FOOD OF CHIRONOMID LARVAE IN POLK COUNTY LAKES [1]

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The lakes of the Winter Haven area of Polk County, Florida, produce Chironomidae (= Tendipedidae), locally called "blind mosquitoes", in large numbers. *Glyptotendipes paripes* predominates, and *Tendipes decorus* is the most common of the lesser species. In the summer of 1956 a preliminary survey was made to determine whether nutrient effluents were the cause of eruptions of chironomid populations. Limnological and entomological assessments were made concurrently on thirteen lakes. Larval stomachs of *G. paripes* and *T. decorus* were studied for comparisons of food with the lake planktons. Larvae collected in January 1957 were then used for seasonal comparisons, although the plankton was not sampled at that time for lack of personnel.

The summer field work was done by two men: E. H. McConkey of the State Board of Health's Bureau of Entomology did the limnological work and Harry J. Hutton of the Polk County Arthropod Control Program did the larval sampling and lake bottom survey. Assistance in the ion measurements was rendered by the Bureau of Laboratories of the State Board of Health while the Bureau of Sanitary Engineering advised on B.O.D. and O_2 measurements. Plankton determinations and counts, in water samples and in stomachs, were made by the junior author. The winter larval collections were made, again, by Harry J. Hutton.

I. THE LAKES

Since it was desirable to learn the role of pollution in chironomid production, the study lakes were selected as follows: *Undisturbed*, Lakes Thomas (Auburndale) and "X" (Lake Wales); *"Industrial"*, with canning plants only significant nutrient source, Lakes Tracy (Haines City) and Conine (Winter Haven); *"Citrus"*, grove fertilizer runoff only significant nutrient source, Lakes Tennessee (Auburndale) and "Y" (Lake Wales); *"Septic-tank"*, with non-sewered homes only possible nutrient source, Lakes Deer (Winter Haven) and Lena (Auburndale); *"Sewage-plant"*, receiving effluents from sewage-treatment plants, Lakes Gibson (Lakeland) and Effie (Lake Wales); *"Chain-o-lakes"*, interconnected lakes with sewage-treatment plant, canning plants, septic tanks, and fertilizer run-off all as possible nutrient sources, Lakes Cannon, May, and Lulu (Winter Haven). Morphometric, limnological, and chironomid surveys were made on these 13 lakes in the summer of 1956.

The lakes varied from 3 to 635 acres in size and 4 to 22 feet in maximum depth. They were mostly quite turbid, with Secchi disc visibilities running from 6 inches to 4 feet in all but the two undisturbed lakes where they were 5 to 12 feet. Water temperatures (summer) ranged from 26.5° C to 32.0° with little change from surface to bottom. The pH readings ranged from 4.4 to 9.5, the two undisturbed lakes being quite acid (4.4-5.0) and the 11 disturbed lakes being circumneutral to basic. Alkalinity was low in the undisturbed lakes (6-9 p.p.m.) and medium (max. 197 p.p.m.) in the disturbed lakes. Dissolved oxygen one foot off the bottom ranged from zero

[1] Contribution No. 63 of the Florida State Board of Health, Entomological Research Center, Vero Beach.

to 14.1 p.p.m. and from 0 to 191% saturation, the supersaturations associated usually with algal blooms. The biological oxygen demand (B.O.D.) ranged as a means from 0.4 p.p.m. in the undisturbed lakes to 11.4 (7.6-19.0) p.p.m. in the lakes with sewage-treatment plants. Potassium ranged from 0.4 to 0.8 p.p.m. in the undisturbed lakes and from 1.4 to 4.9 p.p.m. in the disturbed lakes. Phosphates ran from 0 to 2.0 p.p.m. and ammonia from 0.05 to 0.57 p.p.m. Nitrates ranged from 0.22 to 8.86 p.p.m.

Temperatures in both disturbed and undisturbed lakes were only slightly higher than those recorded for an undisturbed lake and pond in the Welaka area by Pierce (1947). In all chemical characteristics, O_2, pH, alkalinity, and dissolved ions, the undisturbed lakes closely resembled Pierce's waters while the disturbed lakes were higher on virtually all counts. The high potassium levels of the disturbed lakes may be the result of commercial fertilizer washing in as well as increments from sewage plant effluent. Barrett (1957) showed that this ion is not used by plankton much beyond the naturally occurring levels (usually < 1 p.p.m.), therefore its artificial excess in disturbed lakes should give an indication of the artificial load of phosphates and nitrates introduced simultaneously but possibly consumed by plankton.

The artificial introduction of nutrient ions apparently resulted in a great increase in pH and in plankton, especially Myxophyceae (Brannon, 1945), and the plankton in turn increased the dissolved oxygen. The sum total of morphometrical and physical measurements is a fairly representative picture of central Florida lakes, all of which are essentially eutrophic. The differences in chemical measurements between the undisturbed and disturbed lakes reflect the eutrophication speed-up which is expected with increases in nutrient inflow (Hasler, 1947; Sawyer, 1947; Edmonton et al, 1956).

II. The Lake Plankton

Fifty-two limnological stations were established on the thirteen lakes, and all were visited two or three times between June and August. The average plankton counts per lake represent an arithmetic mean for all visits to all stations on any one lake. Plankton samples were collected one foot off the bottom, using a 3000 cc. Kemmerer sampler. A liter bottle was filled and centrifuged, the concentrate preserved with formalin and transported to Vero Beach for analysis at the E.R.C. laboratory. Identification was carried to genus in the more readily identifiable forms but for such groups identifiable only by rare specialists, as the blue-green algae (= Myxophyceae), most of the identification was to cells, filaments, spirals, or colonies only. Counting was by aliquot in a Sedgwick-Rafter cell under the compound microscope with calibrated optical micrometers.

The distribution and abundance of plankters is shown in a summary form in Figure 1. The poorness of the plankton in the undisturbed lakes is evident. There is a good correlation between plankton numbers and disturbance of the lakes by nutrient addition, this being especially noticeable in the critical blue-green algae.

Protozoa occurred in all lakes but the undisturbed Lake Thomas. They were especially abundant in Lake Lulu (7,220,048/L) where the dominant form was an actinopod, in Lake Effie (6,852,044/L) where euglenoids predominated, and in Lake "X" (1,357,024/L) where *Dinobryon* and other chrysomonads predominated. None of the protozoan forms identified belonged to the recognized "sewage protozoa".

ROTIFERS varied from 13/L in Lake Thomas to an enormous 76,564/L in Lake Lulu. Since any count above 1000 per liter is considered unusual and the highest recorded density from unpolluted waters is 5800 per liter (Pennak, 1953), it seems that the following lakes could be considered "polluted" by the rotifer criterion: May (mostly *Trichocerca* and *Brachionus*), "Y" (mostly *Brachionus, Keratella* and *Trichocerca*), Lena (mostly unidentified), and Lulu (mostly *Trichocerca*).

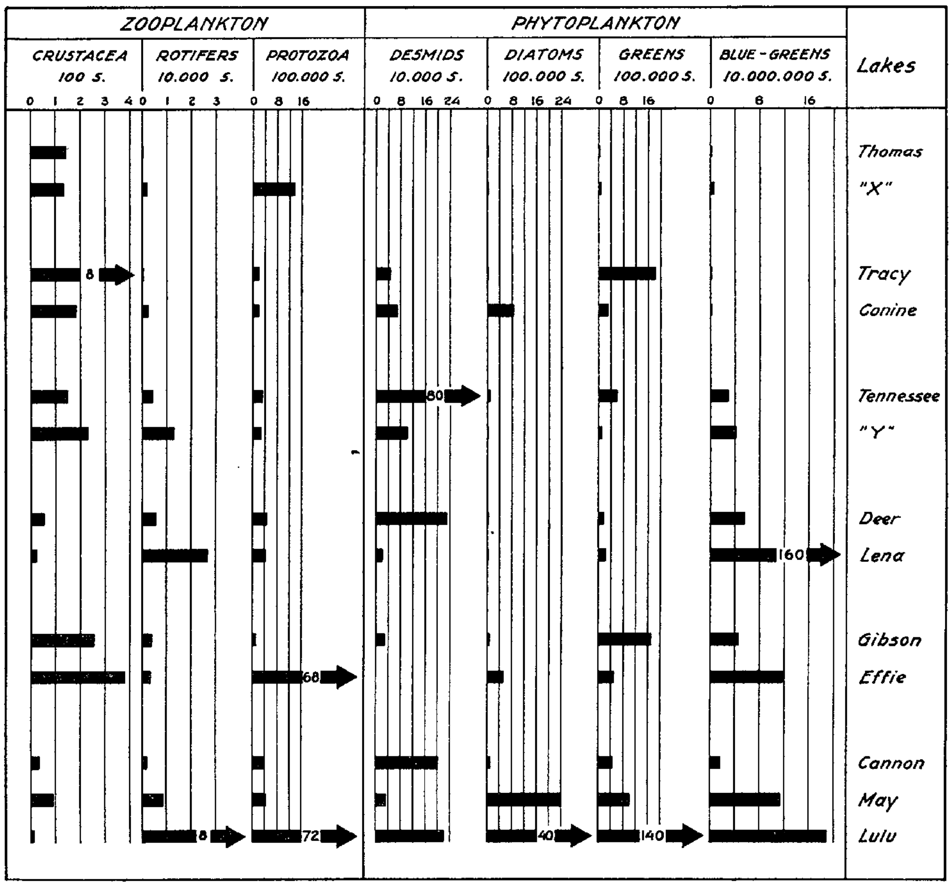

Fig. 1. Numerical occurrence of major plankton groups in Polk County lakes, summer 1956.

CRUSTACEA were scarce in all lakes. They were mostly Eucopepoda and Cladocera. The total absence of Ostracoda reflected the sparsity of vascular vegetation in these lakes.

MYXOPHYCEAE were scarce in undisturbed lakes and in "industrial" lakes. The "citrus" lakes averaged 24 and 40 million per liter while the lakes receiving effluents from either septic tanks or sewage-treatment plants averaged from 12 to 1616 million organisms per liter. The most widespread forms were round cells of various sizes (*Microcystis* type). These were especially numerous in Lakes Lulu and Effie, the two lakes on which municipal sewage-treatment plants were located. Blue-green filaments (single cells, narrow and very long) occurred in all but the undisturbed lakes; in Lake Lena, which bloomed chronically, they averaged 1,596,624,000 per liter.

CHLOROPHYCEAE, exclusive of Desmids, were found in relatively small numbers in all lakes, with *Scenedesmus* predominating. The latter averaged 13,844,000 per liter in Lake Lulu. Desmids were in very small numbers but in all lakes except the two undisturbed; the predominant form was *Staurastrum*.

BACILLARIOPHYCEAE were well under the blue-green algae in abundance. They reached above 72,000 per liter only in Lakes May and Lulu. Diatoms have a pronounced annual cycle of abundance frequently peaking in the cold season, so their position in these lakes cannot well be judged from summer sampling only.

As in their physical features, so in zooplankton the undisturbed lakes resembled those studied by Pierce (1947), but the disturbed lakes were enormously richer in rotifers, although the same genera predominated. The phytoplankton in the disturbed lakes generally exceeded densities found by Pierce, even those in the St. John's River when in algal bloom (average for summer—16,600,500 blue-green cells per liter). The green algal densities were far above Pierce's findings in the Welaka area, as were also desmids and diatoms. On the whole, the plankton densities during the summer of 1956 in the Polk County lakes more nearly resembled the classically high densities found during seasonal peaks in the Illinois River at the turn of the century (Kofoid, 1910) and in Lake Mendota (Birge and Juday, 1922) than those found in natural Florida waters by Pierce (1947).

III. THE CHIRONOMID FAUNA

Each of the 13 lakes was visited three times during the summer and systematically sampled with a 6-inch Ekman dredge. Sampling was along various transects intersecting at the center of the lake. Bottom characteristics and depth were recorded for each haul. All chironomid larvae were preserved and sent to the Vero Beach laboratory for identification and counting.

The chironomid fauna of these lakes was not very diverse. The two species whose food habits were studied were absent from the undisturbed lakes. *G. paripes*, the predominant pest species, was most abundant in the Winter Haven "Chain-o-lakes" and in the "citrus" lakes. *T. decorus* was abundant only in one of the "industrial" lakes (L. Tracy) and in one of the "sewage plant" lakes (L. Effie). The ecological influence of lake bottom type precluded any correlation directly with plankton density.

Of the 127 positive dredge hauls for *G. paripes*, 75% were on pure sand and 18% on peaty sand. The preference for sand and avoidance of muck definitely restricted this species in the deeper lakes to a littoral band of sand and peat. Small areas of sand in the deeper waters also produced this species although the surrounding muck bottoms were devoid of them. Although *T. decorus* was not absent from muck, of the 38 positive dredge hauls 92% had sand as a bottom ingredient, while peat prevailed considerably more than in the *G. paripes* sites. These apparent preferences for certain bottom types in both *G. paripes* and *T. decorus* may be related to actual preferences for tube building material. However versatile these larvae may be in utilizing materials, it has been shown that in choice experiments chironomid larvae exhibit very definite selectivity (Ohgaki, 1942). The preference of sand by *G. paripes* seems to limit the percentage of lake bottoms available to them as living substrates, in which case hydraulic dredging, commonly practiced in these lakes, may conceivably expand suitable bottom areas by mixing naturally accumulated muck deposits with sand or exposing the underlying sands.

IV. THE FOOD OF *G. paripes* AND *T. decorus*

From the summer collections, 259 *G. paripes* from nine lakes and 95 *T. decorus* from two lakes were dissected and stomach contents studied. For winter comparisons 25 *G. paripes* and 13 *T. decorus* were examined. Only large larvae were used. The contents of the forepart of the alimentary tract were much better preserved than those of the hindpart. The practice was then set of utilizing only the gut down to and including the fourth abdominal segment. The gut was dissected out of this portion of the larva and its contents, usually holding together well, were dispersed in a small amount of formaldehyde. In order to particulate the material as homogeneously as possible, the mixture was gently macerated in a mortar. From this point onwards the identification and counting of plankton—which constituted the entire contents—were carried out with the Sedgwick-Rafter cell technique given above for lake plankton studies. For convenience the larvae were pooled for each lake at each visit, the variable numbers in the pools always being correspondingly adjusted in the final "per ½ gut" datum.

Since plankters vary so much in size, the average green algal cell being about 100 times the average blue-green algal cell in volume and in turn but 1/100 the average crustacean nauplii, the commonly employed numerical representation of lake plankton (Fig. 1) gives a distorted picture of plankton as a food supply for other animals. From measurements with calibrated ocular micrometers, the volume, in cubic microns, was estimated for all the common plankters found. The lake plankton volumes were then computed (Table I) for comparisons with larval stomach contents and also computed volumetrically (Table II).

The average half-gut of *G. paripes* measured 741 million cubic microns and of *T. decorus*, 417 million cubic microns. The food totals for summer stomachs (Table II) represented stomach food densities of 10% and 1½% for the two species while the winter densities (Table III) were, respectively, ½% and 1½%. By comparison the lake plankton dilutions in the summer averaged .004% for the *G. paripes* lakes and .015% for the *T. decorus* lakes. Plankton in the larval stomachs was therefore 2500 times as concentrated in *G. paripes* stomachs as in the lake waters and in *T. decorus* 100 times. This gives a rough estimate of the efficiency of the filter-feeding mechanism in these chironomid larvae.

The larvae of *G. paripes* fed overwhelmingly (98.7%) on phytoplankton, with blue-green algae (60.7%) and green algae (31.3%) accounting for most of the dietary. The dominance between these two algal groups was evenly divided among the nine lakes. The blue-green algal food, volumetrically, was evenly divided between colonies and single cells. The green algal food occurred mainly as single cells, with *Scenedesmus* easily predominating. Desmids constituted 5.9% of the total food with a maximum in any one lake of 28.3%; the predominant form was *Staurastrum*. Diatoms, though numerous in the stomachs, nevertheless accounted for a mere 0.8% of the total food bulk. Protozoa represented the same percentage but they did reach as high as 15% in one lake. Rotifers were taken sparingly in larvae from several lakes and Crustacea only in one lake. The winter stomachs presented a very different picture, with Crustacea predominating as bulk (60.0%), green algae in second place (27.8%), and blue-green algae in a very minor role (2.4%).

TABLE 1. VOLUMETRIC ANALYSIS OF PLANKTON FROM 13 POLK COUNTY LAKES, SUMMER 1956, NINE OF WHICH PRODUCED *G. paripes* AND TWO, *T. decorus*. IN 10^6 μ^3 PER ml.

	1*	2	3	4	5	6	7	Total
G. paripes lakes								
Conine	1.0	1.2	.1	tr	3.8	.3	tr	6.6
Tennessee	4.6	2.1	11.2	tr	8.0	.4	.2	26.5
"Y"	11.1	.3	.3	tr	5.6	1.4	.6	19.4
Lena	98.0	2.2	.2	tr	3.7	3.0	tr	107.1
Deer	25.2	.5	.5	tr	5.7	.7	tr	32.6
Gibson	23.2	10.6	.1	tr	1.4	.6	.5	36.3
Cannon	4.1	1.8	.5	tr	4.9	.3	tr	11.6
May	5.8	4.2	tr	2.9	2.7	1.3	tr	17.1
Lulu	31.7	41.7	.7	1.4	8.3	7.6	tr	91.5
Average:	22.8	7.1	1.5	.5	4.9	1.7	.2	38.8
T. decorus lakes								
Tracy	tr	108.3	.4	tr	2.2	tr	4.2	115.2
Effie	33.2	1.5		tr	139.1	.5	3.2	177.5
Average:	16.6	54.9	.2	tr	70.7	.3	3.7	146.3
Non-producing lakes								
Thomas	tr	tr		tr		tr	.2	.3
"X"	.2	1.6		tr	13.5	.2	.2	15.6

* Column headings for major plankton groups: 1. Blue-green algae, 2. Green algae, 3. Desmids, 4. Diatoms, 5. Protozoa, 6. Rotifers, and 7. Crustacea.

The larvae of *T. decorus* in the summer fed also predominantly on phytoplankton (91.7%), but more on green algae (50.8%) than blue-green (26.2%). The blue-green algae were altogether single cells; the green algae were likewise single cells, with *Scenedesmus* predominating. Desmids figured more prominently (13.1%) than in *G. paripes* stomachs, with *Staurastum* similarly predominating. Zooplankton, all forms, were fed upon more than in *G. paripes*, Crustacea alone amounting to 5.0% of the food by bulk. The winter stomachs, as in *G. paripes*, contained far less blue-green algae, slightly more green algae and considerably more Crustacea.

TABLE II. VOLUMETRIC ANALYSIS OF STOMACH CONTENTS OF *G. paripes* AND *T. decorus* FROM THE LAKES OF THE WINTER HAVEN AREA, SUMMER 1956.

		G. paripes									*T. decorus*		Averages	
Lake: No. stomachs		Con. 10	Tenn. 50	Y 40	Lena 4	Deer 17	Gibs. 11	Can. 50	May 60	Lulu 17	Tracy 25	Effie 70	*G. paripes* 259	*T. decorus* 95
Blue-green algae	$10^6\ \mu^3/\frac{1}{2}$ gut	1.1	26.3	137.6	5.5	1.3	99.3	55.3	6.6	10.2	tr	2.1	45.5	1.6
Green algae		12.5	15.0	.6	.9	5.2	8.8	12.7	35.9	125.0	1.5	4.1	23.5	3.1
Desmids		5.2	4.7	tr	1.6	3.4	1.3	6.5	8.4	.1	3.2		4.4	.8
Diatoms		.5	.4	tr	.1	.2	.1	.1	1.8	.1	.1	.3	.6	.1
Protozoa		.4	.2	1.0		1.8	tr	.8	.2	2.6	tr	.1	.6	.1
Rotifers			1.3	.3		.1		.1	.3		.1	tr	.2	.1
Crustacea					.5						.5	.3	.1	.3
Phytopl.		19.3	46.4	138.2	8.1	10.1	109.5	74.6	52.7	135.4	4.8	6.5	74.0	5.6
Zoopl.		.4	1.5	1.3	.5	1.9	tr	.9	.5	2.6	.6	.4	.9	.5
TOTAL		19.7	47.9	139.5	8.6	12.0	109.5	75.5	53.2	138.0	5.4	6.9	74.9	6.1
Blue-green algae	% of Food	5.6	54.9	98.7	64.0	10.8	90.7	73.3	12.4	7.4	tr	30.4	60.7	26.2
Green algae		63.5	31.3	.4	10.5	43.3	8.0	16.8	67.5	90.6	27.8	59.4	31.3	50.8
Desmids		26.4	9.9	tr	18.6	28.3	1.2	8.6	15.8	.1	59.3		5.9	13.1
Diatoms		2.5	.9	tr	1.1	1.7	.1	.1	3.4	.1	1.8	4.4	.8	1.6
Protozoa		2.0	.3	.7		15.0		1.1	.4	1.8	tr	1.4	.8	1.6
Rotifers			2.7	.2		.9		.1	.5		1.8	tr	.3	1.6
Crustacea					5.8						9.3	4.4	.2	5.0
Phytopl.		98.0	97.0	99.1	94.2	84.1	100.0	98.8	99.1	98.2	88.9	94.2	98.7	91.7
Zoopl.		2.0	3.0	.9	5.8	15.9	tr	1.2	.9	1.8	11.1	5.8	1.3	8.3

V. Discussion

The larvae of both *G. paripes* and *T. decorus* live in tubes on the lake bottoms which they build of bottom materials held by salivary secretion or silk. Within these tubes they spin nets which strain particulate matter out of the water made to flow through the tube by undulations of the larva's body (Leathers, 1922; Walshe, 1947, 1951; Ohgaki, 1942; Tsilova, 1955). The net and its contents are then consumed and a new net is spun.

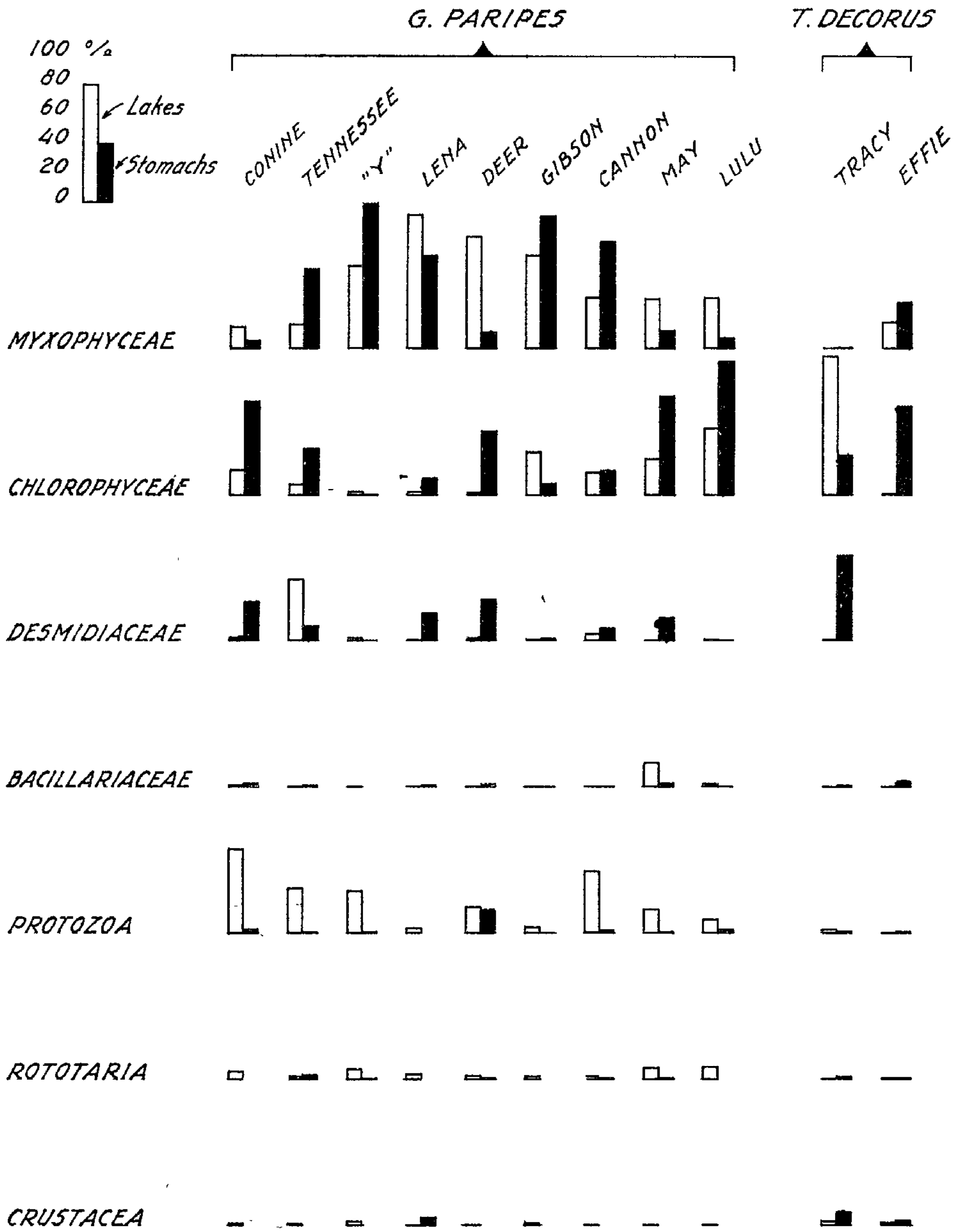

Fig. 2. Volumetric comparisons, on percentage basis, of major plankton groups, in stomachs of *G. paripes* and *T. decorus* with plankton in lakes from which collected.

Walshe (1951) found individual filterings to last from 1 to 5 minutes, with undulation frequencies ranging from 111 to 200 per minute. This activity goes on night and day. Such a feeding method can be inferred to be non-selective except for the exclusion of very fine particles which if smaller than the mesh of the net may pass through. In *T. plumosus*, Walshe (1947) found all particles greater than 17 μ in diameter and most over 12 μ retained. Tsilova (1955) reports only that particles leaving the tubes are incomparably smaller than those entering. These important details have yet to be determined for *G. paripes* and *T. decorus*.

Correlations between lake plankton and *G. paripes* larval stomachs for the summer of 1956 are given on a percentage basis, volumetrically, in Figure 2. The preponderance of blue-green algae in most *G. paripes* lakes and *G. paripes* stomachs is evident, but the picture is clouded by a few reversed ratios, as in Lakes Deer and Cannon. This may be due to the larvae filtering out mainly the larger blue-green cells and colonies. In both lakes small ($< 100\ \mu^3$) cells predominated in the lake plankton, constituting 99.2% of blue-green algal bulk in Lake Deer and 98.2% in Lake Cannon. The blue-green algal cell stomach content, contrariwise, was only 6.4% small cells in Lake Deer and 41.3% in Lake Cannon. The proportion of blue-green algal material existing in the lakes as free and small cells, which this analysis determined crudely only, may then determine the proportion of it actually retained in the larval nets, —assuming that the very small cells pass through the nets.

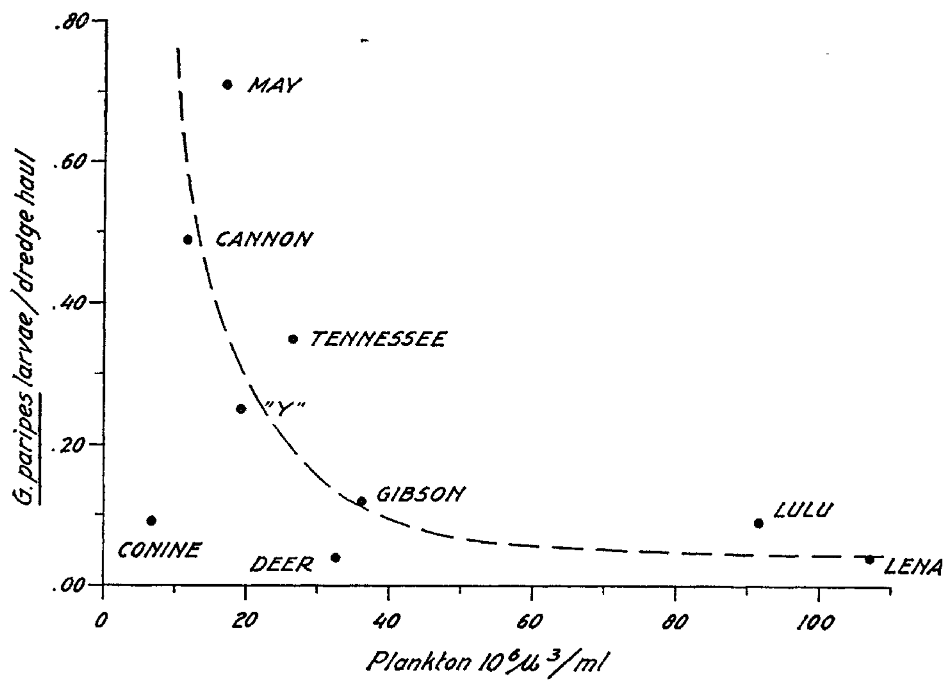

Fig. 3. Relationship between density of *G. paripes* larvae and lake plankton density for nine Polk County lakes, summer 1956.

In all lakes but two, one of *G. paripes* and one of *T. decorus*, the proportion of green algae in the stomachs was much larger than the proportion in lake plankton. This is almost certainly related to the large size of these cells compared, for instance, to most blue-green algal cells or diatoms. The same would apply to desmids which were similarly favored as food in all lakes but one. Diatoms, although reported by most of the literature on chironomid feeding (Thienemann, 1954) as the principal food, in this study showed poorly both in lakes and stomachs.

For virtually all lakes zooplankters constituted a greater percentage of bulk in the lake waters than in the larval stomachs. The most likely explanation is that their motility and large size together prevent their being drawn into the larval nets by the slight current set up by the larval undulations. The exceptions occurring with Crustacea and Rotatoria in *T. decorus* and with Crustacea in *G. paripes* from Lake Lena remain unexplained.

TABLE III. COMPARISON OF SUMMER AND WINTER FOOD HABITS OF *Glyptotendipes paripes* AND *Tendipes decorus*.

FOOD GROUPS		*G. paripes*		*T. decorus*	
		summer 259	winter 25	summer 95	winter 13
Myxophyceae	10^6 μ^3/½ gut	45.52	.10	1.57	.21
Chlorophyceae		23.53	1.16	3.13	4.27
Desmidiaceae		4.38	.23	.84	.67
Bacillariaceae		.57	.02	.07	.09
Protozoa		.57	.13	.04	.03
Rotatoria		.19	.03	.04	.03
Crustacea		.19	2.50	.25	1.00
Phytoplankton		74.00	1.51	5.61	5.24
Zooplankton		.95	2.66	.33	1.06
TOTAL		74.95	4.17	5.94	6.30
Myxophyceae	% of Food	60.7	2.4	26.4	3.3
Chlorophyceae		31.4	27.8	52.7	67.8
Desmidiaceae		5.9	5.5	14.1	10.6
Bacillariaceae		.8	.5	1.2	1.4
Protozoa		.8	3.1	.7	.5
Rotatoria		.2	.7	.7	.5
Crustacea		.2	60.0	4.2	15.9
Phytoplankton		98.8	36.2	94.4	83.1
Zooplankton		1.2	63.8	5.6	16.9
TOTAL		100.0	100.0	100.0	100.0

The difficulty in correlating plankton volume with chironomid larval numbers is that seasonal cycles in both are probably never synchronized, so that there can be no day-to-day correlation between them any more than there can be between plankton volume and its nutrients. The complexity of production, with all its lags and periodic reversals, can be understood only after several years of systematic sampling of nutrients, plankton, and larvae. In the short season here studied, there seemed to be an inverse relationship in the case of *G. paripes* (Fig. 3). This resembles the finding of Bradley (1932) in one of the few studies of mosquito (*Anopheles quadrimaculatus*) numbers as related to plankton abundance, where excessively high plankton densities in low mosquito production waters are attributed to other environmental factors than larval feeding. The two highest plankton lakes in Fig. 3 are Lena and Lulu, both frequently in algal bloom.

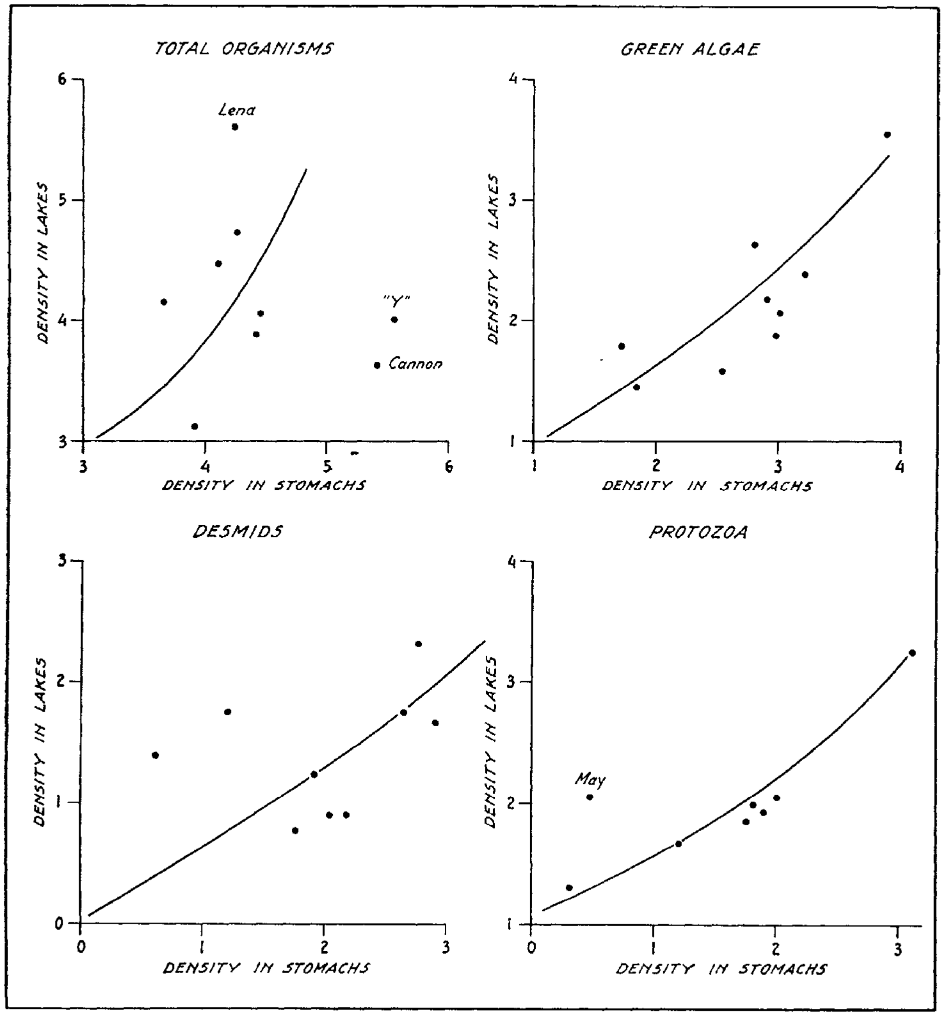

Fig. 4. Plankton density in stomachs of *G. paripes* as related to density in lakes: major plankton groups. Logarithms plotted for organisms per liter in lakes and organisms per half-gut in larvae.

If resort is made to plankton numbers rather than volumes, a relation between *G. paripes* larval feeding and plankton density does appear to exist (Fig. 4). The correlations are not very good with blue-green algae nor with diatoms, nor with total organisms which is so much affected by these small forms. But the correlations are good with green algae, desmids, and protozoa. They are even better with individual genera within these groups, e. g. *Scenedesmus*, *Staurastrum*, and actinopods (Fig. 5). It goes without saying that the possibility of food intake being related to amount of food, viz. plankton, present in the lakes is urgently in need of clarification. Should this be definitely proven, there would be at hand incontrovertible evidence that nutrients added to lakes increase the populations of *G. paripes* by way of the food-chain effect on rate of development and hence abundance.

Accelerated individual growth rates within a population of constantly propagating animals will directly affect production by shortening or telescoping the generations and thus pyramiding the total numbers. If the growth rate of *G. paripes* is proportional to the rate of food intake, a rea-

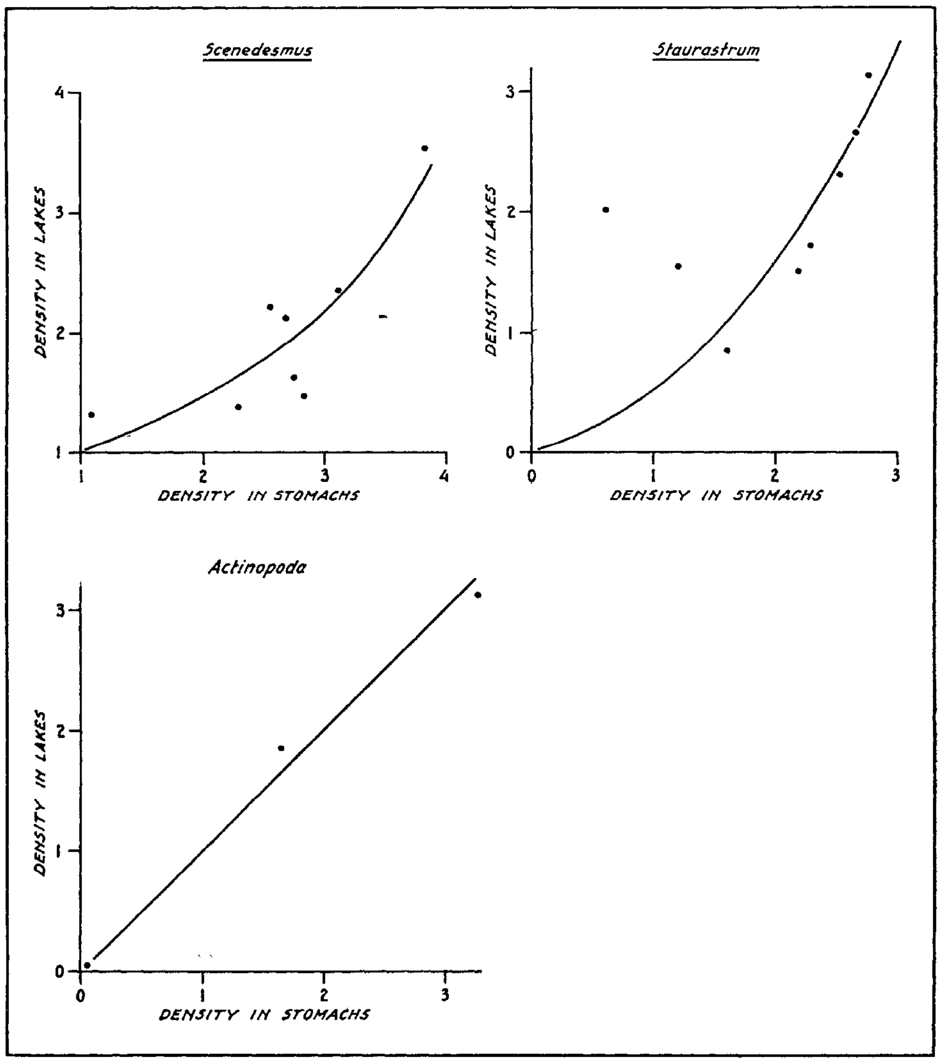

Fig. 5. Plankton density in stomachs of *G. paripes* as related to density in lakes: small plankton groups. Logarithms plotted for organisms per liter in lakes and organisms per half-gut in larvae.

sonable assumption, then its populations will be likewise proportional. The amount of feeding activity, i. e. frequency of spinning nets and eating them and rate of undulation, was measured in one species of *Glyptotendipes* by Burtt (1940) and two species of the same genus by Walshe (1950, 1951). Burtt found the activity correlated with temperature and light intensity, and Walshe found it negatively correlated with dissolved oxygen. But the significant finding of both workers is that the activity is completely independent of the amount of food trapped or load of the nets. It must follow then that light, temperature, and O_2 being equal the rate of food intake must be proportional to the food content of the water, i. e. plankton density. This conclusion from a knowledge of the feeding behavior is substantiated by the findings of the summer 1956 stomach analyses of *G. paripes* and the plankton in the Polk County lakes producing them.

VI. Summary

The summer's survey left no doubt about the dominant role of *Glyptotendipes paripes* in the "blind mosquito" problem. Its larvae occur on sand-peat bottoms and appear to be adversely affected by deposition of organic matter on lake bottoms, such as was demonstrated in Lakes Effie and Lulu. Since, however, an increase in plankton is likely to increase the production of this chironomid, it appears that enriching the lakes, whether through organic or inorganic nutrients, gears the lakes to *G. paripes* production at pest levels. Organic accumulations on the lake bottom may check this, but if dredging operations and other disturbing practices keep sandy bottoms exposed to larval invasion, the problem may become acute. This may be the explanation for the "blind mosquito" situation in the Polk County lakes, but it remains a hypothesis to be demonstrated.

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