EVALUATION OF A SHORTER POND FILLING-STOCKING INTERVAL TO CONTROL FAIRY SHRIMP AND CLAM SHRIMP DENSITIES IN FLORIDA LARGEMOUTH BASS REARING PONDS

by

Gerald Kurten, Lee Hall, and Neil Thompson

MANAGEMENT DATA SERIES
NO. 123
1996

Texas Parks and Wildlife Department
Inland Fisheries Division
Jasper State Fish Hatchery
Jasper, Texas 75951

ACKNOWLEDGMENTS

We greatly appreciate the assistance of David Cauley, Gregg Alvarado, Robert Diggles, Michael Bronson, Joe Limbrick, and John Avery with fertilization, fish stocking and harvest, and data collection. Aaron Barkoh, Michelle Nations, and Richard Anderson provided valuable editorial review of the manuscript. Funding for this project was provided in part through Federal Aid in Sport Fish Restoration Project F-98-DB of the Texas Parks and Wildlife Department.

ABSTRACT

Stocking Florida largemouth bass (Micropterus salmoides floridanus) fry into rearing ponds seven days after initiating pond filling was compared to the usual 14-day post-filling stocking strategy to determine if early stocking would reduce fairy shrimp and clam shrimp densities through fish predation. Zooplankton densities and fish production between the two stocking strategies were also compared. In 7-day ponds, largemouth bass fingerlings appeared to reduce the density and the number of fairy shrimp reaching reproductive size, which may reduce the intensity of fairy shrimp blooms in subsequent years. In 14-day ponds, fairy shrimp were too large at fish stocking for largemouth bass fingerlings to consume and effectively control their densities. In both treatments, zooplankton densities were insufficient for largemouth bass fingerlings to reach the target production size of 38 mm in 14 days. Fish production and fish growth were similar in both treatments.

INTRODUCTION

Fairy shrimp (Anostraca) and clam shrimp (Conchostraca) can present serious problems in earthen fish hatchery ponds. Shrimp can clog outlet screens at pond draining, complicate fish harvest operations, and interfere with enumeration of fry and fingerlings (Hornbeck et al. 1965; Dexter and McCarraher 1967; McCraren et al. 1977). More importantly, shrimp may compete directly with fry or desirable zooplankters for food (Pennak 1989) and limit fish production. Hornbeck et al. (1965) reported that increasing fairy shrimp infestations in largemouth bass (Micropterus salmoides) culture ponds over a 3-year period reduced production from 300,000 fish/pond to less than 50,000 fish/pond. Similarly, Dexter and McCarraher (1967) reported fish yields were reduced by 60 to 80% in goldfish (Carrassius auratus) ponds due to clam shrimp infestations.

Insecticides have been effective in the control of Eubranchiopods in hatchery ponds (McCraren et al. 1977). Control is usually achieved with one treatment, followed by inoculation with desired zooplankters to re-establish the zooplankton food base. Hornbeck et al. (1965) reported that largemouth bass survival in ponds treated with Dylox (Trichlorfon at 0.25 mg/l) was increased from 20 to 80% with no adverse effects on largemouth bass. They also reported using Rotenone (2 mg/l) and Malathion (0.5 mg/l) to effectively kill fairy shrimp in laboratory tests. However, no chemical is currently labeled for aquatic use to treat shrimp infestations. For this reason, there is a need to find other alternatives to insecticides for shrimp control in fish hatchery ponds.

Avoiding drying and freezing of pond bottoms during winter months has been suggested as a method of shrimp control based on reports that drying and freezing stimulate egg hatching. Czarnezki et al. (1993) evaluated the effect of leaving ponds full overwinter and not allowing ponds to dry in the spring on clam shrimp densities in walleye (Stizostedion vitreum) culture ponds. Few clam shrimp were observed and fish production was better in those ponds. However, they warned that not allowing ponds to dry out during winter may cause other problems with fish production: vegetation may be difficult to control, and zooplankton populations may be reduced because their eggs also require drying to promote hatching. We have tested this method to some extent at Jasper State Fish Hatchery (JSFH) to control shrimp populations. Largemouth bass rearing ponds are used to hold largemouth bass broodfish or rear crappie (Pomoxis spp.) for several months (January to March) prior to stocking with largemouth bass fry. However, erosion of pond levees and pond bottoms at JSFH and the necessity to work pond bottoms require that ponds be allowed to dry in late summer prior to use the following spring. Although these ponds are usually filled for three months before being used as largemouth bass rearing ponds, high shrimp densities still occur.

Stocking fish when shrimp are small enough to be used as food by the fish may be a viable biological control method. Fairy shrimp have been used successfully to feed larval fish in intensive culture (Meade and Bulkowski-Cummings 1987). A diet study in 1983 at JSFH (unpublished data) revealed that when largemouth bass fry were stocked into ponds containing immature fairy shrimp, up to 30% of the initial largemouth bass diet consisted of fairy shrimp. Since shrimp usually appear three to five days after pond filling, stocking largemouth bass fry seven days after pond filling rather than 14 days after pond filling may control shrimp.

The target production size of Florida largemouth bass at JSFH is 38 mm. Fingerling rearing ponds require good zooplankton densities to provide for rapid growth when fish are stocked at high enough densities to achieve annual production goals. Largemouth bass fingerling rearing ponds are stocked when zooplankton densities peak at 14 days after initiating pond filling, however, rapid onset of shrimp and subsequent competition with desirable zooplankters reduce densities of zooplankton of appropriate size for largemouth bass fingerlings. Reducing fish stocking densities is unacceptable, because it limits fish production and defeats our production goal. Legal chemicals are no longer available to control shrimp densities, and leaving ponds full during winter does not appear to be a desirable alternative to the traditional method of earthen pond management. Also, little is known of shrimp population dynamics and more knowledge may present other management alternatives. The objectives of this study were to (1) evaluate stocking fish 7 days after pond filling as a method of achieving shrimp control in rearing ponds through fish predation, (2) compare the effects of stocking fish 7 days after pond filling to the usual 14-day filling-stocking interval on fish production and zooplankton density, and (3) gain more understanding of shrimp population dynamics.

MATERIALS AND METHODS

Eleven earthen ponds (0.28 - 0.33 ha) were used for this study at the JSFH. Five ponds were started filling on 10 April 1995 (7-day ponds treatment), and six ponds were started filling on 17 April 1995 (14-day ponds treatment). All ponds received, at filling, 256 kg/ha cottonseed meal, 0.5 mg/l phosphorus (P) and 0.5 mg/l nitrogen (N). Nutrient concentrations were determined weekly, and N and P were added to maintain target concentrations of 0.5 mg/l P and 0.5 mg/l N. No additional cottonseed meal was applied. Nutrient levels were determined from 500-ml water samples collected near the pond drain boxes but away from fresh water inflows on Tuesdays at 0800 hours. Analysis of soluble reactive phosphorus, nitrate-nitrogen, and ammonia-nitrogen were performed within six hours of water sample collection. Soluble reactive phosphorus, a measure of biologically available phosphorus (Bradford and Peters 1987), was determined by the stannous chloride method (APHA et al. 1985). Ammonia-nitrogen was determined with an ammonia selective electrode (Fisher Scientific, Pittsburgh, PA [1]) following procedures of APHA et al. (1985). Nitrate-nitrogen was determined with an ion selective nitrate electrode system (Orion model 93-07, Orion Research 1990, Boston, MA). Dissolved oxygen and water temperature were monitored on weekdays at 0700 and 1600 hours with a portable dissolved oxygen meter (Orion model 840, Orion Research 1990, Boston, MA) near each pond drain box but away from fresh water inflows.

Zooplankton samples were taken on Mondays and Fridays between 0600 and 0700 hours by a single oblique 4-m tow at the pond drain box with a 5.75-cm diameter, 80 μm-mesh Wisconsin plankton net. Densities of major zooplankton groups (Cladocera, copepod nauplii,

---

[1] Use of trade or manufacturer's name does not imply endorsement.

copepod adults, shrimp nauplii, and rotifers) were determined on MS-222 sedated samples, within 2 h, by counting subsamples on a plankton counting wheel under 4X magnification.

Because larger fairy shrimp are patchily distributed and are capable of avoiding Wisconsin-style zooplankton nets, a larger net (0.5 m X 0.5 m opening) with a longer tow length and larger mesh size (1.0 mm mesh) was used to assess adult shrimp densities. The net was towed horizontally for 4.5 m from the pond kettle and sampled 1,120 l of water. All fairy shrimp and clam shrimp in each tow were separated and counted, and a sample of 30 each was measured for total length. Only fairy shrimp and clam shrimp were counted in these tows.

To provide a quick qualitative assessment of shrimp densities, visual observations were made of each pond on Mondays and Fridays of each week. The degree of shrimp infestation was recorded as negligible, light, moderate, or heavy along with the type of shrimp recorded as clam shrimp, fairy shrimp, or mixed. One recorder conducted all observations, in the afternoon, by walking from the pond drain box to approximately half way around the pond.

Ponds were stocked with Florida largemouth bass at an average rate of 383,592 fry/ha on 25 April 1995. Stocking biomass averaged 13.4 kg/ha, and stocking length averaged 13.7 mm (Table 1). Fish were sampled while crowded in hauling units prior to stocking. Fish/kg and estimated number stocked were determined from a length-weight table which was verified by small sample counts. Each Monday and Friday after stocking 25 fish from each pond were captured with a dipnet at the pond drain box, measured for total length, and preserved in 10% formalin for later gut content analysis (Parmley et al. 1986). Fourteen days after stocking, fingerlings were harvested by lowering the pond and dipnetting the fish from the drain box and weighing them into hauling tanks. Fish were sampled while crowded in hauling tanks for average total length and fish/kg estimates. Growth and survival (percent return) were determined from stocking and harvest variables.

Means and standard errors of zooplankton densities, shrimp densities, and shrimp lengths for both treatments were plotted using the GPlot procedure of the Statistical Analysis System (SAS Institute 1988) to examine zooplankton and shrimp succession patterns over time. Means of fish production variables, zooplankton densities, shrimp densities, and nutrient concentrations were compared with the Ttest procedure of SAS. Observational data was analyzed by chi-square comparison of scoring distributions using the Freq procedure of SAS. Significance level was set at $\underline{P} \leq 0.05$.

RESULTS AND DISCUSSION

Stocking Florida largemouth bass fry seven days after pond filling did not improve fish production over the usual 14-day filling-stocking interval. Production of Florida largemouth bass fingerlings was similar between treatments (Table 1) indicating that when faced with shrimp infestations it is not beneficial to wait the usual 14 days for zooplankton populations to peak before stocking fry. This allows the pond manager more flexibility when coordinating draining of spawning ponds and stocking of rearing ponds, because apparently a wider range of stocking days will not adversely impact production. Fingerlings averaged 26.8 mm at harvest. The target production size of 38 mm was achieved in only one pond. However, that pond had a low survival rate that may have resulted from poor initial post-stocking survival and therefore a lower actual stocking density. Survival was significantly negatively correlated with stocking density ($r^2 = 0.37$; $p = 0.05$), and growth was significantly negatively correlated with stocking biomass ($r^2 = 0.36$; $p = 0.05$) and stocking length ($r^2 = 0.49$; $p = 0.02$) (Table 2). These correlations suggest largemouth bass food resources limited fish production, and stocking densities were too high for the fish to maintain adequate growth with limited food resources.

At fish stocking (25 April 1995), both fairy shrimp and clam shrimp were significantly smaller in 7-day ponds than in 14-day ponds (Table 3). Therefore, the strategy of stocking fish earlier when shrimp were smaller was achieved. However, by seven days after filling, fairy shrimp had probably already grown too large for most of the fish to consume, since both fairy shrimp and fish were of similar size in 7-day ponds at fish stocking. Although clam shrimp were probably small enough at fish stocking in 7-day ponds, they were not an important food item of the fish probably because their hard outer shell make them unpalatable. Dexter and McCarraher (1967) reported that clam shrimp were not eaten by fingerling northern pike (Esox lucius) in production ponds. There was no significant correlation between fish production variables and initial population parameters of shrimp.

Stocking fry seven days after pond filling may have benefitted fish culture in shrimp-infested ponds. Technicians reported that clogging of drain screens with shrimp at pond harvest (8 May 1995) was less problematic in 7-day ponds than in 14-day ponds. Observations of the ponds on 5 May 1995 indicated that shrimp infestations just prior to harvest were lower in 7-day ponds than in 14-day ponds. Two 14-ponds were scored as heavily and lightly infested. All 7-day ponds were scored as negligible. However, on all observation dates scores for shrimp populations were not significantly different between treatments, suggesting that fish did not control shrimp populations through predation in any greater degree in 7-day than 14-day ponds.

Actual tow net sampling of ponds was consistent with observational data but more sensitive to population parameters of shrimp. Clam shrimp and fairy shrimp populations were characterized by rapid growth, low population densities, and similar time of appearance, however clam shrimp populations declined more rapidly than fairy shrimp populations. In both 7- and 14-day ponds clam shrimp disappeared before ponds were drained. Clam shrimp populations seemed to consist of a single cohort with maximum density shortly after pond filling, followed by a gradual decline to disappearance by the third week after pond filling (Figure 1). Like clam shrimp, fairy shrimp populations seemed to consist of one cohort which decreased in density over time (Figure 1). Although the ultimate size of fairy shrimp was similar in both 7- and 14-day ponds (Figures 1 and 2), the incidence of fairy shrimp infestations appeared to be lower in 7-day than in 14-day ponds. At draining, only one 7-day pond was still infested with a low density of fairy shrimp. In 14-day ponds, three ponds were still infested with moderate densities of fairy shrimp at draining. Therefore, tow net sampling suggests that 7-day fry stocking may have had a slight impact on fairy shrimp populations. The lower density of larger individuals in 7-day ponds by the third sampling date suggests that fewer fairy shrimp survived to reproductive age in 7-day ponds. This could result in a reduction of infestation in later years if fewer fairy shrimp survived to produce eggs. This contention will be investigated in a subsequent study.

Stocking fish at 7 days after pond filling resulted in zooplankton densities similar to those in ponds stocked at 14 days post-filling and impacted by shrimp infestations. Apparently shrimp competition impacted zooplankton production, delaying or preventing the characteristic increase in zooplankton densities usually observed in fertilized ponds within 14 days after pond filling (Geiger 1983). This is probably a result of the rapid depletion by shrimp of phytoplankton, a major zooplankton food source. Zooplankton succession was similar between 7- and 14-day ponds (Figure 3). Total numbers of organisms averaged 110/l. Of these, 93 organisms/l were rotifers. Since rotifers are too small to be suitable food items for small largemouth bass (Parmley et al. 1986), very little desirable zooplankton was available as food for our largemouth bass fingerlings.

The majority of food organisms in fingerling largemouth bass stomachs were Cladocera, copepod nauplii, and the dipteran larva, Chaoborus (Table 4). Few fairy shrimp and clam shrimp were found in largemouth bass stomachs indicating they may not be preferred food items for largemouth bass. However, population estimates derived from shrimp samples at fish stocking revealed maximum pond densities of only 2.1 times that of largemouth bass for fairy shrimp and 6.0 times the densities of largemouth bass for clam shrimp. Densities of shrimp after fish stocking were actually much lower than largemouth bass densities. Therefore, stomach content analysis from 25 fish from each pond may have not been sensitive enough to detect predation relationships between largemouth bass fingerlings and shrimp. Although not numerically dominant in largemouth bass stomachs, Chaoborus represented an important food resource in terms of weight of food ingested by fingerling largemouth bass. As a class of food organisms, it probably has a high appeal to largemouth bass fingerlings because of the large variation of sizes present in the ponds. Chaoborus ranged in size from < 1 mm to 10 mm in length. High densities of Chaoborus were observed at fish stocking, but their densities were not assessed. Largemouth bass in 7-day ponds ingested significantly higher numbers of Cladocera and copepod nauplii than those in 14-day ponds. However, we believe that the larger size of Chaoborus in 14-day ponds prevented the largemouth bass from relying on smaller zooplankters and accounted for this difference.

MANAGEMENT IMPLICATIONS

Although this study did not provide an immediate solution to fairy shrimp and clam shrimp infestations of largemouth bass rearing ponds, it did provide useful information that can be used to develop strategies to reduce the impact of this culture problem. When faced with shrimp infestations, waiting 14 days to stock largemouth bass fry is apparently not beneficial because competition from shrimp may not allow adequate desirable zooplankton populations to develop. If the pond manager observes shrimp in an unstocked rearing pond, he could target that pond for stocking at a reduced density with the largest fish possible. Sometimes when largemouth bass spawning ponds are drained, one or two ponds will have poor survival but larger fish not stockable with other smaller fish harvested near the same time. These fish would be good candidates for stocking into shrimp-infested ponds.

This study also provided some basis for further study of shrimp control in rearing ponds. Since both fairy shrimp and clam shrimp populations seem to consist of a single cohort lasting approximately three weeks, it may be beneficial to fill ponds without fertilization, wait two weeks to fertilize and inoculate, then stock fingerlings after zooplankton populations are established.

During the three weeks prior to fish stocking, shrimp might hatch, complete their life cycle and no longer be a problem.

Further research into stocking fish earlier than seven days after pond filling may prove beneficial in controlling shrimp because the shrimp may be smaller and more vulnerable to fish predation. However, at this facility, rearing ponds are too shallow and pond filling capabilities are too slow to adequately protect fish from severe temperature changes. Also, stocking densities would have to be reduced because fish predation would inhibit zooplankton population development.

LITERATURE CITED

APHA (American Public Health Association), American Water Works Association, and Water Pollution Control Federation. 1985. Standard methods for the examination of water and wastewater. 16th edition. Washington D.C.

Bradford, M. E., and R. H. Peters. 1987. The relationship between chemically analyzed phosphorus fractions and bioavailable phosphorus. Limnology and Oceanography 32:1124-1137.

Czarneski, J. M., E. J. Hamilton, and B. A. Wagner. 1993. Water management to control clam shrimp, Cyzicus morsie, in walleye, Stizostedion vitreum, production ponds. Journal of Applied Aquaculture 2(3/4):235-242.

Dexter, R. W., and D. B. McCarraher. 1967. Clam shrimp as pests in fish rearing ponds. Progressive Fish-Culturists 29:105-107.

Geiger, J. G., 1983. A review of pond zooplankton production and fertilization for the culture of larval and fingerling striped bass. Aquaculture 35:353-369.

Hornbeck, R. G., W. White, and F. P. Meyer. 1965. Control of Apus and fairy shrimp in hatchery rearing ponds. Proceedings of the Annual Conference of Southeastern Association of Game and Fish Commissioners 19:401-405.

McCraren, J. P., and T. R. Phillips. 1977. Effects of Masoten (Dylox) on plankton in earthen ponds. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 31:441-448.

McCraren, J. P., J. L. Millard, and A. M. Woolven. 1977. Masoten (Dylox) as a control for clam shrimp in hatchery production ponds. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 31:329-331.

Meade, J. W. , and L. Bulkonski-Cummings. 1987. Acceptability of fairy shrimp (Streptocephalus seali) as a diet for larval fish. Progressive Fish-Culturist 49:217-219.

Parmley, D., G. Alavarado, and M. Cortez. 1986. Food habits of small hatchery-reared Florida largemouth bass. Progressive Fish-Culturist 48:264-267.

Pennak, R. W. 1989. Fresh-water Invertebrates of the United States, Third edition. John Wiley and Sons, Inc. New York. 628 pp.

SAS Institute. 1988. SAS/STAT user's guide, release 6.04 edition. SAS Institute, Cary, North Carolina.

Table 1. Stocking and harvest variables of ponds stocked with Florida largemouth bass fry seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995.

Treatment	Pond	Hectares	Stocking density (fish/ha)	Stocking biomass (kg/ha)	Stocking length (mm)	Harvest density (fish/ha)	Harvest biomass (kg/ha)	Harvest length (mm)	Growth rate (mm/day)	Survival (%)
14 days	34	0.33	314,135	8.80	13.0	229,938	28.27	22.8	0.82	73.2
	35	0.36	417,538	19.82	15.4	152,389	30.87	24.4	0.64	36.5
	36	0.30	368,743	8.12	11.7	195,145	36.29	23.8	0.93	52.9
	37	0.30	410,204	9.82	12.9	123,078	35.54	24.5	0.89	30.0
	38	0.34	376,883	6.40	10.9	33,280	24.27	38.4	2.12	8.8
	Average	0.33	377,501	10.59	12.8	146,766	31.04	26.8	1.08	40.3
7 days	40	0.28	407,803	17.55	15.0	209,205	38.00	26.1	0.80	51.3
	41	0.28	418,177	15.65	14.2	112,927	18.94	27.3	0.94	27.0
	42	0.28	371,576	13.00	14.0	220,596	31.33	23.1	0.70	59.4
	43	0.28	351,586	9.85	13.0	208,779	55.36	29.6	1.28	59.4
	44	0.28	384,819	28.61	18.0	212,883	44.98	26.9	0.59	55.3
	45	0.28	404,132	12.71	13.6	186,307	29.87	27.3	0.92	46.1
	Average	0.28	389,682	16.23	14.6	191,782	36.41	26.7	0.87	49.8
Overall Average		0.31	383,592	13.41	13.7	169,274	33.73	26.8	0.98	45.1

Table 2. Pearson correlation coefficients (probability in parenthesis) of harvest and stocking variables for Florida largemouth bass rearing ponds stocked at seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995.

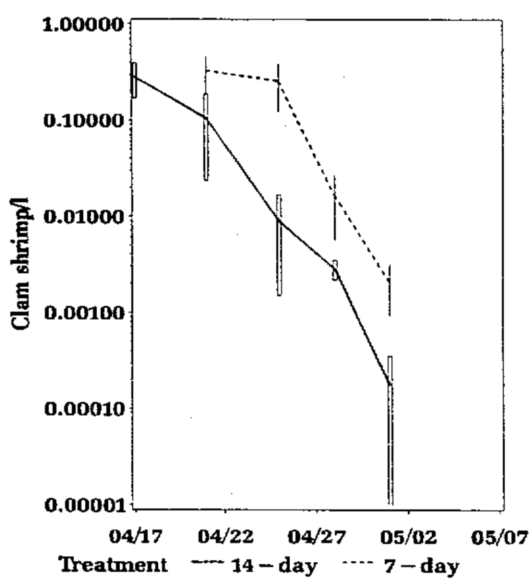
	Stocking variable		
Harvest variable	Density (fish/ha)	Biomass (kg/ha)	Length (mm)
Length (mm)	0.04832 (0.8878)	-0.22115 (0.5134)	-0.34805 (0.2942)
Density (fish/ha)	-0.41082 (0.2094)	0.28641 (0.3932)	0.42171 (0.1964)
Biomass (kg/ha)	-0.24504 (0.4677)	0.20942 (0.5366)	0.26050 (0.4391)
Growth rate (mm/day)	-0.17085 (0.6155)	-0.59949 (0.0513)	-0.69943 (0.0166)
Percent survival	-0.61101 (0.0458)	0.13898 (0.6836)	0.28434 (0.3968)

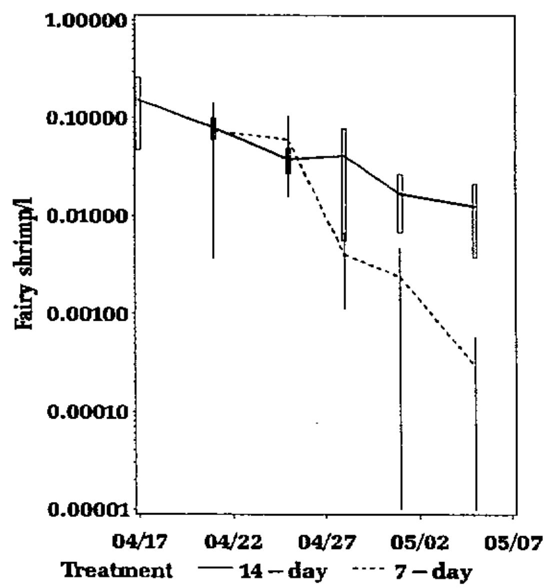
Table 3. Population estimates for fairy shrimp and clam shrimp in ponds stocked with Florida largemouth bass at seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995 and the results of t-test. Shrimp densities are in organisms/l and lengths are in mm. Number of infested ponds is in parenthesis.

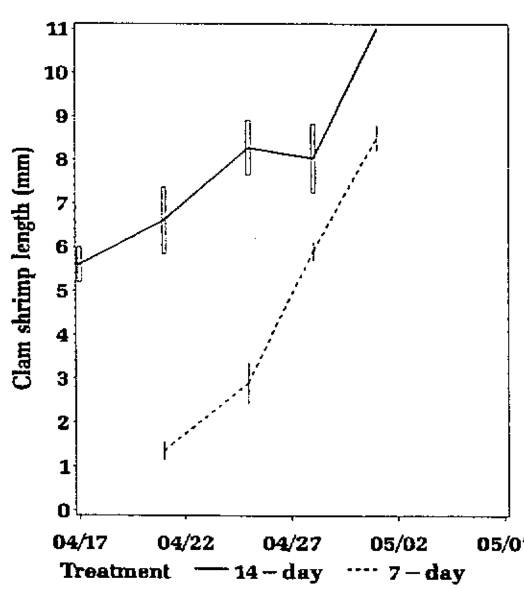
Sampling date	Population parameter	Treatment		P	t
		7-Day	14-Day		
21 April 1995	Fairy shrimp density	0.112 (4)	0.080 (5)	0.7890	-0.2910
	Clam shrimp density	0.329 (6)	0.131 (4)	0.3369	-1.0215
	Fairy shrimp length	4.3 (4)	17.6 (5)	0.0068	3.7952
	Clam shrimp length	1.3 (6)	6.6 (4)	0.0051	6.7492
25 April 1995	Fairy shrimp density	0.061 (6)	0.038 (5)	0.6458	-0.4857
	Clam shrimp density	0.256 (6)	0.015 (3)	0.1364	-1.7689
	Fairy shrimp length	12.5 (6)	22.0 (5)	0.0002	6.0237
	Clam shrimp length	2.9 (6)	8.3 (3)	0.0003	6.6395
28 April 1995	Fairy shrimp density	0.008 (3)	0.042 (5)	0.4070	0.9244
	Clam shrimp density	0.016 (6)	0.003 (5)	0.2672	-1.2473
	Fairy shrimp length	18.0 (3)	26.4 (5)	0.0508	2.4348
	Clam shrimp length	5.9 (6)	8.02 (5)	0.0546	2.5733
1 May 1995	Fairy shrimp density	0.014 (1)	0.021 (4)	.	.
	Clam shrimp density	0.004 (3)	0.001 (1)	.	.
	Fairy shrimp length	24.8 (1)	29.0 (4)	.	.
	Clam shrimp length	8.5 (3)	11.0 (1)	.	.
5 May 1995	Fairy shrimp density	0.002 (1)	0.021 (3)	.	.
	Clam shrimp density	0	0	.	.
	Fairy shrimp length	30.0 (1)	26.4 (3)	.	.
	Clam shrimp length	.	.	.	.

Table 4. Stomach contents (average percent composition) of Florida largemouth bass fingerlings from ponds stocked at seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995.

Treatment	Organism	Percent composition		
		28 April	1 May	5 May
7-day	Backswimmer	0.12	0.14	0
	Bass	0.12	0.14	0
	Chaoborus	9.67	22.43	10.39
	Cladocera	16.54	46.64	21.44
	Clam shrimp	0.20	0.07	0.11
	Copepod	0.31	0.14	0.03
	Fairy shrimp	0.16	0.07	0
	Nauplii	72.85	30.38	68.01
	Nematode	0.04	0	0.03
14-day	Backswimmer	0	0.84	2.93
	Bass	0	0.84	2.93
	Chaoborus	61.21	75.31	40.83
	Cladocera	20.61	6.69	0.98
	Clam shrimp	0.30	0.42	1.71
	Copepod	0	0	0
	Fairy shrimp	1.82	0	1.22
	Nauplii	16.06	15.06	49.39
	Nematode	0	0.84	0


Clam shrimp/l
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day


Fairy shrimp/l
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day


Clam shrimp length (mm)
0
1
2
3
4
5
6
7
8
9
10
11
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day

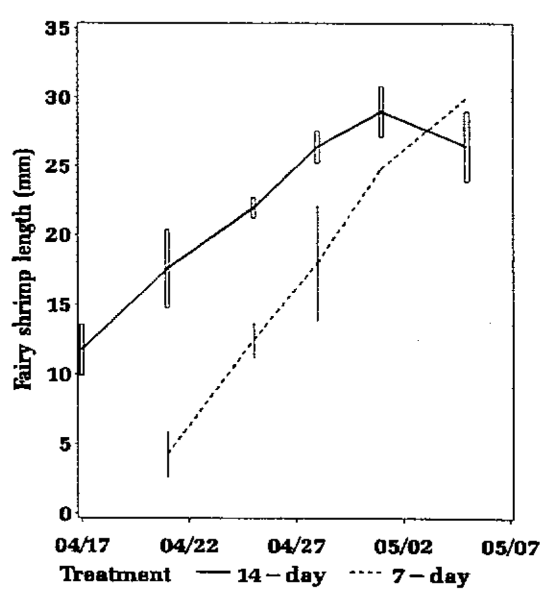
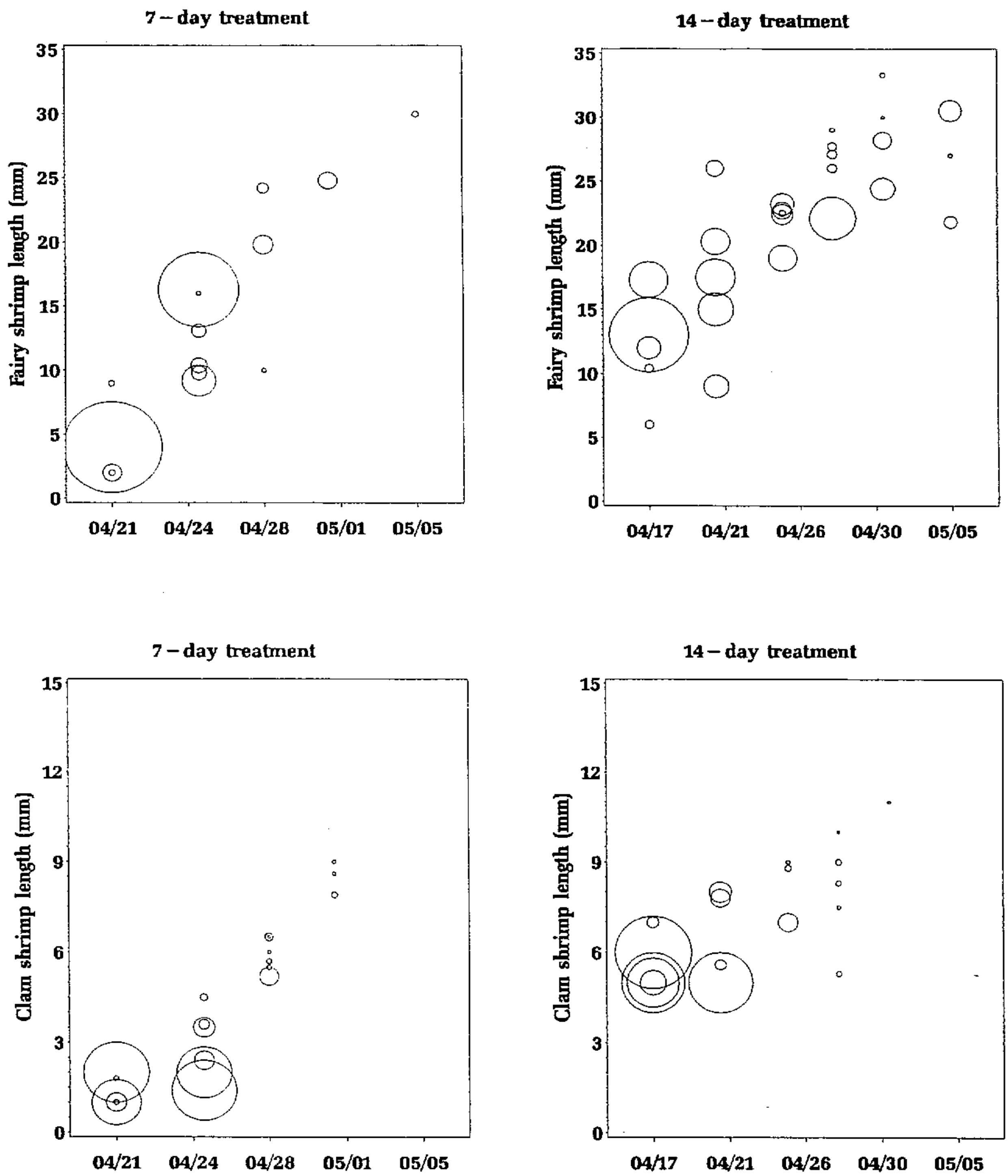

Fairy shrimp length (mm)
0
5
10
15
20
25
30
35
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day

Figure 1. Clam shrimp and fairy shrimp densities and lengths in ponds stocked with Florida largemouth bass fry at seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995. Shrimp densities are in organisms/l. Horizontal bars are standard errors.



7 – day treatment
14 – day treatment
Fairy shrimp length (mm)
0
5
10
15
20
25
30
35
04/21
04/24
04/28
05/01
05/05
04/17
04/21
04/26
04/30
05/05
7 – day treatment
14 – day treatment
Clam shrimp length (mm)
0
3
6
9
12
15
04/21
04/24
04/28
05/01
05/05
04/17
04/21
04/26
04/30
05/05

Figure 2. Fairy shrimp and clam shrimp length, density, and number of shrimp infested ponds at the Jasper Fish Hatchery in spring 1995 for 7-day or 14-day filling-stocking interval treatment ponds. Each circle represents a pond on the corresponding date. Size of circle is relative density of shrimp.

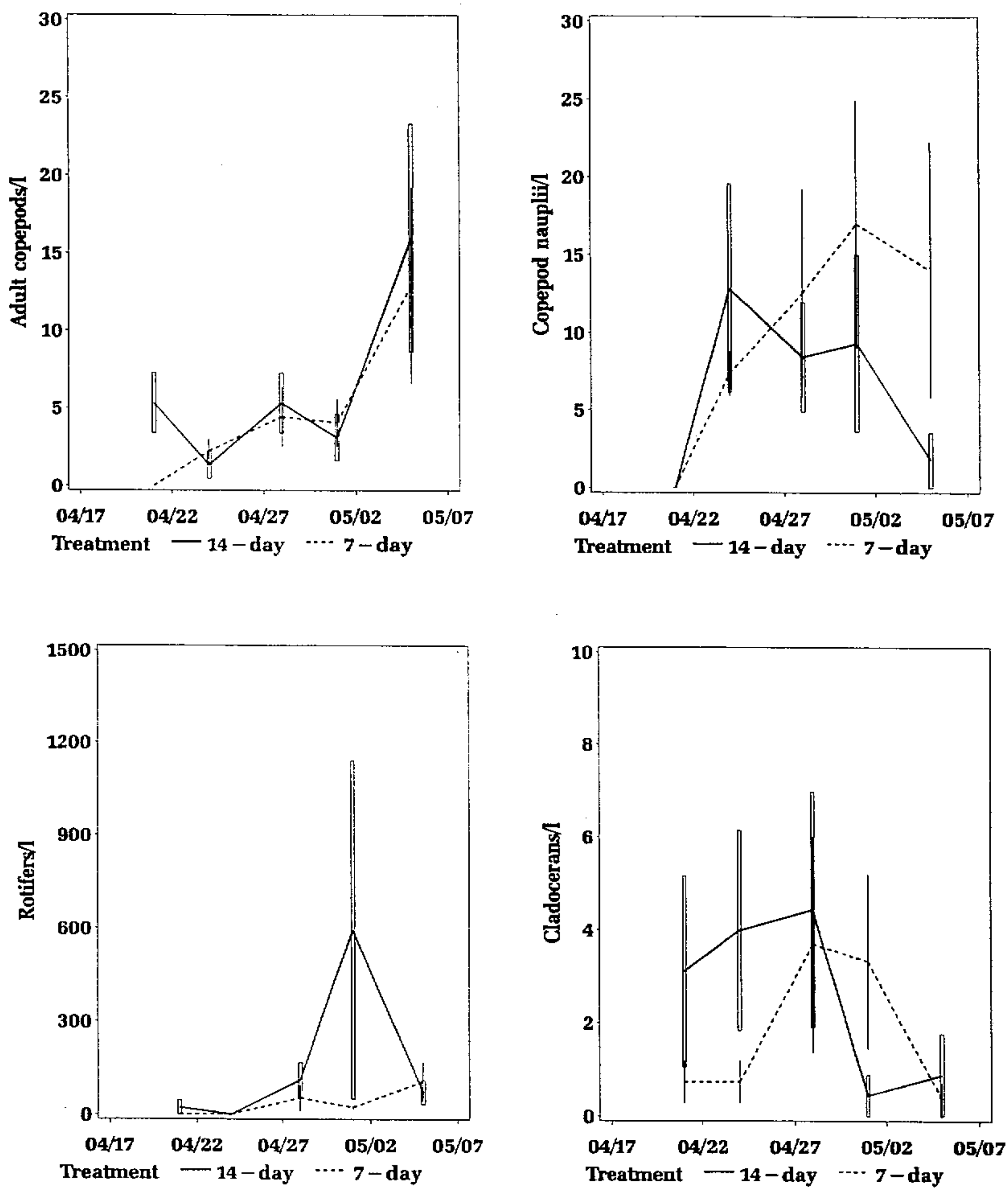

Adult copepods/l
0
5
10
15
20
25
30
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day
Copepod nauplii/l
0
5
10
15
20
25
30
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day
Rotifers/l
0
300
600
900
1200
1500
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day
Cladocerans/l
0
2
4
6
8
10
04/17
04/22
04/27
05/02
05/07
Treatment — 14 – day ···· 7 – day

Figure 3. Zooplankton densities (organisms/l) in Florida largemouth bass rearing ponds stocked at seven or 14 days after filling at the Jasper State Fish Hatchery in spring 1995.