was still 60 per cent of the original number placed in the troughs. A breakdown of the mortality figures is presented below.

Original number of sac fry (volumetric calculation)	4,130*
Number of fingerlings stocked (actual count)	2,478
Total observed losses (actual count)	1,568
SURVIVAL	60%

* It will be noted that the total number of fingerling fish stocked and the observed losses are less than the original estimate by 84 fish. This difference of two per cent is attributed to an error in the original estimation.

Losses attributed to each cause are as follows:

Cause	Number	Per cent of loss
Scyphidia and ensuing treatment	703	44.8
Possible thiamine deficiency	720	46.0
Ichthyophthirius and ensuing treatment	42	2.7
Accidental losses	22	1.4
Sacrificed fish	21	1.3
Non-feeders	10	0.6
Unexplained mortality	50	3.2
	1,568	100.0

An analysis of the mortality data presented above indicates several pertinent observations.

1. Two factors were responsible for 91 per cent of the losses. The suspected thiamine deficiency undoubtedly contributed to the excessive loss following the formalin treatment for *Scyphidia* since symptoms associated with formalin toxicosis were not pronounced.

2. Cannibalism was not considered a factor in the observed losses since no lacerations or teeth marks were noted on any of the moribund fish. No regurgitated or partially engulfed fish were seen.

3. If fresh carp flesh is used in the diet it should be supplemented with beef liver. Any other fish flesh which contains the anti-thiamine factor should also be suspect.

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A PRELIMINARY REPORT ON THE AGRICULTURAL PRODUCTION OF THE RED-SWAMP CRAWFISH (PROCAMBARUS CLARKI) (GIRARD) IN LOUISIANA RICE FIELDS

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INTRODUCTION

In most parishes of southern Louisiana crawfish are a highly popular food. They are prepared for eating in eight or more ways — boiled, bisque, stew, etoufee, fried, salad, cocktail, and pie. The supply is hardly able to meet the demand during late winter and early spring, the principal season of use.

It is not uncommon for rice fields to occasionally produce a crop of the red-swamp crawfish. These occurrences are fortuitous, however, and only during the last four or five years have rice fields been managed purposely to produce crawfish.

This paper is a report on field trials that led to the development of procedures for the successful production of a commercial (or recreational) crop of crawfish. Such information is needed as a preliminary guide for SCS conservationists to use in helping farmers develop plans for working crawfish into their rice rotations. These rotations and other land use and conservation practices needed are part of basic conservation plans for entire farms. The data also will serve as a basis for detailed research into the development of refined procedures.

According to Penn (1959) there are four genera and 29 species of crawfish in Louisiana. This paper deals with *Procambarus clarki* (Girard).

METHODS OF STUDY

Four crawfish fields were selected on farms in Acadia Parish, Louisiana. Weekly observations were made on these farms. Many other areas and conditions in southwestern Louisiana were observed. Field techniques and procedures were devised and put into practice on the ground. These were evaluated and compared to different methods of plant and water management for crawfish.

FOOD OF THE CRAWFISH

The red-swamp crawfish eats dead and living plant and animal matter. (Viosca, 1953.) In the flooded rice stubble fields, crawfish were seen eating green rice regrowth, rice straw, and various aquatic plants. It has not been determined that the addition of fertilizer to the water of a rice-crawfish field will grow enough extra pounds of crawfish to pay for the fertilizer. Forney (1958), however, fertilized bait crawfish ponds for increased production.

GROWTH RATE OF CRAWFISH

Field observation cages 1/5000 of an acre in size were constructed and placed in natural conditions. They were 12 inches high. The frames were made from cypress boards and covered with ¼-inch hardware cloth. This was covered with screen wire temporarily when very small crawfish were placed in the cages.

These cages were placed in rice fields being managed for crawfish production. They were pushed down into the mud so as to make as near as possible a natural condition. Table I gives the results obtained in the spring of 1961 when crawfish weighing about 5.5 grams each were confined.

Cage number 1 was stocked at the rate of 10,000 per acre. It can be noted that these crawfish made the most rapid growth. Cages 2 and 3 were stocked at a rate of 100,000 per acre which was believed to be much higher than normal field concentrations. The crawfish in these cages had lower rate growth as compared with Cage 1. This was true even when the 20 crawfish in Cage 2 were fed supplemental food of fish heads, beef melt and cottonseed cake. These growth rates compared favorably with Broom's work (1961) in Alabama.

Table I — Spring Growth Rate of Immature Crawfish

Date	Cage No. 1		Cage No. 2 (fed sup. food)		Cage No. 3 (not fed sup. food)	
	No. of Crawfish	Av. Wt. (Gr)	No. of Crawfish	Av. Wt. (Gr)	No. of Crawfish	Av. Wt. (Gr)
4/10/61	2	5.5	20	5.5	20	5.75
4/26/61	2	11.0	20	10.7	20	10.00
5/10/61	2	19.0	20	16.4	20	11.85
5/26/61	2	18.0	20	15.9	20	11.0
6/12/61	2	15.0	18*	21.2*	all died	

* Cage was placed in a field of growing rice.

In the latter part of May, as the water became warm and then hot, growth stopped. With this water condition all crawfish, on the average, lost weight. In June, Cage 2 was moved to a field of growing rice where the water was shaded, cool, clear, and the field was well fertilized. The crawfish in this case again began to put on weight.

Therefore, it appears practical to add fresh water to the field, perhaps beginning in April, and repeat often enough to keep the water level stable and fresh. It was observed that the addition of fresh water to a rice field in May stimulated crawfish movement and feeding activity.

The months of September and October appear to be the peak hatching time for crawfish eggs since at this time more crawfish were observed with newly hatched young. Viosca (1953) says that egg hatching in native swamps reaches its climax in September.

With this hatching date in mind, females with eggs under their tails (already laid) were collected in August and placed in the observation cages. Table II gives results of the growth rate of these young.

Table II — Fall and Winter Growth Rate of Crawfish Following Birth

Date	Size of Crawfish
8/30/61	Female w/eggs
9/18/61	Young — ⅛" long
10/27/61	Young — ¾" long
11/ 9/61	Young — 1" long
11/29/61	Young — 1½" long
12/ 7/61	Young — 1½" long
12/19/61	Young — 2 grams (av)
1/ 2/62	Young — 4 grams (av)
1/19/62	All dead

Table III gives growth of small crawfish hatched in the wild and collected on October 27, 1961. The age at collection time was assumed to be two and one-half months, based on data in Table II.

Table III — Fall and Winter Growth Rate of Crawfish Hatched in Wild

Date	Av. Size	Number
10/27/61	1" long	18
11/29/61	2" long	10
12/19/61	3.1 grams	10
1/ 2/62	3.6 grams	10
1/19/62	3.5 grams	10
2/ 2/62	6.7 grams	9
2/16/62	8.2 grams	9
3/ 6/62	10.5 grams	8
3/27/62	10.5 grams	4
4/13/62	14.0 grams	3
5/31/62	16.0 grams	2

The minimum size for edible crawfish is 15 to 20 grams each. Based on the information in Tables II and III, it takes about 210 days for late summer or fall hatched crawfish to reach this size.

Crawfish have been observed with young every month of the year. Some larger adults survive the winter and can be seen in swamps in January and February (Penn 1943). This accounts for the varied sizes in rice fields during late winter and early spring. However, the size becomes more uniform by mid-April when apparently the young of the year begin to reach maturity.

CRAWFISH FIELD MANAGEMENT

General Procedure. A prospective crawfish field begins with an area of native pasture that is planned in rotation with a forthcoming rice crop. To date the most successful procedure generally follows this sequence:

Time	Practice
Early Spring	Field plowed
May 1st *	Field replowed and rice planted
May 15 - August 1st	Field flooded — growing rice
August 1st *	Water drained off rice
August 15 *	Rice harvested
September 1st * - Nov. 1	Field reflooded
September 1st - June 30	Field remains flooded
December * - March	Crawfish harvested

* Dates approximate, may vary 10 - 15 days

Stocking. It appears that the irrigation of rice once in two years, provides enough moisture to maintain a resident population of crawfish in most southwestern Louisiana fields. Unsuccessful attempts to raise a commercial crop of crawfish have occurred on fields that had not been planted to rice in four or more years. On such fields it may be necessary to stock adult crawfish at the rate of 5 - 10 pounds per acre in May. They should be put into the water which is on the growing rice.

Soils. The soils in the rice area vary from clay to silty clay loams. They are Baldwin, Crowley, Harris, Iberia, Portland, and Sharkey soils.

Table IV shows the average results of soils analysis on five rice fields. Although not conclusive, it appears that a crawfish crop does not remove plant nutrients.

Table IV — Comparison of Soil Nurtients on Crawfish Field with Normal Rice Field

Nutrients *	Rice Fields Following Crawfish (3 fields)		Rice Fields With No Crawfish (2 fields)	
	Average	Range	Average	Range
Available P_2O_5	19 ppm	(14-21)	12 ppm	(7-17)
Available K_2O	59 ppm	(41-82)	46 ppm	(32-60)
Calcium	983 ppm	(771-1134)	821 ppm	(861-880)
Available Magnesium	250 ppm	(207-313)	171 ppm	(129-213)
pH	5.8	(5.5-5.9)	5.9	(5.8-5.9)

* Analysis made by Soils Laboratory, Louisiana State University, Baton Rouge.

Water Management. In early spring when a field is plowed in preparation for rice planting, *a few* crawfish usually are plowed out of the ground. When the field is flooded to irrigate the growing rice in early summer, this sparse resident population in the ground comes out of its burrows into the field. Mating has been observed in the water while the rice is growing during April and May. Penn (1948) says that copulation reaches a peak during the month of May. The water remains on the rice for three or four months. As long as the water is present, shaded by the rice, cool, and the field is well fertilized, some of the crawfish appear to stay in the rice field all summer and fall. Others, wanting to lay eggs, burrow in levees, high spots in the field, or banks of ditches and canals, or migrate to adjacent fields.

When the water is drained off the rice in late summer or early fall for harvest, a few crawfish move out with the water. However, it seems most of them have left the water to burrow into moist ground. One hundred and fifty female crawfish captured in August as the water

was being drained off the rice field for harvest were examined. They all contained huge masses of black eggs internally, nearly ready to be spawned. About the same time, three others that had burrowed into the ground in adjacent fields were dug up; they all had eggs under the tail (hatching).

In late summer when water is drained off the rice crop, it takes about two to three weeks for the field to become dry enough for rice harvest. No appreciable hatch has occurred by this time. Soon after the rice harvest, the field is reflooded and in another three to four weeks recently hatched crawfish can sometimes be found in the flooded rice stubble. They are extremely small, however, and difficult to find. Several hatches of crawfish have been counted and the number varied from 284 to 492 per individual female. Some young may have been lost during the capture process.

The field remains flooded from September or October, until late June the next year when the crawfish season ends. Many adult crawfish from the previous season's crop can usually be caught in the field by December. Most of these are above average size and have external characteristics which distinguish them from immature ones. These adults are replaced in the catch continuously, during the winter and early spring, by young of the year as they mature and reach marketable size and as the adults of the previous season die out.

Water should be a minimum dept of six inches at all times on the field. Fields with water deeper than about 18" did not produce more pounds than those with water 6" - 18" deep. On the other hand, deep water makes the harvest more difficult. Large outside levees around a rice field make water-holding easier.

Vegetative Management. One field which was flooded with water 36" to 48" deep immediately following rice harvest failed to produce crawfish of sufficient size for harvest. With this deep flooding, the rice stubble did not sprout and make green regrowth; thus, it was assumed that the food supply was greatly reduced. It seems advisable to allow time enough for the stubble to sprout before reflooding (about one week); then do not flood too deeply so as to allow the rice stubble to grow. Grazing the stubble field with cattle removes vegetation which serves as food for crawfish.

Insecticides. Various insecticides are toxic to the red-swamp crawfish (Muncy, 1963). Fields on which insecticides have been used for control of the rice insects have failed to produce crawfish. Evidence of crawfish should be noted on the field selected for management and careful attention should be paid to present and past use of insecticides on the field.

Predators. Fish are probably the worst pedators on crawfish. Green sunfish and bullhead catfish were examined in the fields and found to have eaten crawfish. The draining of the water from the rice for harvest eliminates most fish; therefore, no other control appears necessary at this time. However, if water from a bayou or big irrigation canal is used to reflood the stubble, it is advisable to put a one-quarter inch or smaller screen over the inlet to prevent fish large enough to spawn next spring from entering the field. Water depth of over six inches or more seemed to prevent excess predation of wading birds.

HARVESTING THE CROP

Usually, with the management procedures outlined, harvest can begin in late December or January. Weather appears to be an influencing factor in beginning time of harvest. The winter of 1962-63 was a severe one for southwestern Louisiana. One cold front followed another continuously without the usual two or three-week warming trend in late January or February. Harvest was about five to six weeks late in all crawfish fields this year. It appears that a warming trend is needed in late winter to stimulate feeding and movement to traps.

The crawfish harvested in December, January, and early February are usually larger ones, weighing about 10 to 11 per pound. These are adults which apparently survived from the season before, and include a few early-hatched, large but immature individuals which evi-

dently must be the earliest hatched in May or June (instead of October). Penn (1948) reports that crawfish hatched in late summer or fall do not reach maturity before May of the next year. These immature or so-called young of the year can be distinguished from adult carry-overs.

Most commercial crawfishermen now use the standard cylinder-type or funnel-entrance trap. Catfish heads, gizzard shad, buffalo-carp, and beef melt are the baits commonly used. It is wise to remove the old bait each time the cylinder trap is checked and add one piece of fresh bait. It is important to have the bottom of a funnel-entrance trap on flat ground so the crawfish will crawl in, not under the entrance. A well-baited and placed trap will catch three-quarters to one pound in six to eight hours. They are usually checked in early morning and late evening. The common crab or crawfish net is used by sports crawfishermen when the crawfish are "really biting," and a person should check them every 10 to 15 minutes to catch enough for the family freezer or to boil.

The harvest is conducted in various ways. Some farmers contract their fields to commercial fishermen for a set fee per pound of crawfish harvested. Others fish the field themselves and sell directly to the public or wholesale buyers. Still others allow the public to fish at so much a pound, or a combination of these methods is used. Retail prices usually begin at 35 cents per pound live weight and go down to a low of 10 cents, depending on the production.

The larger crawfish have smaller percentages of tail meat. When crawfish weigh eight to 10 per pound, there is only about nine pounds of tail meat per 100 pounds of live crawfish. In average size crawfish, 25 to 30 per pound, there is 14 pounds of meat per 100 pounds of live crawfish. Peeled tail meat usually sells from $2.00 to $3.50 per pound.

A well-managed and diligently harvested field yields between 400 and 1,000 pounds of live crawfish per acre. This production is accomplished only with heavy fishing and if all crawfish 15 or more grams in weight are harvested.

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ABSTRACT

A Preliminary Report on the Agricultural Production of the Red-Swamp Crawfish (*Procambarus Clarki* (Girard) in Louisiana Rice Fields.

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A summary of field trials that led to the development of procedures for the successful production of commercial or recreational crops of crawfish is presented.

Four crawfish fields were selected in Acadia Parish, Louisiana, and weekly observations were made and recorded. Field management techniques and procedures were devised and put into practice on the ground.

These were evaluated and compared to different methods of land and water management for crawfish.

Observations were made on crawfish growth obtained in study cages placed in rice fields at different stocking rates. Three tables on this growth rate are presented.

Soil samples on crawfish and non-crawfish fields were taken, analyzed, and compared.

Production on the fields were determined and recorded as high as 1,000 pounds per acre.

From these trials, observations, and records, field management techniques of a preliminary nature were devised and are presented. These techniques involve water management, vegetative management, field selection, and harvest methods.

THE EFFECT OF FORMULATION DIFFERENCES ON THE TOXICITY OF BENZENE HEXACHLORIDE TO GOLDEN SHINERS

FRED P. MEYER *[1]

ABSTRACT

Emulsifiable oil preparations of benzene hexachloride were found to be 25 times more toxic to golden shiners than wettable powder formulations containing the same level of gamma isomer. Tests of the individual components of the oil preparation other than the pesticide indicated that none of these was toxic to fish at the levels normally applied. The addition of a hydrocarbon solvent to a formulation increased the toxicity many times. No difference was noted in the toxicity of the active ingredient used in the various formulations.

Lethal dosages for copepods were not affected by formulation differences. Although aqueous solutions of the oil preparation killed much more quickly than the wettable powder, similar levels of activity produced equivalent results.

INTRODUCTION

Benzene hexachloride, a chlorinated hydrocarbon insecticide, is known to have a relatively low toxicity to warm water fish. This property has provided activity against many arthropods and its use in fish culture for the control of copepod parasites is widely practiced.

Among the copepod parasites of fish, few cause such extensive economic losses to the fish farmer as the "anchor worm," *Lernaea cyprinacea.* Benzene hexachloride has been used with varying degrees of success since Giudice[2] demonstrated its effectiveness as a control for *Lernaea* infestations. Stevenson (1954) found that treatments of 2.0 ppm benzene hexachloride (hereafter referred to as BHC) containing 5% gamma isomer and 7.5% other isomers were effective in reducing the parasite burden on goldfish without significant losses of fish. More recently, Shilo, *et. al.* (1960), Lewis (1961), and McNeil (1961) have discussed their varying degrees of success in using BHC to control anchor parasites.

In the fish farming area of Arkansas, BHC (12% gamma isomer, 34% other isomers) in the form of a wettable powder is used as a standard treatment for *Lernaea* infestations. Five applications at the rate of 1.35 pounds per acre-foot of the above powder applied at five-day intervals are generally effective in controlling the parasites.

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