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EFFECTS OF SUPPLEMENTAL FEED AND FERTILIZER ON PRODUCTION OF RED SWAMP CRAWFISH, *Procambarus clarki*, IN POOLS AND PONDS

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ABSTRACT

Some effects of supplemental feed and fertilizer upon production of red swamp crawfish, *Procambarus clarki*, were measured during a five-month period at Baton Rouge, Louisiana. The tests, in vinyl-lined pools and earthen ponds, also evaluated stocking rates of 10,000 and 20,000 young per acre, effect of artificial cover on survival of young, and necessity of soil as substrate in crawfish production. The influence of feed, fertilizer, and soil on total hardness of well water was studied. The relationhip of total hardness of water to survival and growth of young crawfish was observed.

Survival of crawfish in pools with soil was: fed, 65 percent; fertilized, 56 percent; control, 78 percent. In pools with no soil, survival was: fed, 0 percent; fertilized, 32 percent; control, 0 percent. Survival in pools was apparently not affected by increasing the stocking rate from 10,000 to 20,000 per acre, or by adding artificial cover. Average net production in pools with soil ranged from 90 to 372 pounds per acre. Feeding significantly increased production, but fertilization did not.

Average net production in earthen ponds ranged from 107 to 251 pounds per acre. No significant increase was shown by feeding or fertilization, but many fed crawfish had matured and burrowed by draining time.

Total hardness of well water in pools was increased from approximately 6 ppm in controls to 7 ppm by feeding, to 17 ppm by fertilizing, and to 65 ppm by adding soil. Well water added to earthen ponds developed a total hardness similar to that of pools with soil. Survival and growth of young crawfish in pools was minimal at a total hardness of approximately 17 ppm, and best near 65 ppm.

Sex ratio of pool-reared crawfish was 1 male: 1.25 female. Sex ratio of pond-reared crawfish was 1.08 males: 1 female.

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INTRODUCTION

Annual crawfish production in Louisiana has fluctuated in recent years from 200,000 pounds to 10,000,000 pounds (Broom, 1963; La Caze, 1966). This resource, valued at approximately $4 million annually, is comprised largely of the red swamp crawfish, *Procambarus clarki*. The crawfish crop is harvested from natural waters, from rice fields, and from impoundments designed solely for crawfish production.

Viosca (1961) reported that 2,000 acres in Louisiana were devoted to crawfish farming in 1959. La Caze (1966) indicated that approximately 6,000 acres in southwest Louisiana were impounded for crawfish production in 1965. He also noted that the number of active farms increased as natural production decreased.

It is apparent that proper management of crawfish ponds is a means by which annual production might be stabilized and become more predictable.

The Louisiana Cooperative Fishery Unit, with special encouragement by the Louisiana Wild Life and Fisheries Commission, and Louisiana Crawfish Industry Development Association, has begun work on such management techniques. This report includes preliminary results of experiments at Baton Rouge, Louisiana, during 1966-67. Variables considered were stocking rates in pools and ponds, supplemental feed and fertilizer, soil or no soil as substrate, cover as a factor in survival, and total hardness of the pool and pond water.

MATERIALS AND METHODS

Pools

Twenty-four vinyl-lined pools, 10 feet in diameter and 30 inches deep, were filled with four inches of alluvial soil from the Mississippi River flood plain, Ben Hur Farm, L.S.U.; filling was completed with well water from the same area. Forty-eight pools were prepared by filling with well water only.

Young crawfish, 7 to 11 mm total length, were stocked in pools on December 2, 1966 at rates of 10,000 and 20,000 per acre. Artificial cover was provided in certain pools by 2-inch sections of garden hose.

Certain pools received commercial, pelleted fish feed in amounts proportional to stocking rates, but in excess of the crawfish's feeding capacity. Feeding was discontinued when water temperature was below 50° F.

All fertilized pools received two applications of fertilizer at the rate of 100 pounds 8-8-2 per acre on November 28, 1966 and December 5, 1966.

Several pools were maintained as controls, and received no feed, fertilizer, or soil.

Ponds

Nine earthen ponds, 0.1 to 0.25 acres, were stocked with 20,000 young crawfish per acre on December 12, 1966. These crawfish were from the same brood stock and of the same size as those stocked in vinyl pools. The ponds were located near the pools on Ben Hur Farm, L.S.U., and contained the same soil type as that used in vinyl pools. Three each of the earthen ponds received feeding at the same rate as in fed pools, three were fertilized, and three were controls with no feed or fertilizer added. Ponds were drained and poisoned for resident crawfish prior to stocking, but no provision was made to exclude any overland migrations which might have occurred.

Water Chemistry

Just prior to draining, water in pools and ponds of all experiments were analyzed for several chemical factors, including pH, total hardness, bicarbonates, carbonates, oxygen and carbon dioxide.

Draining and Recovery

All pools and ponds were pumped dry and all crawfish counted and weighed. Substantial samples were sexed, measured, and weighed individually. Pool experiments were terminated April 21, 1967, after 140 days, when an overturn and oxygen depletion killed crawfish in certain pools. Pond experiments were terminated on May 17, 1967, after 156 days.

Proximate Analysis of Crawfish

In order to determine possible relationships of total hardness of water to chemical composition of crawfish, samples of crawfish were analyzed for protein, fat, total minerals, calcium, magnesium, nitrogen, phosphorus, and potassium. Analyses were done by the Feeds and Fertilizer Laboratory, Louisiana State University, Baton Rouge.

RESULTS AND DISCUSSION

Pools with Soil

Production per acre in pools with soil ranged from an average of 90 pounds to an average of 372 pounds (Table 1). Significant increases in standing crop were produced by adding pelleted fish feed, and by increasing the stocking rate. Little effect on standing crop was produced by light fertilization with 8-8-2.

Survival in this group of pools varied from an average of 50.0 percent to an average of 82.2 percent (Table 2). There were no clearcut effects of treatment upon survival rate, but in two of three treatments, survival was slightly lower at the higher stocking rate. Competition is reflected here, and in the average weight of surviving crawfish at the higher stocking rate. In fed pools, competition for food was at a minimum, and there was no difference in average size of crawfish at the two stocking rates. Only in fed pools did crawfish become large enough for harvest by draining time.

Pools with No Soil

Production in pools with no soil substrate was limited to fertilized pools, and was only 38-52 pounds per acre. Survival occurred only in fertilized pools, and was 42.4 percent at 10,000 crawfish per acre and 26.4 percent at 20,000 per acre (Tables 1, 2). Possibly, the competition for the limited minerals in the pool water brought on the decrease in survival at the higher stocking rate. Average size of the surviving crawfish in the higher rate was much less than the size of surviving crawfish at the lower stocking rate. Effect of artificial cover on survival was inconclusive, since this cover was added only to pools with no soil, where survival was extremely low.

Earthen Ponds

Pounds per acre of crawfish produced in ponds varied from an average 107 pounds to 251 pounds, and survival from 18.6 percent to 104.9 percent (Tables 1, 2). The low poundage recovered, and percent survived, from fed ponds was caused by maturation and burrowing of the crawfish. It is significant that these crawfish in both pools and ponds matured and paired off at only 4 to 5 months of age. One pond had contamination by resident crawfish, and resulted in the recovery of more crawfish than were stocked.

Despite contamination and burrowing, estimates of yield per acre were similar to results from pool experiments. Further, these results agree with those of Forney (1958) who reared 89 to 352 pounds per acre of bait crawfish (*Orconectes immunis*) in New York with heavy fertilization. Thomas (1965) estimated that harvest of red swamp crawfish by trapping in Louisiana has ranged up to 1,000 pounds per acre. Broom (1961) produced a maximum net yield of approximately 1,200 pounds per acre by supplemental feeding red swamp crawfish in pools and ponds at Auburn, Alabama. Although our estimate for fed ponds was obviously low, the average weight of remaining crawfish indicated

Table 1. Production of Crawfish in Pools (140 days), and in Ponds (156 days).

Treatment	Stocking rate (per acre)	Net yield (pounds per acre) Mean	Range
Pools/Soil			
Control	10,000	111	(61-161)
	20,000	128	(105-150)
Fertilized	10,000	90	(44-144)
	20,000	139	(61-228)
Fed	10,000	204	(194-228)
	20,000	372	(289-444)
Pools/No Soil			
Control	10,000	--	--
	20,000	--	--
Fertilized	10,000	52	(9-93)
	20,000	38	(0-94)
Fed	10,000	--	--
	20,000	--	--
Earthen Ponds			
Control	20,000	198	(119-277)
Fertilized	20,000	251	(247-255)
Fed	20,000	107*	(93-121)

*Many crawfish had matured and burrowed.

the value of feeding. Again, light fertilization produced no significant increase in production. Both fertilized and control ponds produced 40 to 50 per cent greater yields than pools with soil, presumably because of vegetation and other natural food accessible near the edges of earthen ponds.

Total Hardness of Water

When hardness of the experimental waters was suspected as a limiting factor in growth of crawfish, all waters were analyzed for total hardness at draining. Well water, which was used to fill pools and ponds, had only 6.1 ppm total hardness; feeding raised the value to 7.3 in pools, and two applications of 8-8-2 fertilizer increased the hardness to 17.5 ppm (Table 3). Pools with soil, and earthen ponds developed a similar total hardness, with a maximum of 81.5 ppm in fertilized ponds.

Table 2. Survival, and Average Weight at Draining, of Young Crawfish Stocked in Pools and Ponds. Initial Average Weight was 16.3 Milligrams.

Treatment	Stocking rate (per acre)	Average survival (per cent)	Average weight (grams)
		Pools/Soil	
Control	10,000	82.2	6.1
	20,000	73.6	3.9
Fertilized	10,000	50.0	8.3
	20,000	59.0	5.4
Fed	10,000	69.4	13.3
	20,000	61.1	13.8
		Pools/No Soil	
Control	10,000	--	--
	20,000	--	--
Fertilized	10,000	42.4	5.6
	20,000	26.4	3.3
Fed	10,000	--	--
	20,000	--	--
		Earthen Ponds	
Control	20,000	104.9**	9.2
Fertilized	20,000	79.5	7.1
Fed	20,000	18.6*	12.9

*Many crawfish matured and burrowed.
**Contamination by resident crawfish.

It is apparent that there is a minimum requirement of approximately 17 ppm total hardness (calcium and magnesium) for young crawfish to survive. There probably exists a direct relationship between total hardness and growth of crawfish (Table 3). The calcium-magnesium ratio in production waters should also be investigated.

These findings support Viosca (1961), who recommended use of high calcium fertilizers or lime in certain acid areas when crawfish production is desired.

Other water chemistry factors did not measurably affect production.

Proximate Analysis of Crawfish

To further explore the relationship of total hardness to the crawfish, proximate analyses of exoskeleton and peeled tail meat were done for samples from each treatment in the experiments (Tables 4, 5). Few differences in the analyses were noted. However, in fertilized pools

TABLE 3.—EFFECTS OF FEED, FERTILIZER, AND SOIL UPON TOTAL HARDNESS OF WELL-WATER USED TO FILL POOLS AND PONDS IN CRAWFISH EXPERIMENTS.

Treatment	Total hardness (ppm) Mean	Range
Pools/No Soil		
Control (well water)	6.1	(4-8)
Fertilized	17.5	(16-20)
Fed	7.3	(5-9)
Pools/With Soil		
Control	56.9	(50-65)
Fertilized	63.3	(60-65)
Fed	60.5	(40-80)
Earthen Ponds		
Control	48.0	(46-50)
Fertilized	81.5	(80-83)
Fed	58.0	(36-88)

Table 4. Proximate Analysis of Exoskeletons of Red Swamp Crawfish Reared in Pools and Ponds. Mean Values are Per Cent of Wet Weight.

Treatment	Protein	Fat	Moisture	Ash	Ca	Mg	N	P	K
Pools									
Control; Soil	10.5	0.7	73.7	12.6	4.19	0.062	1.7	0.35	.018
Fertilized; Soil	11.1	0.7	72.7	12.5	3.88	0.073	1.8	0.36	.019
Fed; Soil	11.0	0.7	73.5	11.8	4.11	0.070	1.8	0.34	.019
Control; No Soil	NO SURVIVAL								
Fertilized; No Soil	10.0	0.6	77.4	9.0	3.49	0.031	1.7	0.40	.017
Fed; No Soil	NO SURVIVAL								
Ponds									
Control	10.4	0.6	72.2	13.8	4.74	0.083	1.7	0.45	.018
Fertilized	11.1	0.3	67.8	14.3	4.88	0.091	1.8	0.41	.019
Fed	12.7	0.7	68.3	13.6	4.92	0.077	2.1	0.37	.022

Table 5. Proximate Analysis of Peeled Tail Meat of Red Swamp Crawfish Reared in Pools and Ponds. Mean Values are Per Cent of Wet Weight.

Treatment	Protein	Fat	Moisture	Ash	Ca	Mg	N	P	K
Pools									
Control; Soil	11.6	0.9	82.9	2.6	0.51	.039	1.9	0.17	.022
Fertilized; Soil	13.5	1.6	81.8	2.3	0.30	.040	2.2	0.14	.024
Fed; Soil	14.2	1.8	81.8	2.1	0.39	.039	2.3	0.19	.022
Control; No Soil	NO SURVIVAL								
Fertilized; No Soil	12.8	1.2	82.5	2.7	0.68	.026	2.1	0.23	.024
Fed; No Soil	NO SURVIVAL								
Ponds									
Control	12.5	1.2	81.9	3.0	0.55	.054	2.0	0.25	.022
Fertilized	13.5	1.2	82.4	2.5	0.46	.031	2.2	0.19	.026
Fed	14.3	2.4	79.5	2.1	0.36	.034	2.3	0.17	.028

with no soil (total hardness 17.5 ppm), total mineral content of crawfish exoskeletons was significantly less than in other treatments. The reduction in mineral content was reflected in decreases of 20 percent in calcium and 60 percent in magnesium. It was observed at draining that crawfish from pools with no soil had thin, relatively flexible exoskeletons.

Observations on Biology

Sex ratios of crawfish at draining indicated that there was 1 male: 1.25 females in pools, and 1.08 males: 1 female in ponds. The discrepancy might be explained by females burrowing first into the soil in ponds in advance of reproduction, whereas in pools they could not burrow.

Relative weights of male and female crawfish from pools at draining indicated that males become 10 to 35 percent heavier than females at maturity. This difference was largely in more bulky chelae, a secondary sexual characteristic of the male crawfish.

SUMMARY

1. Significant increases in standing crop of crawfish were produced by adding pelleted fish feed in pools.
2. Fertilization produced little increase in yield of crawfish in pools with soil or in ponds.
3. Fertilization increased survival in pools with no soil.

4. Increasing the stocking rate from 10,000 to 20,000 per acre did not significantly affect survival.
5. Addition of dry, pelleted fish feed did not significantly increase hardness of well water.
6. Fertilization, and addition of soil significantly increased hardness of well water.
7. Approximately 17 ppm total hardness was the minimum required for survival of young crawfish.
8. Apparently a direct relationship existed between total hardness and survival, production per acre, and average size of crawfish.
9. Mineral content of crawfish exoskeletons from pools with no soil was significantly less than that from pools with soil or from ponds.
10. Sex ratios favored males in pond experiments and females in pools.
11. Average weight of mature male crawfish was greater than that of mature females.

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POND CONSTRUCTION AND ECONOMIC CONSIDERATIONS IN CATFISH FARMING

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Profitable catfish farming requires careful attention to suitable water supplies; good fishpond sites; hatching, feeding, and handling fish; and adequate facilities for an orderly operation of harvesting and marketing.

Good agricultural land is often suitable for catfish farming and has been widely used. Land that is poorly suited for other farm uses may also be developed into profitable ponds for raising catfish. In addition to the primary purpose of growing fish, a fish farm may provide secondary benefits such as: (1) irrigation water; (2) water for livestock; (3) feeding and resting areas for waterfowl; (4) boating; (5) fishing; (6) picnicking; and (7) water for fire fighting.

POND SITES, DESIGNS, AND CONSTRUCTION

A catfish pond needs complete protection from floodwaters, proper distribution of water supplies, and convenient drainage facilities.

Successful fishpond sites require soils of good water-holding quali-