blakiston's Son & Company, Inc.

Schneberger, Edward and Minna E. Jewell. 1928. Factors Affecting Pond Fish Production. Kans. Forestry, Fish and Game Comm., Bull. No. 9: 5-14.

Smith, O. R. 1940. Placer Mining Silt and its Relation to Salmon and Trout on the Pacific Coast. Trans. Am. Fish. Soc. Vol. 69: 225-230.

Spieth, Herman T. 1941. Taxonomic Studies on the Ephemeroptera II. The Genus Hexagenia. The American Midland Naturalist, Vol. 26, No. 2: 233-280.

Wagner, George. 1908. Notes on the Fish Fauna of Lake Pepin. Transactions, Wisconsin Academy of Sciences, Arts, and Letters, Vol. XVI, Part 1, No. 1, 23-37.

Wallen, I. Eugene. 1951. The Direct Effect of Turbidity on Fishes. Bull. Oklahoma A & M College, 48: 27 pp.

———, 1952. Temperature Effects on Farm Ponds. Presented at the Sixth Oklahoma Conservation Conference, Feb. 9, 1952.

Walton, Izaak. 1653. The Compleat Angler; or the Contemplative Man's Recreation. London.

LITERATURE CITED (CONTINUED)

Ward, H. B. and G. C. Whipple. 1918. Fresh-Water Biology. New York: John Wiley and Sons, Inc.

Welch, P. S. 1935. Limnology. New York: McGraw - Hill Book Company, Inc.

——, 1936. A Limnological Study of a Small Sphagnum - Leatherleaf - Black Spruce Bog Lake with Special Reference to its Plankton. Pap. Mich. Acad. Sci., Arts, Let. 21: 727-751.

——, 1948. Limnological Methods. Philadelphia: The Blakiston Company.

——, 1952. Limnology (Second Edition). New York: McGraw - Hill Book Company, Inc.

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