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Crawfish Production: Pond Construction and Water Requirements

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The commercial culture of crawfish (*Procambarus* spp.) for human consumption is done exclusively in earthen ponds and relies on extensive management. Annual hydrological cycles of flooding and drying mimic the environmental conditions from which these animals evolved. Aquaculture of procambarid crawfish relies solely on natural reproduction—no hatcheries or nurseries are required—and autumn pond flooding coincides with completion of the reproduction cycle. The presence of water in ponds during autumn, winter and spring permits young crawfish to feed, grow and reach maturity within 3 to 4 months.

Crawfish retreat to sealed burrows during the summer to survive the excessive heat, and mature females will complete reproduction within the protection of the burrow. Therefore, following the hydrological cycle of natural habitats, ponds are drained and remain dry for a period during the summer. Temporary dewatering of ponds during the summer also promotes aeration of the bottom sediments, reduces aquatic predators, and allows vegetation to grow so that crawfish will have cover and food resources when ponds are flooded. Unlike many forms of aquaculture, crawfish production does not depend on supplemental feeding. Rather, crawfish get their nourishment from the indigenous food web of a vegetal detrital system.

Although there are several variations in crawfish production methods, all commercial efforts fall under one of two major production strategies—crawfish monocropping or a rice-crawfish rotational approach. Crawfish monocropping refers to the production of crawfish only, typically in permanent ponds. Rice-crawfish rotation involves rotational strategies in which rice fields are transitioned to crawfish ponds after the rice is harvested. Sometimes the same field is used each year in a rice-crawfish-rice rotational strategy, but usually the rice crop (and thus the crawfish crop) is grown in alternating fields each year so that rice weeds and diseases can be controlled.

Regardless of the production strategy used, crawfish are grown in shallow earthen ponds 10 to 24 inches deep. Relatively flat, drainable land with suitable levees is required for harvesting and for managing vegetation. Both monocropping and crop rotation use an annual wet/dry cycle and rely on natural reproduction and a forage-based food system.

Crawfish monoculture ponds

Location

Location is one of the most critical considerations for establishing crawfish ponds. Obviously, the pond needs to be close to a suitable water and power source. The pond bottom elevation needs to be sufficiently high to allow total drainage of the pond when required. Soil type is critical; soil must contain enough clay to hold water when the pond is flooded and to provide structural integrity to crawfish burrows (often 36 inches deep or more). Most soils that will form a thin ribbon when moist contain sufficient clay (> 27 percent clay) for crawfish ponds.

The topography of the location is also important. Flat, open pond bottoms with little slope make it easier to establish rice or other forage crops and to harvest crawfish efficiently (Fig. 1). While heavy equipment can be

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Figure 1. One of several abandoned catfish ponds on this farm that have been laser leveled and readied for conversion to a crawfish pond.

used to shape the pond bottom as desired, moving large volumes of soil may not be recommended. Removing top soil from large hills during severe leveling operations will sometimes limit forage establishment in those areas, and deep fills within the pond floor will often cause soft spots that could hinder subsequent equipment traffic. Locations that require minimal leveling are preferred.

There are other considerations for determining suitable locations for crawfish ponds:

- Flood probability—Flooding from outside the pond at a time when ponds should be dry can be problematic for forage establishment or management, and over-flooding when ponds are full can bring in predaceous fish, flush crawfish from the pond, and prevent harvesting if flood waters cover traps.
- Contamination possibility—Contaminants from nearby agricultural fields, industrial sites, and livestock facilities, and salt water intrusion in coastal areas, should be avoided.
- Wildlife hazards—Locations near large piscivorous bird roosts or rookeries should be avoided.
- Access—All-weather access to ponds is crucial for farm employees, but easy access by the public can sometimes increase the potential for theft.

Design and layout

Serious consideration should be given to the size and shape of crawfish ponds before construction begins. However, topography, location of water sources and drainage structures, and features such as access points, roads, tree lines, prevailing wind directions, and natural slope also should be considered during planning and may be more important than pond size.

Commercial ponds range from a couple of acres to more than 50 acres, but 10 to 20 acres per pond seems to be the most efficient size for pond management. Pond size should be compatible with water availability and pumping capacity. While some very large ponds are serviced by a limited supply of water and/or pumping capacity, this can be a problem during prolonged drought and/or when water demand for other crops is high. As a rule, pond size should be matched to water capacity that can provide a 4- to 6-inch flood depth across the entire pond in 7 days or less in dry weather (minimum capacity of 15 to 20 gpm per acre).

Pond shape and design are more critical than actual size. Because harvesting is done with traps evenly spaced and set in rows or access lanes, ponds that are square or rectangular are easiest to harvest. Where possible, harvesting lanes should be positioned along the long axis of the pond. The maximum slope of the bottom should be 6 inches or less within perimeter levees of a pond or sections of a pond with differential water levels. Interior levees should be avoided or kept to a minimum. Interior levees are used mainly to partition the pond into workable sections due to excessive slope of the land, to increase burrowing surface area in very large ponds, or to maximize water circulation. The ratio of linear levee area to pond surface area that provides optimum burrowing surfaces has not been determined, but it is thought that 10- to 20-acre square ponds or similar size sections within larger impounded areas provide an adequate ratio.

Some producers have circulated and reused water in attempts to maximize production, but the economic efficacy of pumping water to manage dissolved oxygen has not been fully established, especially when energy costs are high. Under this management practice, interior or baffle levees are strategically placed inside the pond to force aerated water to flow over large areas of the pond and prevent channelization from the inlet to the outlet (Fig. 2). If a pond is designed with baffle levees they

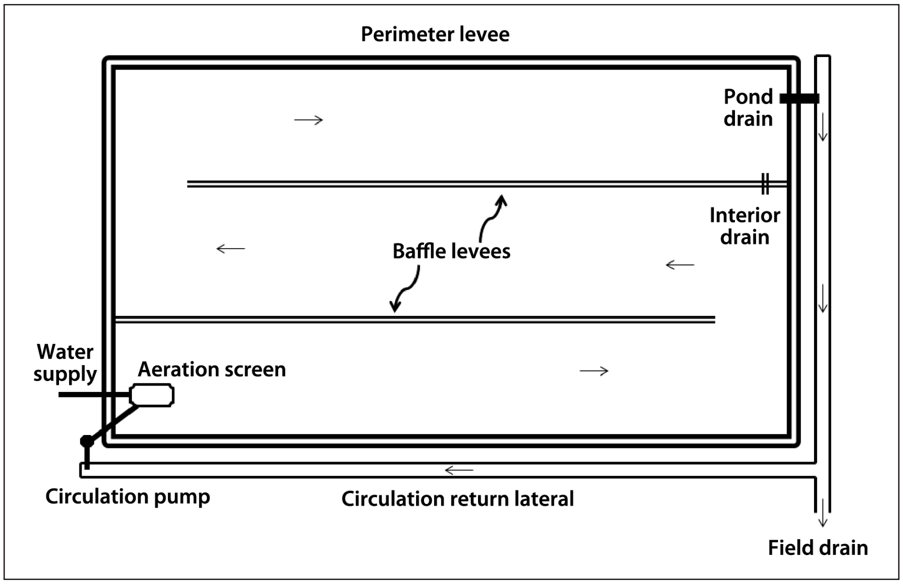

Figure 2. Depiction of baffle levees and an outside water return lateral to achieve a water recirculation system for a crawfish pond. Straight arrows indicate the direction of water flow.

should be positioned lengthwise to make harvesting more efficient (i.e., longer and fewer trapping lanes).

The size and placement of drains is important. Drains should empty overflow from heavy rains without water topping levees. They should also facilitate full and rapid draining for the management of forage crops. Complete pond drainage is a key consideration in pond design and construction. Standing water during the dry phase hinders tillage operations and forage establishment and can harbor predatory fish. Drain location is also important for efficient recirculation systems (Fig. 2). Water should be aerated at influent points and fish screening devices should be installed at both water influent and effluent sites.

Construction

Pond construction should be completed before the initial stocking of broodstock. It is often very difficult and more expensive to make changes or modifications to existing permanent ponds between production seasons, and extensive renovation that involves disturbances to levees or major areas of the pond bottom can decrease production the following year. Levee renovation can kill broodstock and young within burrows, and pond bottom renovation can hamper forage establishment if not accomplished in a timely manner.

Pond construction typically consists of clearing and/or leveling the area within the confines of the pond, forming levees, installing water inlets and outlets and a drainage system, and, in some cases, preparing the pond for recirculation capabilities. The large perimeter levee is formed by moving soil from inside or outside of the pond. Smaller interior levees, if needed, are often built with soil pulled from nearby. Placement of the bar ditches for the perimeter levee may depend largely on the construction equipment used. Levees constructed with a dozer could have the bar ditches outside of the pond, inside, or both. An excavator makes a deeper, narrower ditch, which is best positioned on the outside of the pond. Construction that uses dirt hauling equipment may not result in a bar ditch on either side of the perimeter levee.

Deep bar ditches on the interior of the pond usually should be avoided. While there could be some benefits to burrowed crawfish during a dry summer from the water reservoir such ditches provide, these ditches are difficult to drain completely and can harbor harmful fish populations from one season to the next. Moreover, deep interior ditches can impede proper water circulation for dissolved oxygen management, take up valuable real estate for growing a forage crop, and make harvesting operations inconvenient or inefficient. Shallow interior ditches that do not prevent forage establishment or hamper harvesting can sometimes be an asset for pond bottom draining, but may become filled in over time.

Levees designed to hold water in (and in some cases hold flood water out) should be built wide enough, high enough, and with the proper slope to withstand soil settlement, wind and rain erosion, and damage caused by burrowing crawfish and rodents. The minimum base width and height should be 9 and 3 feet, respectively. A greater breadth and height are recommended, particularly if vehicles will travel on the levee. The cores of perimeter levees should be free from woody debris that would cause seepage problems as it decays. Interior baffle levees designed to divert water flow or provide more burrowing area are not usually built to the standards of the perimeter levees, but if not well built they may erode or settle below the water surface over time, making them ineffective and requiring more maintenance.

Commercial catfish ponds can be converted to crawfish ponds with very little modification (Fig. 1). The levee system and water inlets/outlets of catfish ponds are usually adequate; however, the slope and bottom contour may need to be modified to get the smooth, even bottom and overall slope of no more than 6 inches that are recommended for crawfish production.

Crop rotation

Location

Where crawfish production will be integrated with rice, the location of crawfish ponds will often be determined by existing farms or fields. If crawfish are to be grown on only a portion of the total acreage, it is best to locate the crawfish ponds in fields that have the best wet weather access, the least possibility of non-intentional flooding, and the least chance of pesticide contamination from other crops nearby. Crawfish ponds also need adequate volumes of good quality water.

Where new rotational cropping operations will be established, follow the recommendations for the location of monocropped crawfish ponds.

Design, layout and construction

Because most rice-crawfish rotational operations are initiated in existing rice fields, the design and layout are largely already established (Fig. 3). However, existing agricultural fields may need to be modified for the best integration of crawfish production. Often, perimeter levees of rice fields will need to be strengthened and increased in height to support the deeper floods and longer duration (up to 10 months) of floods necessary for crawfish production. In rice fields, interior levees often follow the contour of the field, which creates irregular sizes and shapes of sub-sections within the fields. Where possible and practical, it is best to renovate such fields for crawfish by releveling them and decreasing and/or straightening the interior levees. Crawfish harvesting is more efficient when boats can travel in relatively straight lines and have to traverse fewer levees. Rice crops, on the other hand, require more precise management of water depth and the ability to get water on and off the field in a reasonable time. Therefore, compromise is often necessary when rice and crawfish are grown in the same field.

Aeration (at water inlets to the pond) and fish exclusion devices (at surface water inlets and outlets) should be added when rice fields are modified for crawfish. Another consideration is the source water for crawfish ponds. It is often necessary to introduce water to crawfish ponds at times when rice fields are being drained. If surface water is used in crawfish ponds, either as the primary source or as part of a water recirculation system, it is important to ensure that tail water from other agricultural fields (containing pesticide residues) is not discharged into crawfish ponds as it is drained from fields upstream of the water pump.

Water requirement and management

Water of adequate quantity and quality must be available for crawfish aquaculture. Aside from the water required to establish the forage crop (often rice, which uses a high volume of water), water is used to fill crawfish ponds and replace losses from evaporation and seepage during the 7- to 9-month production season. Additional water is often required to correct for low dissolved oxygen levels by flushing ponds with fresh, oxygenated water. Both groundwater and surface water are used in crawfish aquaculture. Groundwater is preferred because it has fewer biological and chemical hazards (e.g., predatory fish and pesticides) than surface water, but it is also more expensive to pump.

Crawfish aquaculture uses more water than most other agricultural crops and discharges greater volumes of effluent. The environmental impact of this effluent on receiv-

Figure 3. Typical rice field/crawfish pond found in south central Louisiana. Notice the large leveled fields with little to no slope and low, minimum levees. For reference of water depth, crawfish traps are approximately 22 inches tall.

ing streams is of great concern. To help crawfish producers protect and conserve water resources, a series of voluntary Best Management Practices (BMPs) have been identified and published in a manual entitled "Crawfish Environmental Best Management Practices" (Publication 3186, Louisiana State University Agricultural Center, Baton Rouge, LA). Applying BMPs in crawfish aquaculture will not only conserve the resource and protect the environment, but also reduce the cost of production and potentially increase profit margins.

Table 1. Important water quality variables (and desired levels) for crawfish aquaculture.*

Variable	Lethal low	Desirable	Lethal high	References**
Temperature (°C)	0	21 – 27	34	1, 2
Dissolved oxygen (mg/L)	< 0.5	> 2	–	3, 4
pH	3.0	6.5 – 8.5	> 10.0	2, 5
Total hardness (mg/L as $CaCO_3$)	***	> 50	***	6, 7
Total alkalinity (mg/L as $CaCO_3$)	***	> 20	***	2, 7
Un-ionized ammonia (mg/L)	–	< 0.06	2.65	5
Nitrite (mg/L)	–	< 0.6	5.95	5
Ferrous iron (mg/L)	–	< 0.09	0.1	8
Hydrogen sulfide (mg/L)	–	< 0.002	> 0.1	7, 8
Salinity (g/L)	–	< 6	15	9, 10

* Source: McClain, W.R. 2005. Crawfish culture in forage-based production systems. pp. 151–169 *in* A. M. Kelly and J. Silverstein, editors. Aquaculture in the 21st Century. American Fisheries Society, Symposium 46, Bethesda, Maryland.

** References are as follows: 1 = Johnson, 1982; 2 = Huner, 1990; 3 = Avery and Lorio, 1996; 4 = McClain, 1999; 5 = Hymel, 1985 ; 6 = de la Bretonne et al., 1969; 7 = Boyd, 1990; 8 = Culley and Duobinis-Gray, 1990; 9 = Loyacano, 1967; 10 = Perry and LaCaze, 1969.

*** Indicates data are unavailable.

Water quality

The water quality requirements for crawfish production are similar to those for other freshwater aquaculture species, and like most species under culture, hypoxia or low dissolved oxygen (DO) level is the primary water quality concern for earthen ponds. Even though crawfish may be more tolerant to low DO than finfish, severe and prolonged hypoxia can be a problem in forage-based crawfish ponds because of the large amount of vegetative biomass decomposing. To maintain satisfactory DO levels (> 0.5 to 1 ppm) producers can delay fall flooding until temperatures are cooler, keep initial flood depths relatively shallow, and exchange ("flush") hypoxic water as needed. Due to the constraints in large, forage-based production systems, DO management is easier with preventative measures than with corrective measures.

Other water quality variables of importance and their desirable ranges are listed in Table 1. Concentrations of most nutrients in crawfish ponds are generally acceptable. Though water may be very turbid in late spring when forage biomass has declined, this is normal and is not harmful to the crawfish. Producers should be careful, however, when introducing surface water, especially in industrial and agricultural regions. Pesticides and other toxicants can be very detrimental to crawfish and/or the aquatic fauna that serve as food resources for crawfish. Groundwater can be low in DO and high in hydrogen sulfide, but these are easily remedied with aeration before water is introduced into the pond or during discharge at one end of larger ponds.

Water quantity and effluent estimates

Research has shown that about 91 inches of water is required to maintain a typical rice field/crawfish pond at near full-flood depth of 12 inches from October flood-up through mid-June drawdown. About 40 percent of this water requirement will be supplied by precipitation, but the balance must be provided by surface or groundwater. Of the 91 inches of water used during a crawfish production season, an average of 74 percent will be lost to evaporation, evapotranspiration (by plants), and percolation through the pond bottom sediments. Research indicates that about 23 inches of effluent is discharged during an average crawfish production cycle, with 37 percent of it released from the pond at the end of the production season, 29 percent discharged as precipitation overflow and temporary levee failures during the season, 22 percent lost from seepage and other minor leaks of the perimeter levee, and 12 percent released as intentional flushing to maintain an acceptable concentration of DO for crawfish. The amount of water needed and the quantity of effluent discharged could be decreased by making levees higher and capturing and storing more rain water. Rather than maintaining water levels at or near the top of overflow structures, retaining more freeboard will increase storage capacity for rainfall and reduce pumping costs and unnecessary discharge.

Summary

The size, shape and characteristics of crawfish ponds vary widely within the industry, as do the methods of construction. Most successful crawfish ponds have these traits in common: soils with high clay content; relatively flat, yet well drained bottoms; a reliable water source; and perimeter levees sufficient to hold water at desired depths for up to 10 months annually. All prospective crawfish ponds should meet these basic requirements, with other features added to fit specific needs and situations. Other valuable resources on crawfish pond construction and water/effluent guidelines can be obtained from the Cooperative Extension Service and USDA's Natural Resources Conservation Service.

Resources

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