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By Willis Ratzlaff

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The Limnology of Some Roadside Ditches in Chase and Lyon Counties, Kansas

by

Willis Ratzlaff [1]

THE PURPOSE of this investigation was to study limnological conditions each month for the period March, 1950, through March, 1951, and to make a checklist of copepods and cladocerans collected during that period. The problem resolved itself into two phases:

1. Recording limnological data for dissolved oxygen, free carbon dioxide, phenolphthalein alkalinity, methyl orange alkalinity, hydrogen ion concentration, seston, and water temperatures.
2. Identification of copepods and cladocerans.

Pennak, 1949, lists some investigations similar to this study but none of them were undertaken in Kansas. As far as can be ascertained, the only published work about plankton studies in Kansas is by Leonard and Ponder, 1949. It consisted primarily of a checklist of crustaceans collected within a two-and-one-half-mile radius of Lawrence, Kan. Brooks, 1947, and Shields, 1948, wrote master's theses on subjects similar to this study, their work being done on Lyon County State Lake. Pennak states that there is much limnological literature which contains detailed accounts of the chemistry, physics, and biology of a great many bodies of water but most of it is concerned only with summer investigations. As a result, there is a gap in our over-all concept of year-round ecological conditions of bodies of water. Another characteristic is that nearly all limnological investigations have dealt only with lakes or streams. It is hoped that this study will help to fill a part of the gap in our year-round information about smaller bodies of water.

Much credit is due Roland Nelson for assistance in the chemical analysis of water; Merle E. Brooks for assistance and guidance in preparing slides and in identification of organisms; Ted F. Andrews for the guidance in organization and direction of this study; John Breukelman for making suggestions for improvement of composition; Frank U. G. Agrelius for aid in identifying some of the plants; and Robert Riggs and Robert Stapleford for photographs of collection areas and collection equipment. Credit is also due the persons who gave a measure of inspiration through their interest in this study.

1. Willis Ratzlaff is an instructor in Biology at Arkansas City High School.

Description of Ditches Studied

GENERAL DESCRIPTION

All of the ditches studied are along Highway US 50S in Eastern Kansas between Emporia and Strong City. Figure 1 shows the general position of the ditches relative to the highway. They are in the bottom land in the Cottonwood River valley where the elevation is 1,140±20 feet above sea level. All have mud bottoms of varying thicknesses as shown by Table I. During heavy rainfall the volume of water in these ditches changed in a very few hours. All water level declines were gradual.

1. Typical roadside ditches viewed from steep hill north of ditches. Highway U. S. 50S is just to the south of the ditch.

2. Station 1 looking west along the north side of highway U. S. 50S. Typical late spring vegetation may be seen in the background.

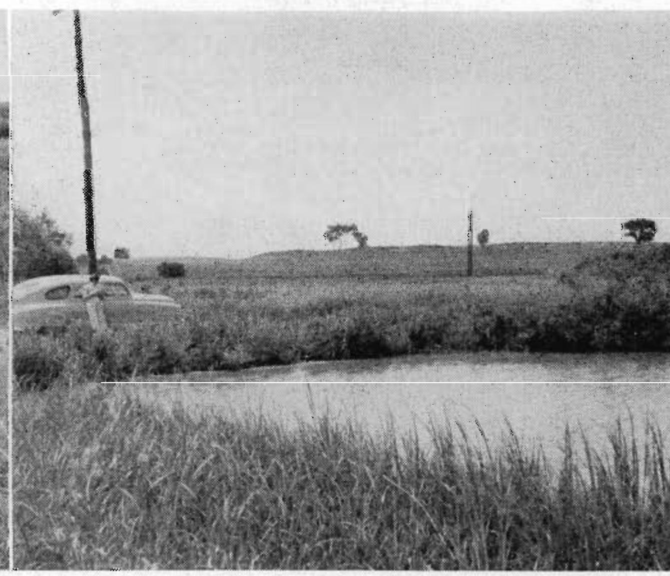
TABLE I. Chief physical characteristics of ditches studied.

Station	Length in feet approx.	Width in feet approx.	Depth in feet max. approx.	Depth in feet average approx.	Mud on bottom inches approx.	Location*
1	4,800	35	2.0	1.2	12	1.1
2	1,800	50	4.0	3.2	3	1.9
3	1,300	50	5.0	4.0	3	2.2
4	330	35	2.0	1.0	9	3.6
5	650	40	3.0	2.0	9	3.6
6	2,000	200	1.0	0.5	0–1	13.5

* Distance in miles east of Strong City, Kan.

The vegetation associated with these ditches is similar except for station 6 which has not been established long enough to exhibit characteristic vegetation of swamp-like areas. The dominant aquatic vegetation was water willow, *Justicia americans* (L.), and cattails, *Typha latifolia* L. Sedges were abundant at all stations; *Cyperus esculentus* L., *Carex vulpinoidea* Michx., and *Eleocharis macrostachya* Britt. were most common. No other aquatic spermatophytes were observed. The dominant terrestrial plants were grasses common to marshy areas. The two most common were rush grass, *Sporobolus asper* (Michx.) and cord grass, *Spartina pectinata* Link.

3. Station 1 looking east. Typical winter vegetation is evident in this picture.



4. Station 3 looking northwest. Typical early summer vegetation.

Eastern cottonwoods, *Populus deltoides* Marsh, and common willow, *Salix* spp. were in evidence at all stations except station 6. Figures 2, 3, and 4 are pictures of typical vegetation of these ditches.

Fishes entered these ditches during overflows of the Cottonwood River. The white crappie, *Poxomis annularis* Rafinesque, was the dominant species. Other important fishes in order of their abundance were the northern fathead minnow, *Pimephelas promelas promelas* Rafinesque, green sunfish, *Lepomis cyanellus* Rafinesque, and black bullhead, *Ameiuras melas melas* (Rafinesque). Fishermen frequently obtain some of the smaller fishes for bait. Others catch the larger ones for food. It is quite common to see people fishing at stations 2 and 3 and catching pan fish that many fishermen would not be ashamed to display.

Station 1

Ordinarily there is water in station 1 (Fig. 5) but this ditch usually dries up after about two months in dry weather, beginning in August. Because of the irregular bottom, several small pools of water become evident in the process of drying up. Water willows were particularly abundant and furnished much of the organic matter of the water upon their decay.

5. Station 1 looking west, parallel to highway U. S. 50S.

6. Station 2 looking west from drive shown in Figure 1.

Station 2

Of all ditches included in this study, the water level of station 2 (Figs. 6, 7, and 8) receded the most slowly. This is probably due to seepage from the limestone strata in the bordering hills. It has not dried up for at least two years but does so in extremely dry seasons. This ditch is divided by a drive (Fig. 1) but the water is continuous through a concrete tube (Fig. 7). The vegetation was essentially the same as at station 1 except that cattails were lacking and the water willows were restricted to narrow groups along the sides. Cottonwood trees were lacking except at the extreme eastern end. Willow trees were confined to the western third of the ditch. Fishes were particularly abundant.

Station 3

The water level fluctuates more in station 3 (Fig. 9) than in any of the other stations. During the time that station 2 receded less than one foot, station 3 receded more than two and one-half feet. This station, as station 2, seldom dries up. The vegetation was essentially the same as at station 2 except that willow trees were almost entirely lacking and the cottonwood trees were restricted to the extreme eastern end.

7. Station 2 looking northwest toward drive. Concrete tube under drive.

8. Station 2 looking east from drive shown in Figure 1.

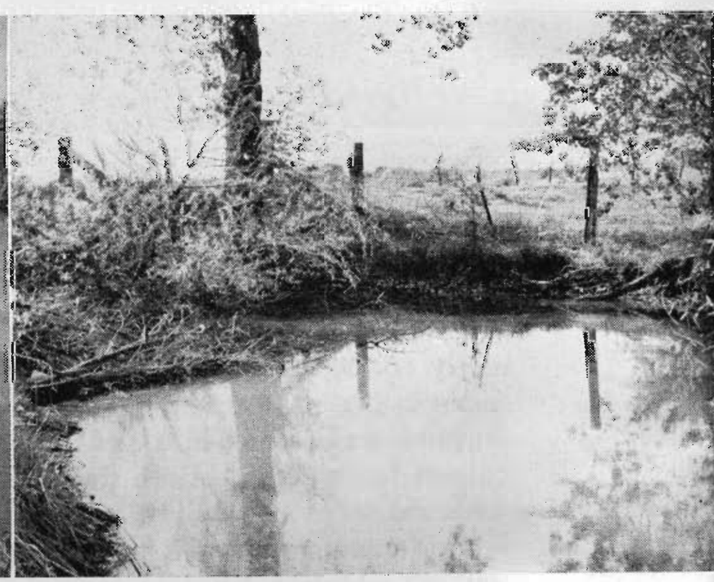
Stations 4 and 5

Station 4 (Figs. 10 and 11) and station 5 (Figs. 12 and 13) are separated by a driveway and at periods of heavy rainfall are directly connected through two concrete tubes under the drive. It seems apparent that station 4 is spring-fed except during dry periods, because water runs in a small steady stream from it through the culvert to station 5. Both stations are lined on each side with cottonwood trees and willow trees. No aquatic spermatophytes were in evidence in station 4, but station 5 had a single clump of water willows. Station 4 has an occasional algal pulse made up primarily of *Spirogyra.* Both stations have much decaying organic matter due mostly to dead branches and leaves that have fallen from the trees. Station 4 is normally clear but station 5 is usually quite turbid. The fishes in both stations seemed in poor physical condition but were more numerous in station 5 than in station 4.

STATION 6

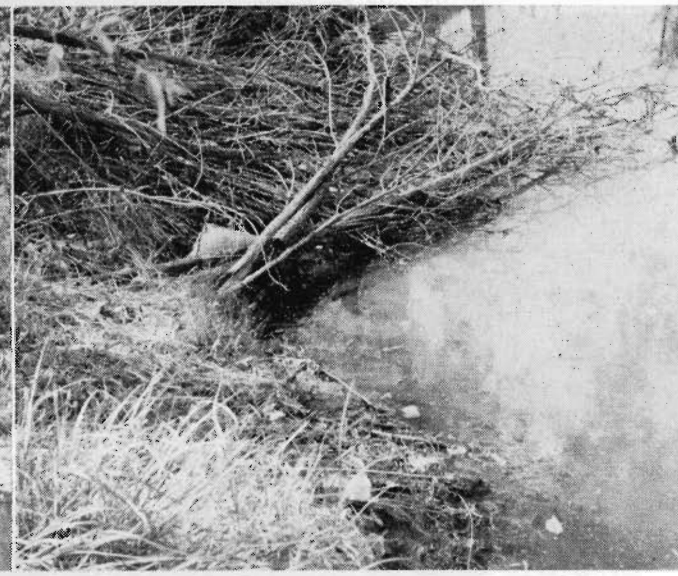
Station 6 (Fig. 14) differs from any of the other stations in that trees, aquatic spermatophytes, or perennial grasses were not present. As a ditch it has been there only since the summer of 1948 when Highway US 50S was rebuilt and rerouted to the north. This would account for the scarcity of most plants common to the other five collection areas. The dominant plant was smartweed, *Polygonum longistylum* Small; others of importance were annual sunflower, *Helianthus annuus* L., white sweet clover, *Melilotus alba* Desr., yellow sweet clover, *M. officinalis* (L.), and giant ragweed, *Ambrosia trifida* L. This station could hardly be called a ditch since it is merely a depression with gently sloping sides with its width about 200 times its depth. Until it dried up in mid-November, station 6 contained an abundance of small sunfishes, mostly *Lepomis humilis* (Girard), and several small carp, *Cyprinus carpio* L. In the spring an abundance of frog eggs, from which may frogs, *Rana pipiens* (Baird), developed, were observed. The tadpoles survived remarkably well and by the time the water level had receded to three to four inches the immediate surrounding area was teeming with young frogs.

9. Station 3 looking east. Cottonwood trees in left background.



10. Station 4 looking northeast.

11. Station 4 looking west from drive. Shiny area in background is floating algae.



12. Station 5 northwest corner with trash in water.

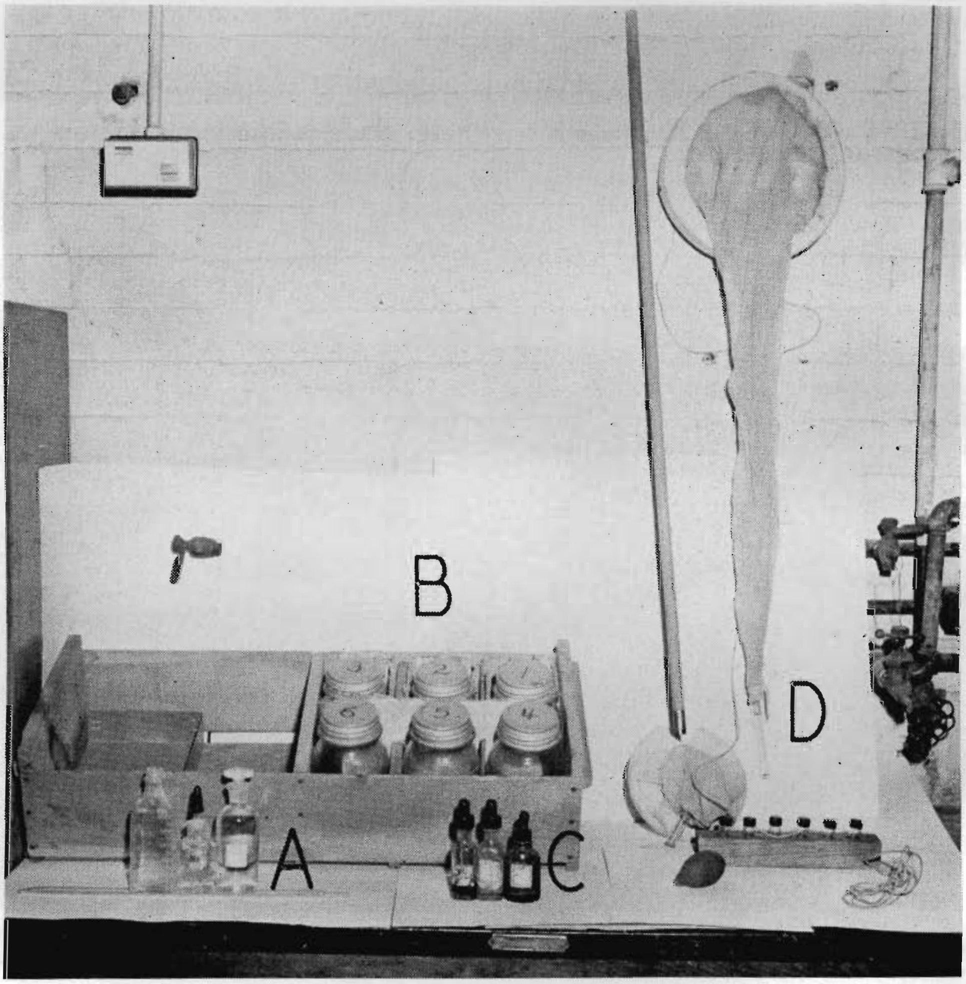
13. Station 5 looking east. Typical summer vegetation.

14. Station 6 looking east. Vegetation in foreground is clover. Highway U. S. 50S is on elevated grading at left.

Methods and Materials

COLLECTION AND PRESERVATION OF PLANKTON

Each station was visited from one to four times per month for the period from March 23, 1950, to March 22, 1951. During periods of little weather change, collections were taken once each month; but during rainy periods and in the spring and fall, collections were taken as many as four times per month. Plankton samples were taken at various depths with a plankton tow net and a small dip net. Both nets were constructed of bolting silk with 50 meshes per inch (Fig. 15). All plankton samples were preserved in five milliliter vials (Fig. 15, part D) with a solution of 95 percent ethyl alcohol and five percent glycerin and were labeled according to station number and date of collection.

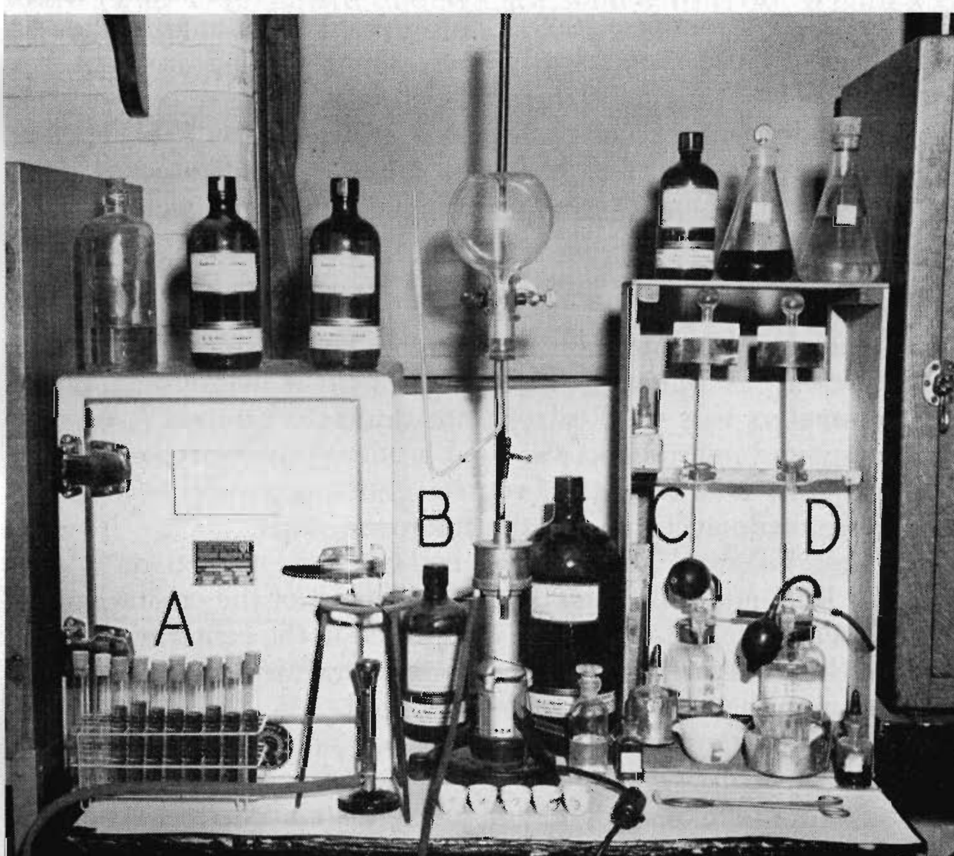


15. Limnological apparatus used in the field.
    A. Materials for free carbon dioxide determination.
    B. Containers for taking larger samples of water to the laboratory.
    C. Chemicals for dissolved oxygen determination.
    D. Tow net and bottles for plankton samples.

COLLECTION AND ANALYSIS OF WATER SAMPLES

Water samples were collected at or near the surface at the same time plankton samples were taken. None were taken during May, 1950. All chemical determinations of water samples were accomplished according to methods given in *Laboratory Manual for Chemical and Bacterial Analysis of Water and Sewage* by Theroux, Eldridge, and Mallman, 1943, pages 8-11, 38, and 144-147. The following data were recorded: water temperature, pH, total hardness, free carbon dioxide, phenolphthalein and methyl orange alkalinity, dissolved oxygen, and seston—total, organic and inorganic.

The Winkler method was used for dissolved oxygen determinations and the results were converted to percent saturation according to Rawson's nomogram in *Limnological Methods* by Welch, 1948, page 366. Free carbon dioxide was determined at the time of collection; and at this time the dissolved oxygen was run up to and



16. Limnological apparatus used in the laboratory.
    A. Color comparator for determining pH.
    B. Centrifuging equipment, crucibles, Bunsen burner, and oven used in seston determination.
    C. Titration equipment for alkalinity determination.
    D. Titration equipment for completing the dissolved oxygen determination that was begun in the field.

including the addition of sulphuric acid. Water temperatures, taken with a mercury bulb thermometer, were also determined at the time of collection. Water for the remainder of the limnological tests was transported to the laboratory in one-quart Mason jars (Fig. 15, part B).

Determinations of pH during March and April were made with a Coleman pH meter which employs a continuous type quinhydrone electrode. It was abandoned in favor of the simpler colorimetric methods using bromcresol purple and phenol red indicators with standard colors (Fig. 16, part A). During May, June, July, December, and January pH determinations were not recorded.

Seston was quantitatively determined by centrifuging a 500 ml. sample in a Foerst centrifuge at approximately 15,000 rpm. The centrifugate was placed in weighed porcelain crucibles, dried in an electric oven at 103° F. overnight, cooled and weighed again (Fig. 16, part B). The difference in weights was the total seston, called total residue by Pennak, 1949. The crucibles containing the dry seston were placed over a carbon-free flame, cooled and weighed again. The loss in weight due to ignition was the organic seston. The remainder was the inorganic seston, called ash by Pennak, 1949. All weights were recorded to 0.0001 gram and indicated as milligrams per liter. Quantitative organic and inorganic weights were converted to percents of total seston.

IDENTIFICATION OF ORGANISMS

Each plankton sample was poured into a Petri dish for preliminary identification. A binocular microscope with a magnifying power of 30 diameters was used to separate similar organisms. An ordinary compound microscope was used in identifying species.

Permanent whole mounts of representative copepods and cladocerans were made according to the following steps:

1. Three layers of slide-ringing cement were placed on a glass slide to a little more than the thickness of most of the crustaceans.
2. A small amount of glycerin was placed in the center of the ring. Just a little less than a drop at room temperature—the amount depending upon the size of the ring—was used.
3. Several organisms which under the binocular microscope appeared to be of the same species were placed in the glycerin in the center of the ring. Small flattened loops of stainless steel wire were used to transfer specimens from the Petri dish to the slide.
4. Another layer of slide-ringing cement was placed on the ring to insure the security of the cover slip.
5. A cover slip was placed gently over the glycerin with a small forceps. This eliminates small bubbles that occur when the cover slip is dropped into place.

6. After the glycerin had spread out under the cover slip a sealer of slide-ringing cement was applied to the edge of the cover slip.

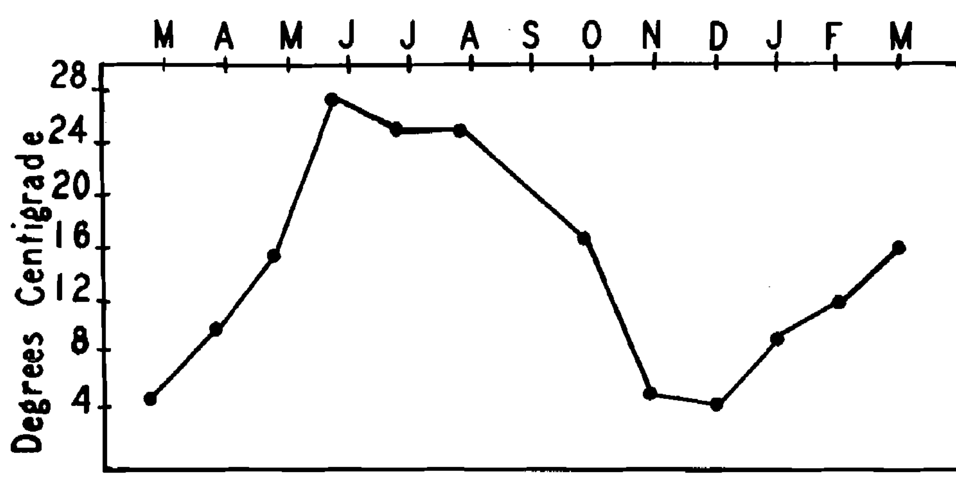
7. The slide was labeled according to species, date collected, and station where collected.

Microcrustaceans were identified according to unpublished keys and figures of Pennak, 1951, and with the aid of keys by Birge, 1918, and Marsh, 1918. Plants were identified according to Fernald, 1950. Fishes were identified according to Hubbs and Lagler, 1947.

Results and Discussion

PHYSICAL CONDITIONS

Water temperatures (Fig. 17) varied from 1° C. on March 30 and November 11, during which times ice covers were present, to 30° C. on June 12 which was during the warmest month included in this study (Fig. 17). These findings are similar to those reported by Leonard and Ponder, 1949, and Pennak, 1949. The maximum readings were five to seven degrees higher than those recorded from Lake Erie by Chandler, 1942 and 1944.



17. Average monthly water temperature for six roadside ditches, 1950-'51.

Turbidity of water is due to suspended matter, such as clay, silt, finely divided organic matter, and micro-organisms; and turbidity is measured in terms of the depth of water through which a standard light source is visible. It is apparent, since seston is made up of much the same material that determines turbidity, that a direct relationship exists between turbidity and seston readings. For this reason direct turbidity readings were not made a part of this study.

CHEMICAL CONDITIONS

Hydrogen ion concentration. According to Pennak, 1949, and others, determinations of pH by indicators and standard colors are subject to an error of ± 0.1 pH unit. Since microcrustaceans apparently survive wide pH ranges, exact determinations are not necessary for most limnological studies. As shown in Table II, no definite upward or downward trends in pH are apparent. In general, the readings do not vary much from a mean pH of 7.7 and all of them are in the 7.1 to 8.0 range. The greatest range is from 7.1 to 7.9 in station 6, and the smallest range is from 7.6 to 8.0 in station 2. These values are approximately 0.3 pH unit below that reported by Scott, 1927, who also found that pH is an index of the relative plankton content, maximum and minimum coinciding with maximum and minimum plankton distribution. Juday, Birge, and Meloche, 1935, reported a pH range of 4.4 to 9.4 on the surface. Dexter, Shilling, and Sanner, 1942, reported a pH range of 6.8 to 8.3 with an average of 7.7. They found that the pH fluctuation followed that of temperature and believed it to be correlated with photosynthetic activity. Underhill, 1939, found a pH range of 5.7 to 6.1 in a stagnant pool. He stated that increase in pH can be explained by the loss of carbon dioxide through aeration or photosynthesis, and decrease in pH to accumulation of carbon dioxide as a result of organic decay.

TABLE II. Determinations of pH in six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Aug.	Sep.	Oct.	Nov.	Feb.	Mar.
1........	7.4	7.7	7.8	7.4	7.9	7.9	7.8	7.7
2........	7.7	7.7	7.6	7.8	8.0	8.0	7.6	7.6
3........	8.0	7.8	7.5	7.5	7.9	7.8	8.0	7.5
4........	8.0	7.9	7.4	7.5	8.0	8.0	7.9	7.5
5........	8.0	7.7	7.4	7.4	8.0	8.0	7.9	7.5
6........	7.9	7.7	7.9	7.4	7.3	7.3	7.1	

Total Hardness. Table III shows the total hardness as determined by the soap method. These readings are accurate only to the extent that substances in the water will combine with soap. The readings were consistently high for all stations. The lowest readings were obtained from station 6 which consistently had lower readings than the other stations. These high readings were probably due to the presence of lime in the water. Station 6, which had the lowest total hardness readings, was farthest from the limestone bearing hills. Readings varied up to 186 ppm. from one month to the next. They ranged from 100 ppm. in station 6 in February to 400 ppm. in station 4 in October. The lowest average hardness was 155 ppm. at station 6. The highest average hardness was 306 at station 4. The average for six stations was 254 ppm.

TABLE III. Total hardness in ppm. for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1....	202	313	352	268	260	280	240	340			240	270
2....	214	282	263	224	270	300	280	320	280	200	240	310
3....	124	338	205	148	240	220	200	240	240	180	200	270
4....	247	276	338	246	320	330	400	360	300	200	340	310
5....	240	298	273	219	300	305	240	360	300	220	310	310
6....	112	298	172	121	120	115	160	200			100	

Free carbon dioxide. Table IV shows the free carbon dioxide in ppm. as $CaCO_3$. Station 4 generally had more free carbon dioxide than the other stations; this was probably due to the abundance of algae and other decaying organic matter. Station 6, which had the least apparent decaying vegetation, had the least free carbon dioxide. These results indicate considerably more than the 0.0 to 4.0 ppm. free CO_2 reported by Chandler, 1942 and 1944, and 0.8 to 2.4 ppm. free CO_2 reported by Pennak, 1949. Results similar to this study were reported by Pennak, 1949, and by Juday, Birge, and Meloche, 1935. In general, greater quantities of free CO_2 occurred during the summer months, when bacterial decay was most rapid, and little or none occurred during the cooler months.

TABLE IV. Free carbon dioxide in ppm. as $CaCO_3$ for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1.....	0	1	3	7	15	19	10	8			8	2
2.....	0	4	5	7	11	11	9	0	1	0	6	0
3.....	0	2	2	3	6	8	3	1	1	1	3	0
4.....	0	1	4	10	22	8	25	5	2	2	24	0
5.....	0	2	3	10	8	11	15	7	1	4	9	2
6.....	0	0	1	1	1	1	4	2			2	

Alkalinity. Total alkalinity is the sum of the carbonate and bicarbonate ions plus the presence of hydroxides, borates, silicates, and phosphates to a lesser degree. According to Pennak, 1949, and Juday, Birge, and Meloche, 1935, "bound" and "half bound" carbon dioxide refer respectively to that carbon dioxide which converts CaO to $CaCO_3$ and that which converts $CaCO_3$ to $Ca(HCO_3)_2$. Table V shows phenolphthalein alkalinity for the six Kansas roadside ditches. Phenolphthalein alkalinity was consistently present only during early spring months. Chandler, 1942 and 1944, reported carbonate alkalinity readings from 0.0 to 5.3 ppm. and 1.0 to 5.0 ppm., respectively, in western Lake Erie.

TABLE V. Phenolphthalein alkalinity in ppm. as $CaCO_3$ for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1....	17	0	0	0	0	0	0	0			0	5
2....	12	11	0	0	0	0	0	0	0	0	0	0
3....	12	6	0	0	0	0	0	0	0	0	0	0
4....	26	1	4	10	0	0	0	0	0	0	0	0
5....	22	12	0	0	0	0	0	0	0	0	0	0
6....	6	0	0	4	0	2	0	0			0	

Table VI shows the methyl orange alkalinity. The readings were lowest during April in all stations except 6, which exhibited its lowest reading in February. The highest readings from stations 1, 5, and 6 occurred in November, the highest reading from station 3 in March, 1950, the highest reading from station 4 occurred in October, and the highest reading from station 2 occurred in December. The readings ranged from 50 ppm. in station 6 in February to 395 ppm. in station 4 in October. In general, the methyl orange alkalinity was high. Station 4 consistently gave highest readings while station 6 gave consistently lower readings. Tressler and Bere, 1935, re-

TABLE VI. Methyl orange alkalinity in ppm. as $CaCO_3$ for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1....	269	87	183	196	225	260	265	290			220	210
2....	256	96	140	154	250	268	265	267	270	160	225	250
3....	223	90	105	102	213	213	204	213	205	170	163	215
4....	258	121	210	228	354	314	395	377	345	250	377	270
5....	255	122	125	175	286	309	332	345	335	270	325	315
6....	95	61	114	67	96	100	164	170			50	

ported maximum methyl orange alkalinity readings of 56 ppm. which they considered soft water. Tressler and Bere, 1933, reported less than 20 ppm. maximum methyl orange alkalinity. Chandler, 1942 and 1944, reported bicarbonate alkalinity as 83 to 94 ppm. and 80 to 93 ppm. respectively.

Dissolved oxygen. Tables VII and VIII show the trends of dissolved oxygen in some Kansas roadside ditches. In these ditches the greatest part of the dissolved oxygen in the water probably was the result of photosynthetic activity and absorption from the air. The amount of dissolved oxygen varied from 2.6 ppm. in station 4 on October 18, to 18.0 ppm. in station 1 on March 22, 1951. The percent saturation varied from 26 percent in station 4 on October 18, to 160 percent in station 1 on August 10, and in station 6 on July 17. On March 22, 1951, the percent saturation was in excess of 160 percent at station 1. Chandler, 1944, reported dissolved oxygen readings from 7.1 to 14.7 ppm. with saturations of 80 to 145 percent. Pennak, 1949, reported readings of 1.5 percent to 267 percent saturation. Juday and Birge, 1932, reported 3.4 to 12.4 ppm. or 34 to 129 percent saturation. Smith, 1934, reported that the addition of one-fourth gram of organic fertilizer per liter reduced dissolved oxygen to below 2.5 cc. per liter at 13° to 25° C. The addition of phytoplankton, however, increased the dissolved oxygen so that 2.5 cc. per liter were present with 1.25 grams per liter of fertilizer.

TABLE VII. Dissolved oxygen in ppm. for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1...	11.8	10.9	6.3	11.0	9.1	9.0	3.0	6.2			9.0	18.0
2...	13.3	11.9	8.7	7.8	6.6	7.1	6.0	12.4	11.4	12.0	7.6	12.0
3...	12.6	10.6	8.0	8.3	9.8	9.6	7.0	11.7	11.2	10.4	11.6	10.8
4...	11.3	9.9	9.7	9.9	6.5	9.6	2.6	8.8	11.2	12.2	9.6	14.0
5...	12.7	11.0	8.4	8.6	11.3	12.0	3.2	8.6	16.6	11.0	10.4	12.4
6...	11.6	12.6	8.4	11.8	9.0	8.8	3.8	11.9			7.0	

The trend was for the amount of dissolved oxygen to be greatest during the cooler months of the year and least during the summer months (Table VII). This was similar to results reported by Pennak, 1949. The percent of saturation varied from 26 percent to highly supersaturated (Table VIII). A departure from the normal in the trends indicated by Tables VII and VIII occurred during October. A possible explanation for this drop in dissolved oxygen was the shorter periods of daylight in October which would have resulted in less photosynthesis. Much decay of algae, leaves, and other organic material occurred in the water during October. Station 4, which was most shaded and contained much *Spirogyra*, exhibited the lowest dissolved oxygen readings.

TABLE VIII. Dissolved oxygen in percent of saturation for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1....	90	84	76	131	109	97	30	49			80	*
2....	99	105	110	93	82	80	62	95	85	105	65	148
3....	95	94	101	103	120	104	73	86	88	90	105	105
4....	87	87	84	124	78	95	26	60	88	110	90	140
5....	97	94	103	102	52	100	32	65	120	93	98	118
6....	105	105	109	147	45	101	37	93			70	

* Saturated in excess of 160 percent.

SESTON

Table IX shows the total seston measured in milligrams per liter. There are not apparent trends in amounts, but rather, fluctuations are the rule. Station 6 generally exhibited higher total seston readings than the other five stations. This was probably due to its comparatively great area and its shallowness so that winds could more easily keep the water stirred so that the bottom materials were easily resuspended. The total seston varied from 11.4 mg./liter at station 3 in December to 195.8 mg./liter at station 6 in April. Average total seston was 53.8 mg./liter. Pennak, 1949, found a total seston range from 36.3 mg./liter to 5480.4 mg./liter in seven Colorado reservoir lakes. Pennak also concluded that seston is the most reliable and least variable measure of the standing crop of plankton.

TABLE IX. Total seston in mg./liter for six roadside ditches, 1950-'51.

Sta.	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1...	19.4	65.0	96.1	46.8	35.2	47.6	89.2	52.5			16.4	27.4
2...	22.1	60.4	37.8	47.7	28.4	28.9	62.6	38.4	12.2	43.8	24.0	40.0
3...	34.4	53.7	72.5	65.8	29.8	31.4	45.8	39.8	11.4	68.4	61.4	64.0
4...	29.5	52.8	50.2	26.7	42.2	107.0	51.4	46.6	36.2	23.0	23.6	17.2
5...	59.4	81.2	62.8	90.1	32.7	54.4	63.0	60.0	85.6	49.0	56.6	77.2
6...	25.9	195.8	127.9	74.2	71.4	87.4	107.4	60.8			70.4	

Table X shows the percent of organic seston which is the weight lost due to ignition. The organic seston varied from 13 percent at station 6 in April to 79 percent at station 2 in December. The average organic seston was 37 percent or 19.9 mg./liter. Pennak, 1949, found an organic seston range from 5.4 mg./liter to 828.7 mg./liter and a percent range from 6.2 to 20.5 percent.

TABLE X. Organic seston in percent of total seston for six roadside ditches, 1950-'51.

Station	Mar.	Apr.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1....	25	31	21	19	33	35	19	34			20	39
2....	25	20	32	23	38	55	19	49	79	35	28	37
3....	25	27	25	22	28	41	23	49	63	23	17	57
4....	24	59	23	20	33	23	19	39	41	56	29	50
5....	26	19	34	24	34	39	19	32	30	32	27	28
6....	23	13	17	35	18	25	14	32			28	

ZOOPLANKTON

Copepoda. Only five species of copepods collected from six roadside ditches were identified. Tables XI, XII, XIII, XIV, XV, and XVI show the relative abundance of copepods and cladocerans according to month of collection. Brooks, 1947, reported 13 species

TABLE XI. Monthly presence of copepods and cladocerans in station 1, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Paracyclops fimbriatus	O	A	D	A	A	A	A	D	D				D
Macrocyclops ater	D	D	O	A	A	A	A		O			D	O
Eucyclops prasinus		O	O	A	O	O							
Diaptomus clavipes		A		D	D	O	D	O	O			O	
CLADOCERANS													
Ceriodaphnia laticaudata		A		A	A	O			O				
Ceriodaphnia reticulata		O		O			O	O					
Daphnia longispina		O		O	O	O	A					O	
Chydorus sphaericus		O		A	O	O			O				
Bosmina longirostris		O		A	A		A	O	O			O	
Pleuroxus denticulatus		O				D	O	O	O				
Scapholeberis mucronata				O		O	O	O	O				
Kurzia latissima					O	A	O		O				
Simocephalus vetulus					O								
Pleuroxus hamulatus						O							
Moina micrura						O							
Diaphanosoma brachyurum							O						
Leydigia quadrangularis									A				
Macrothrix laticornis									O				

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

TABLE XII. Monthly presence of copepods and cladocerans in station 2, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Eucyclops prasinus	D	D	D	A	A	A	O	A	A	O	O	O	O
Paracyclops fimbriatus	O	O	A	O	O		O	O	A	O		A	D
Diaptomus clavipes		O		A	D	O	A	O	A	O	A	O	O
Macrocyclops ater							O	O	A		O		
Cyclops bicuspidatus											O		
CLADOCERANS													
Daphnia longispina	O	O	O	O	O	O	O	O	A	O	O	O	O
Pleuroxus denticulatus	O				A					O	O		O
Bosmina longirostris		O		D	A	O	D	D	D	D	D	D	O
Chydorus sphaericus		O	O	O	O	A				O	O		O
Ceriodaphnia reticulata		O						O	A	O	O	O	
Ceriodaphnia laticaudata		O			O	O	O		A				
Simocephalus vetulus		O	O			O			O				
Diaphanosoma brachyurum				A	A	D	A	O	O				
Moina rectirostris				A	O								
Scapholeberis mucronata				O		O							
Leydigia quaerangularis				O									
Alona quadrangularis						O							

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

TABLE XIII. Monthly presence of copepods and cladocerans in station 3, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Paracyclops fimbriatus	D	D	O	O	O	O	A	O	A	O	A	D	D
Diaptomus clavipes	O	O	O	A	A	D	A	D	D	D	A	O	O
Eucyclops prasinus	O	O	D	O		A	A	O	O	O	D		O
Macrocyclops ater			O	A	O	O	O	O	O		O		
CLADOCERANS													
Daphnia longispina	O	O	O	A	A	A	D	O	A		A	O	O
Chydorus sphaericus	O	O	O	O		A	O	O	O	O		O	O
Alona quadrangularis	O	O		O									
Bosmina longirostris		O	O	O		A	O	O	O	O	A	O	O
Simocephalus vetulus			O	A		O							
Moina rectirostris				D	D	A	O						
Diaphanosoma brachyurum				A	A	O	A	O	O				
Scapholeberis mucronata				O	A	A							
Pleuroxus denticulatus						O	O			O		O	
Ceriodaphnia reticulata						O	A		O				

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

of copepods from Lyon County State Lake and Leonard and Ponder, 1949, reported six species from some roadside ditches near Lawrence, Kan. Pennak, 1949, reported only two species from seven Colorado reservoir lakes.

Of the five species collected during this study, *Cyclops bicuspidatus* Claus was found only in station 2 and during January and March, 1951, only. The other four species were found in all stations at most times.

Paracyclops fimbriatus (Fischer) was the most common copepod, being dominant in stations 3 and 4 in March and April, in stations 1 and 4 in May, in stations 4 and 5 in September, in station 1 in October, in stations 1 and 6 in November, 1950, in station 3 in February, and in stations 1, 2, and 4 in March, 1951.

Diaptomus clavipes Schacht was dominant in stations 1 and 6 in June and September, in stations 1 and 2 in July, in station 3 in August, October, November, and December, 1950, and in station 4 in February, 1951.

Eucyclops prasinus (Fischer) was dominant in stations 2 and 6 in March and April, in stations 2 and 3 in May in 1950, and in station 3 in January, 1951.

Macrocyclops ater (Herrick) was dominant in station 1 in March and April in 1950, in February, 1951, and in station 6 in July, 1950.

Cladocera. Sixteen species of cladocerans collected from the six roadside ditches were identified. Brooks, 1947, reported 19 species from Lyon County State Lake and Leonard and Ponder, 1949, reported 12 species from some roadside ditches near Lawrence, Kan. Pennak, 1949, reported five species from seven Colorado reservoir lakes.

Bosmina longirostris (O. F. M.) was dominant in station 2 in June, September, October, November, and December, 1950, and in January and February, 1951, in station 4 in October, November, and December, 1950, and in January, 1951, in station 5 in October, November, and December, 1950, and January, February, and March in 1951, and in station 6 in October, 1950, and February, 1951.

Moina rectirostris (Leydig) was dominant in station 5 in March, April, and May of 1950.

Diaphanosoma brachyurum (Lieven) was dominant in station 2 in August and in station 5 in August and September, 1950.

Pleuroxus denticulatus Birge was dominant in stations 1 and 4 in August, 1950.

Daphnia longispina (O. F. M.) was dominant in station 3 in September, 1950.

Of the 10 species which were not dominant at any time during the study, *Ceriodaphnia reticulata* (Jurine) and *Scapholeberis mucro-*

nata (O. F. M.) were present in all six stations; *Simocephalus vetulus* (O. F. M.) was present in stations 1, 2, 3, 4, and 5; *Alona quadrangularis* (O. F. M.) was present in stations 2, 3, 4, 5, and 6; *Ceriodaphnia laticaudata* P. E. Muller was present in stations 1 and 2; *Kurzia latissima* (Kurz) was present in stations 1, 4, and 5; *Leydigia quadrangularis* (Leydig) was present in stations 1, 2, and 4; *Macrothrix laticornis* (Jurine) was present in stations 1 and 5; *Moina micrura* Kurz was present in station 1; and *Pleuroxus hamulatus* Birge was present in station 1.

Comparison of Tables XIV, XV, and XVI, and Figure 17 indicates a positive relationship between the dominance of *Moina rectirostris* and the highest water temperatures encountered during the study. This species was dominant only when water temperatures were above 25° C. No other relationships between the dominance of any species of microcrustacean and any other condition were made apparent by this study.

TABLE XIV. Monthly presence of copepods and cladocerans in station 4, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Paracyclops fimbriatus	D	D	D	O	O		D	O	O	O	A	O	D
Eucyclops prasinus	A	O	O	O	O	A	A	O	O	O	O	A	
Diaptomus clavipes	O	A	O	A	A	O			O		O	D	
Macrocyclops ater	O	O			O	O	O	O	A	O	O	O	
CLADOCERANS													
Chydorus sphaericus	A	A	O	O	O	O	O		O			O	O
Daphnia longispina	O					O		O	O		O	O	
Alona quadrangularis	O												
Bosmina longirostris		O		A	O		O	D	D	D	D	A	
Pleuroxus denticulatus		O	O	O	O	D	A		O				
Ceriodaphnia reticulata		O						O	A		O		O
Moina rectirostris				D	D	A	O		O				
Diaphanosoma brachyurum					O		A	O	O	O			
Kurzia latissima					O								
Leydigia quadrangularis					O								
Scapholeberis mucronata						A	O	O					

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

TABLE XV. Monthly presence of copepods and cladocerans in station 5, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Paracyclops fimbriatus	A	A	A	A	A	A	D	A	A	A	A	A	A
Eucyclops prasinus	A	A	A	A	A	A	A	A	A	A	A	A	A
Macrocyclops ater	A	O	O	O	O	O	A	A	A	A	A	A	A
Diaptomus clavipes	O	O	O	A	A	O	O	O	A		O	O	O
CLADOCERANS													
Chydorus sphaericus	D	D	D	A			O	A	A	O	O	O	A
Bosmina longirostris	O		O	O	O	A	A	D	D	D	D	D	D
Pleuroxus denticulatus	A		O	O	O	O	A		A	O			
Macrothrix laticornis	A			O	O							O	O
Alona quadrangularis	O							O	A				
Daphnia longispina			O			O		O	A	O			O
Moina rectirostris				D	D	A	O	O	O				
Diaphanosoma brachyurum				A	A	D	D	A					
Simocephalus vetulus				O			O		A	O	O	O	O
Scapholeberis mucronata				O	O	A							
Ceriodaphnia reticulata					O	O	A	O	O	O			
Kurzia latissima					O	O							

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

TABLE XVI. Monthly presence of copepods and cladocerans in station 6, 1950-'51.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
COPEPODS													
Eucyclops prasinus	D	D	O	O	O	O	A						
Diaptomus clavipes	A			D	A	A	D	O					
Macrocyclops ater		O	O	O	D				O				
Paracyclops fimbriatus					O		A	O	D			O	
CLADOCERANS													
Alona quadrangularis	A	O	O			O	A	O					
Chydorus sphaericus	A		O					O					
Pleuroxus denticulatus		O	O										
Scapholeberis mucronata			O				O						
Daphnia longispina				A				O					
Ceriodaphnia reticulata					O	O							
Moina rectirostris					A	D		O	O				
Diaphanosoma brachyurum						O	O						
Bosmina longirostris								D	A			D	

Key to symbols: D—outnumbered all other species.
A—abundant.
O—present in very small numbers.

Zooplankton was abundant at most times at all stations during the year. Station 6, however, was consistently low in plankton production.

Summary

1. The monthly limnological conditions for six roadside ditches in Chase and Lyon Counties, Kansas, were studied for the period March 23, 1950, to March 22, 1951, inclusive. All six ditches are in the flat land along the Cottonwood River. Two of the ditches have a maximum average depth of about four to five feet and seldom dry up. Two of the ditches dry up nearly every year and two dry up only occasionally.

2. Monthly determinations of water temperature, pH, total hardness, free carbon dioxide, phenolphthalein and methyl orange alkalinity, dissolved oxygen, and seston were made. In addition, qualitative determinations of the copepods and cladocerans were made.

3. Monthly average water temperatures varied from 4° C. to 27° C. The mean water temperature was about 15° C.

4. Determinations of pH varied from 7.1 to 8.0 with an average for the 13 months of 7.7. The pH was about the same in all ditches.

5. Total hardness as determined by the soap method ranged from 100 ppm. to 400 ppm. The average total hardness was 254 ppm. One station varied only 100 ppm. to 298 ppm. with an average of 155 ppm. for the year. The average for the other five stations was 266 ppm.

6. Free carbon dioxide varied from 0.0 to 25.0 ppm. The greatest amounts were present during late summer and early fall.

7. Phenolphthalein alkalinity varied from 0.0 to 26.0 ppm. The average was 2.24 ppm. Readings of 0.0 were recorded for most times except during the spring months. Methyl orange alkalinity varied from 50 ppm. to 395 ppm. The average was 217 ppm. The greatest amounts were present during late summer and fall. One ditch had a variation of only 50 ppm. to 170 ppm. with an average of 102 ppm. The average for the other five ditches was 235 ppm.

8. Dissolved oxygen varied from 2.6 ppm. to 18.0 ppm. The average was 9.9 ppm. Dissolved oxygen was least during October when the average for the six ditches was 4.3 ppm. The greatest amounts occurred during the winter and early fall. The percent of saturation varied from 26 percent to more than 160 percent. The average was 85 percent. In October the saturation varied from 26 percent to 73 percent with an average of 44 percent.

9. Total seston varied from 11.4 mg./liter to 195.8 mg./liter. The average was 51.1 mg./liter. The greatest amounts were in station 6 which was shallow and had a great surface area. It was so variable

in the other stations that no trends were apparent. The organic seston ranged from 13 percent to 79 percent. The average was 30 percent.

10. Lower zooplankton production in station 6 was coincident with lower total hardness, lower methyl orange alkalinity, and lower organic seston.

11. *Moina rectirostris* was dominant only during the months when water temperatures were above 24° C.

12. *Paracyclops fimbriatus, Eucyclops prasinus,* and *Macrocyclops ater* were dominant only during the months when water temperatures were low.

13. *Diaptomus clavipes* was dominant over a wide temperature range but was most common in warmer water.

14. *Chydorus sphaericus* was present at most times but was dominant only in station 5 in the spring.

15. *Bosmina longirostris* was the most abundant crustacean collected.

16. *Diaphanosoma brachyurum, Daphnia longispina,* and *Pleuroxus denticulatus* were dominant only during late summer.

17. *Scapholeberis mucronata* and *Kurzia latissima* were collected only during summer and fall.

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