Bilton for their splendid cooperation in collecting the field data. Their cooperation was responsible, in great part, for the success of the study.

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PRELIMINARY STUDY OF THE EFFECTS OF DIQUAT ON THE NATURAL BOTTOM FAUNA AND PLANKTON IN TWO SUBTROPICAL PONDS

By WALTER M. TATUM and ROBERT D. BLACKBURN [1]

ABSTRACT

Two farm ponds in south Florida were treated with a concentration of 0.5 part per million by weight of 1,1'-ethylene-2,2'-dipyridylium dibromide (diquat) on April 4, and May 21, 1962, to determine the effect this aquatic herbicide may have on the bottom fauna and plankton naturally existing in these two bodies of water.

Bottom samples were taken from the ponds with a 6" by 6" Ekman dredge before and after treatment. The organisms were sorted from the debris and counted. Plankton samples were also taken before and after treatment to evaluate the effect of this herbicide on the plankton.

The results in pond number one indicated no change in the number of bottom organisms before and after treatment. However, Chironomids failed to appear in the samples for the first 2 weeks after treatment. The second pond failed to show any reduction in numbers of this particular group of organisms. A large increase in the average number of organisms occurred after treatment in pond number two. Most of this increase in numbers came from the tremendous numbers of *Chaoborus* spp.

Plankton samples before and after treatment in pond number one did not show any measurable difference. The volume of plankton per cubic meter in pond number two decreased the third day after treatment. However it increased during the next seven days to give a greater volume of plankton than before treatment.

Water samples were taken from pond number two at periodic intervals after treatment to determine the persistence of diquat in the pond water. Duckweed *(Lemna minor)*, being very sensitive to diquat, was used as an indicator plant. Diquat was present in the pond water at a concentration of 0.25 p.p.m.w. after three days, 0.01 p.p.m.w. after eleven days, and no detectable diquat sixteen days after treatment.

INTRODUCTION

A considerable amount of information is available on chemical aquatic weed control (Lawrence, 1958; Blackburn and Weldon, 1962). Also, a great deal of information is available on the effects of chemicals on fishes that might exist in waters treated with herbicides (Springer, 1957; Lawrence, 1958; Bond, Lewis, and Fryer, 1959; Surber and Pickering, 1961). However, little is known of the effects of certain promising herbicides on the fish food organisms existing in treated bodies of water.

If a chemical controls aquatic weeds in a body of water, but also kills fish at concentrations necessary to control these aquatic weeds its uses are somewhat limited. Also, if a chemical was found to be an effective herbicide and non-

[1] Fisheries Biologist, Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Florida, and Research Agronomist, Crops Protection Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Fort Lauderdale, Florida, respectively.

toxic to fishes, but toxic to fish food organisms, it too would only have limited usage.

In most cases the cause of stunting fish populations in a body of water is insufficient food for the existing fish populations (Swingle, 1956). If a herbicide is used in a body of water that does not directly affect the fish, but through its effect on the fish food organisms causes a crowded condition in the body of water, then the purpose of using that herbicide is being defeated.

With this in mind, an investigation was initiated to determine the effects of 1: 1′-ethylene-2, 2′-dipyridylium dibromide (diquat), used at 0.5 p.p.m.w. on the existing plankton and bottom fauna in two farm ponds in Fort Lauderdale, Florida.

DESCRIPTION OF AREA

The two ponds used in this investigation are located on the premises of the Broward County International Airport and are presently being managed by the Florida Game and Fresh Water Fish Commission.

Pond number one has a surface area of 0.6 acre and an average depth of 6 feet. The pond was stocked on November 3, 1961, with 600 bluegill and shellcracker *(Lepomis microchirus* and *Lepomis microlophus,* respectively) and on May 9, 1962, with 50 largemouth bass *(Micropterus salmoides).* In addition to the fish stocked large numbers of mosquito fish (*Gambusia affinis*) and flagfish *(Jordanella floridae)* were present in the lake. Before treatment with diquat the pond was 100 percent infested with southern naiad *(Najas guadalupensis)* and chara *(Chara* spp.) in the littoral zone.

Pond number two had a surface area of 0.8 acre and an average depth of 8 feet. It was stocked November 13, 1961 with 50 *Tilapia nilotica.* Undetermined numbers of adult, yearling, and fingerling largemouth bass were also present at the time of stocking. Before treatment the pond was infested with southern naiad in the littoral zone.

MATERIALS AND METHODS

Samples were taken from the pond bottom with a six-inch square Ekman dredge. Four dredge samples were taken from the pond bottom at each sampling date. The bottom organisms were separated from the debris by a sugar flotation method (Anderson, 1959) and classified in taxonomic groups (Pennak, 1953).

In pond number one two plankton samples were taken one-half hour before treatment and two samples were taken three days after application as described by Lagler (1956). When the results from pond number one were reviewed it was deemed advisible to take plankton samples from pond number two 0.5 hour before treatment, and 3, 11, and 16 days after treatment. Water samples were taken on the same days after treatment as the plankton samples to determine the persistence of diquat in the pond water. Duckweed *(Lemna minor* L.) was used as the bio-assay plant (Funderburk and Lawrence, 1962).

RESULTS AND DISCUSSION

Pond Number One

Bottom fauna

The average number of organisms increased slightly after treatment with 0.5 p.p.m.w. diquat. This increase, however, came from the large number of Oligochaeta taken in the first two sampling periods following treatment (Figure 1). This build-up of Oligochaeta is rather a common occurrence when the organic matter is increased in the pond bottom. Colbert (1956) and Hooper and Grzenda (1955) found this to occur when ponds were treated with fish toxicants. The Oligochaeta dropped severely in number in the third sample after treatment. This suggests a possibility of a subtle chronic toxicity to this animal.

Chironomids failed to appear in the first two sampling periods following treatment. However, Chironomids were not abundant before treatment (Table 1). Chironomids were absent from 4 of the 8 samples taken before treatment. Cope (1961) suggested that if sampling periods last for several weeks any disappearance of any particular group of insects could be attributed to a mass

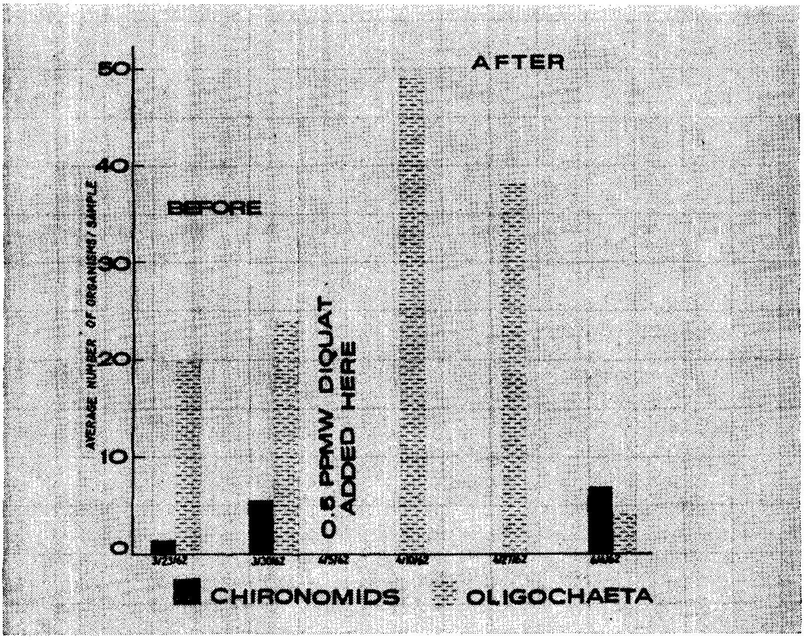

Figure 1. The average number of bottom organisms from pond number one before and after treatment with 6.5 p.p.m.w. of diquat.

TABLE I

THE NUMBER OF CHIRONOMIDS AND OLIGOCHAETA TAKEN FROM EACH OF THE SAMPLES AT EACH SAMPLING PERIOD IN POND NUMBER ONE

	Before Treatment		*After Treatment*		
	Sampling Period 1	*Sampling Period 2*	*Sampling Period 3*	*Sampling Period 4*	*Sampling Period 5*
Sample No. 1					
Oligochaeta	20	8	78	32	..
Chironomids	..	7	..	.	6
Sample No. 2					
Oligochaeta	26	10	43	18	..
Chironomids	..	6	..	..	5..
Sample No. 3					
Oligochaeta	35	65	53	41	4
Chironomids	5	9	..	..	3
Sample No. 4					
Oligochaeta	..	13	22	53	12
Chironomids	..	..	..	..	14

Average number of Oligochaeta before treatment—22.125.
Average number of Oligochaeta after treatment—30.33.
Average number of Chironomids before treatment—3.3.
Average number of Chironomids after treatment—2.33.

emergence. Another possibility is that Chironomids have an acute sensitivity to diquat at this concentration, but repopulate rapidly. Chironomids, however, did not disappear from pond number two the first two sampling periods following treatment. The possibility also exists that the Chironomids showed the effects of heavy cropping by the forage fishes in the pond. Ruggles (1959) noted a severe drop in the number of invertebrates per sample after an increase of chinook salmon and steelhead trout. In addition, Howell, Swingle, and Smith

(1941), and Gerking (1962) report that Chironomids made up by far the largest part of the bluegill diet. Since Chironomids reappeared on the third sampling period after treatment (Table 1) heavy cropping by forage fishes on the Chironomids apparently is not completely responsible for their disappearance during the previous two sampling periods.

PLANKTON

In this particular pond there was little difference in the volume of plankton per cubic meter before and after treatment (4.37 cc cubic meter before and 4.58 cc cubic meter after). Since there was a three day lapse between the two samplings there was a possibility that the plankton was reduced and then re-stabilized during that time.

CONTROL OF WEEDS

The pond, before treatment, had chara and southern naiad completely covering the littoral zone. Southern naiad made up approximately 70 percent of the cover and chara the remaining 30 percent. The chara showed no ill effect from the diquat. The southern naiad was completely controlled by the seventh day after treatment and had shown no regrowth at the end of the summer.

Pond Number Two

Bottom Fauna

The average number of organisms after treatment almost doubled the average number of organisms before treatment. This increase came primarily from the enormous quanitity of phantom midges (*Chaoborus* spp.).

The average number of organisms per sample before treatment was 104. Of these, only 17, or less than 20 percent, consisted of phantom midges. The average number of organisms per sample after treatment was 203. Of these, 133, or over 65 percent, consisted of phantom midges. This sharp increase in this particular group of organisms could be attributed to a natural population fluctuation or to the increased enrichment due to the decaying vegetation after treatment. Hunt (1958) found in sampling a deep lake in southern Florida that the phantom midge density was at its greatest during the summer, with the peak in July. In our investigation, the greatest number of this group came in the samples taken June 1, 1962 (Figure 2). Since the organic matter obviously increased in the pond, and since Chaoborinae untilize organic matter as foodstuff (Pennak, 1953), the increased number of organisms could be attributed to the increased enrichment.

In contrast to pond number one, the average number of Chironomids per sample increased slightly for the first two sampling periods after treatment. The average number of Chironomids per sample before treatment was 36 while the average number of Chironomids per sample after treatment was 38. The average number of Chironomids in the third sample, taken 8 weeks after treatment, however, decreased to a mere 5.5 organisms.

As pointed out previously, the number of Oligochaeta increased considerably in pond number one, but here they were reduced. At first, results from these two ponds appear to be contradictory. However, when considering that Chaoborinae and Oligochaeta utilize similar foodstuff (Pennak, 1953) this might be explainable. Perhaps the phantom midge is a more efficient feeder than the Oligochaeta and through a rapid expansion of its population was able to keep the number of Oligochaeta down. Since Chaoborinae were absent in pond number one, the Oligochaeta, having little competition for the increased foodstuff, were able to increase their number. These explanations are theoretical and will have to be better substantiated with more replications.

Plankton

Figure 3 clearly demonstrates what may occur when diquat or other chemicals are added to a pond with a heavy plankton bloom. The average volume of plankton per cubic meter before treatment was 10.84 cc. Three days after treatment the plankton had dropped to 2.91 cc per cubic meter. At the same time diquat was found to be present in the water at a concentration of 0.25 p.p.m.w. Eleven days after treatment the volume of plankton had increased

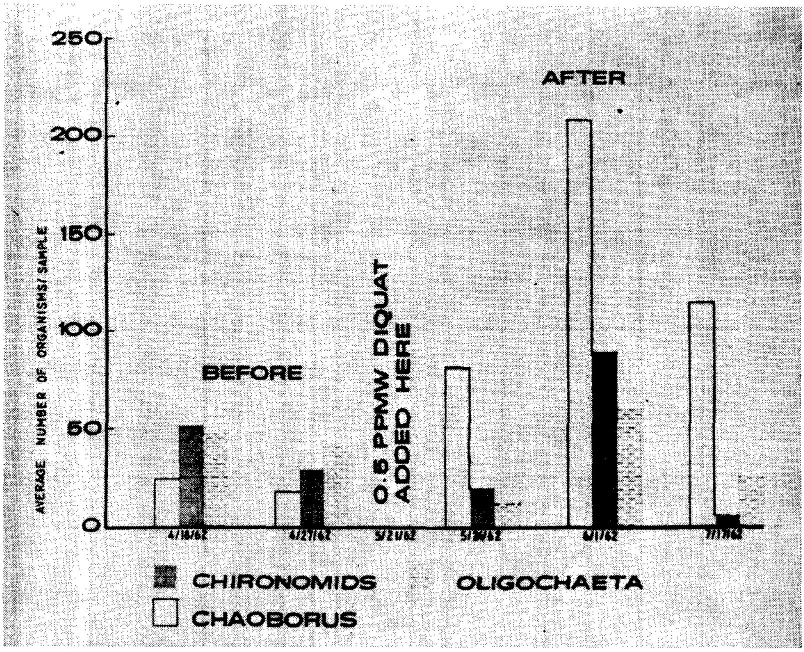

Figure 2. The average number of bottom organisms from pond number two before and after treatment with 0.5 p.p.m.w. of diquat.

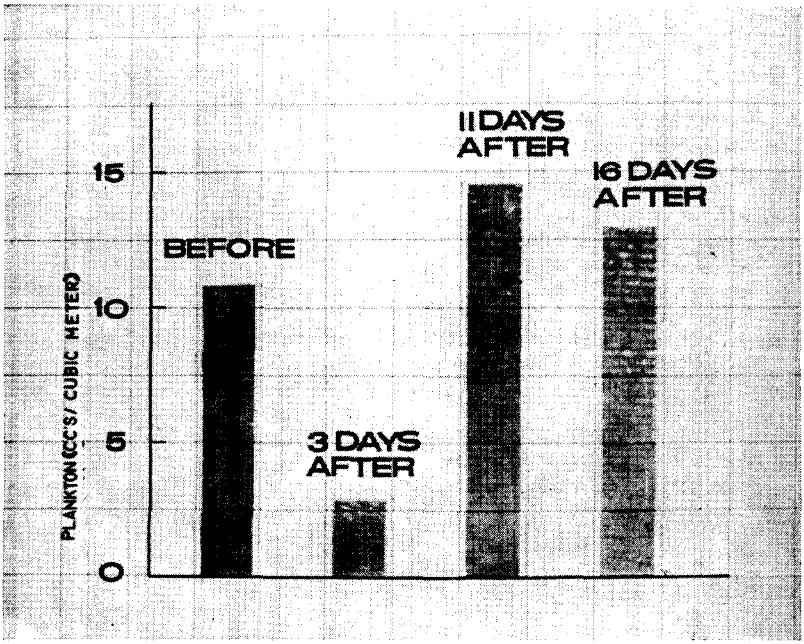

Figure 3. The average volume of plankton per cubic meter from pond number two after **treatment with 0.5 p.p.m.w.** of diquat.

to 14.56 cc per cubic meter. Diquat was present in the pond water at this time at a concentration of 0.01 p.p.m.w. Sixteen days after treatment, the volume of plankton dropped slightly to 13.1 cc per cubic meter. Diquat was not detected in the pond water at this time.

Control of Weeds

Southern naiad completely covered the littoral zone before treatment. Within ten days after treatment, the littoral zone was completely clean of the southern naiad and at the end of the summer had shown no regrowth.

INDICATIONS

Since this report is preliminary no definite conclusions can be drawn as to the effects of diquat on the bottom fauna and plankton. Certain indications however can be pointed out.

1. Plankton appears to be adversely affected by 0.5 p.p.m.w. of diquat, but recovers rapidly.
2. The increased organic matter due to the decaying vegetation appears to benefit certain benthic organisms immediately.
3. Since in pond number one Chironomids were absent from the first two sampling periods after treatment the possibility exists that diquat has an immediate toxicity to Chironomids. In contrast, pond number two showed that there was no immediate toxicity, but suggests a subtle chronic toxicity. Either, neither, or both of these could be correct.
4. Oligochaeta could show a subtle chronic sensitivity to diquat.

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THE PROTEIN REQUIREMENT OF CHANNEL CATFISH, Ictalurus Punctatus (RAFINESQUE)[1]

By MERRIL L. NAIL[2]
Fisheries Laboratory
Agricultural Experiment Station
Auburn University
Auburn, Alabama

ABSTRACT

A study was made to determine the level of dietary protein needed by channel catfish for optimum growth. The experimental work was conducted in the Farm Ponds Laboratory of Auburn University, Auburn, Alabama. Each of 40 stainless steel troughs was stocked with 25 six- to seven-inch fish. These fish were fed experimental diets at a rate of 2.5 percent of their body weight per day. Every 14 to 21 days from June 22 to September 3, 1961, the fish were re-weighed and their daily amount of food adjusted to the new weight.

Eight purified diets were fed, each to five randomly-assigned troughs. These diets contained protein levels of 6.3, 15.8, 25.3 and 34.8 percent at carbohydrate levels of 9.8 and 18.6 percent. Samples of fish were randomly selected at the beginning and at the end of the experiment for carcass analysis. Growth for each diet was compared along with the amount of protein deposited in an effort to determine the level of protein which produced optimum growth.

Statistical analyses indicated that of the levels tested a level of 25.3 percent protein produced optimum growth. Growth was obtained on the lowest level or 6.3 percent protein diet. The estimated maintenance requirement of protein for channel catfish in this experiment was 0.079 gram of protein per day per hundred grams of fish on the 9.3 percent carbohydrate diets and 0.029 gram of protein on the 18.6 percent carbohydrate diets. Based on this data, 0.23 gram of carbohydrate fed per hundred grams of fish would spare 0.05 gram of protein.

INTRODUCTION

The protein requirements of higher animals have been studied extensively for over 100 years. In these studies many attempts have been made to evaluate proteins in relation to such functions as growth, reproduction, maintenance, and milk secretion. From these studies information has been obtained to enable increased and more economical production of all species studied.

Nutritional studies on fish have been conducted for a relatively short period of time. Thus far, the majority of the work conducted on fish nutrition has been done with cold-water species. There has been virtually no nutritional work on warm-water fish reported in the literature.

It has been established that protein is required by all animals for maintenance and growth. However, the level of protein needed for these functions varies with the species. It was the purpose of this experiment to determine the level of protein needed by channel catfish for optimum growth.

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1 This paper taken from a thesis presented to the Graduate Faculty of Auburn University in partial fulfillment for the Master of Science Degree. This work was directed by Dr. E. W. Shell.

2 Presently employed as District Fishery Biologist, Alabama Department of Conservation, Montgomery, Alabama.