Producing Soft Crawfish:

a status report

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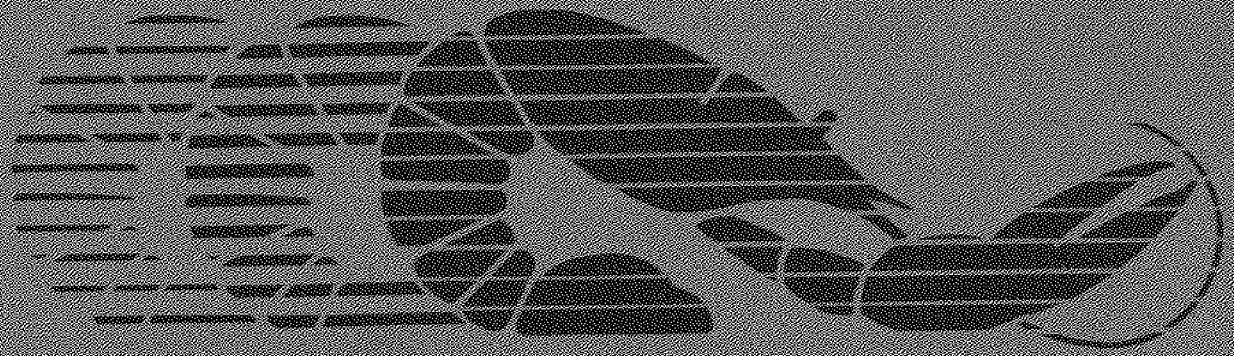

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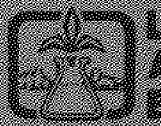

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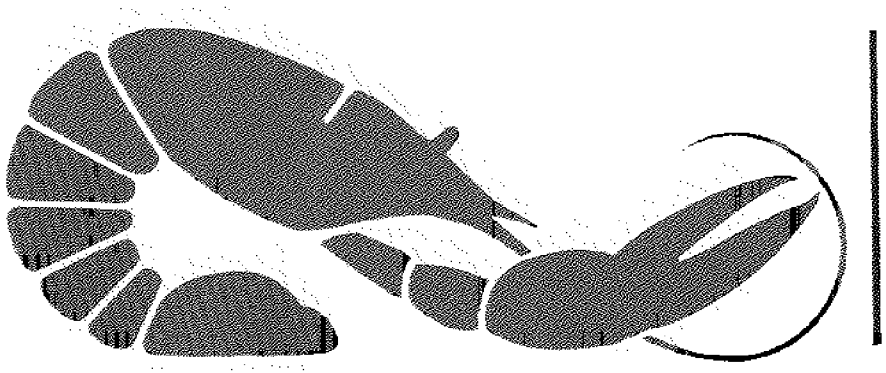

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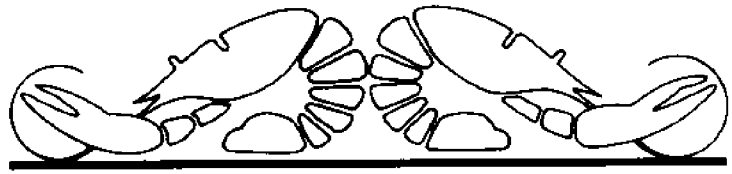

Producing Soft Crawfish: A Status Report

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INTRODUCTION

Louisiana is the center of crawfish production in the United States. The state's extensive freshwater swamps, marshes, and managed ponds yield annually about 100 million pounds, with an approximate value of 70 million dollars.

Within the past ten years, efforts to cultivate crawfish in man-constructed ponds have accelerated, and management schemes for pond-cultured crawfish have improved. With further improvements in management, there will be an expansion of the crawfish season, greater stability in supplies, new crawfish products, increased production, and vigorous market expansion outside the state. Growth will also occur in supporting industries, such as processing plants, trapping supplies, water management equipment, refrigeration, and waste disposal and utilization systems.

Crawfish must be considered a cash crop, that is, the actual amount of protein produced in a given area is small, but the price is high. A production of over 2000 pounds per acre has been achieved, but only the tail meat (12 to 15 percent of the animal) is actually consumed. An alternate approach for utilizing crawfish is to produce and market soft-shelled (commonly called "soft") crawfish. A soft crawfish is one that has discarded its old shell so recently that the new covering, which formed beneath the old shell, has not had sufficient time to harden. With soft crawfish, 70 to 92 percent of the animal is consumed, depending on the type of processing. Thus, the yield of edible protein from a crawfish pond is substantially increased.

Soft-shelled crawfish have been eaten in Louisiana for many years, but commercial development has been limited by the lack of feasible harvesting methods. In 1982, an intensive culture system designed to produce soft crawfish was tested at LSU. Further testing in 1983 and 1984 demonstrated that both the red swamp *(Procambarus clarkii)* and white river *(Procambarus acutus acutus)* crawfish could be held in tanks at high densities and molted to yield a highly priced product. With minor improvements, the culture system can become more efficient. At present, soft crawfish can be produced during the regular crawfish season, normally late February through June, and on occasion from December through July, depending on climatic conditions.

Soft crawfish can be collected by seining and dip-netting, though neither of these methods has been successful commercially. Standard crawfish traps attract few crawfish that are about to molt and the catch is not sufficient for marketing.

Collecting soft crawfish by a modified trawl mounted on the front of a boat is an innovative approach that has worked successfully, especially when an electrofishing system is attached. Ponds must be relatively clear of obstructions, but vegetation is

not a serious hindrance.. With this method, both soft and hard crawfish are collected, along with some debris. Damage to the soft crawfish can occur, making the product less desirable in appearance, but with care this can be controlled. Continued modifications will probably improve operating efficiency further.

An alternative to collecting soft crawfish is to hold and feed hard crawfish until they molt. Immature intermolt (hard-shelled) crawfish of edible size molt within 30 days when fed. Red swamp crawfish that are approaching the molting stage can be easily identified and simply held in tanks without feeding until they molt.

FIGURE 1. This is the typical appearance of the red swamp (left) and white river (right) crawfish.

The following sections discuss current technology for the collection and selection of moltable crawfish, and the procedure for producing soft crawfish in a high-density culture system. The procedures are more easily accomplished with the red swamp crawfish because of readily identifiable color patterns as the crawfish approaches molting (ecdysis), but they are also applicable to the white river crawfish.

FIGURE 2. The actual molting process occurs very quickly. The carapace (section covering the head and body) slowly begins to slip upward as the crawfish retracts its legs and claws from the old exoskeleton. Once its appendages are free, the crawfish flexes the upper portion of its body backward, and the carapace pops open. The crawfish usually rests a few seconds and then, by simply flipping its tail, frees its body.

For the next 12 hours, the crawfish is very soft and of prime quality for eating. Within 24 hours, the new skin becomes somewhat leathery, acceptable for frying but less desirable for other methods of preparation unless the carapace is removed. The tail and legs do not harden as rapidly as the carapace, and, thus, with the carapace removed, the animal can be cooked in a variety of ways. Collecting the crawfish within 12 hours will guarantee a product of highest quality.

COLLECTION, TRANSPORT, AND STORAGE OF CRAWFISH

The production of soft crawfish described in this paper depends on the collection of hard crawfish from ponds and natural crawfish habitats rather than culturing them to a marketable size under hatchery conditions. Thus, the supply coincides with the length of the crawfish season for any given year.

Reasonable attention must be given to obtaining hard crawfish that have not been seriously mishandled during trapping, transporting, and storage. The following points are most important if the producer expects to obtain crawfish of good quality that will not die while in the culture system.

1. Use only crawfish that have been held in traps for a short time and not exposed to low dissolved oxygen and high temperature. In the summer months, crawfish held in traps for several hours frequently die in the traps or within a few days if oxygen is critically low (less than 2 ppm) and the temperature high (above 90°F). Standup traps will permit crawfish to surface if oxygen is low; these are preferable to submerged traps.
2. When collected, all crawfish should be packed *loosely*, maintained under cool conditions (shaded and ventilated), and exposed to water once every three to four hours (sprayed or submerged for three to five minutes).
3. Ideally, the crawfish should be taken to the culture facility within four hours and placed directly in an aerated holding tank containing fresh water or on a tank floor receiving a continuous mist of water. Water temperature should be similar to that of the water from which the crawfish were collected (within 6°F). If the water where the crawfish were collected was above 85°F, the crawfish should be placed in water with a temperature no higher than this. The temperature should then be gradually lowered to 72-80°F over a period of two to four hours. Place the crawfish in the culture tanks after 24 hours of acclimation in the holding tank.
4. Although cold-stored crawfish have survived when placed in a culture system, sporadic high mortality is caused by the stress of temperature change, by trapping and transporting, or by a physiological condition related to the molt cycle. However, cold-stored crawfish may be the only reliable supply for the soft crawfish culturist. If so, the following procedure is recommended until more information is available. (a) Pack crawfish loosely at existing room temperature. (b) Spray with water, drain, and place in cooler. (c) Spray crawfish once a day with cold water (equal to the temperature of the cooler) until they are ready to be placed in the culture system. (d) Remove crawfish and let them adjust to room air temperature slowly (two to four hours or until they become active). (e) Remove dead or weak crawfish. (f) Place active crawfish in culture system.

SELECTION OF CRAWFISH

Molting Cycle

A review of crawfish biology (Huner and Barr 1984) is recommended for persons interested in producing soft crawfish. Both sexes undergo at least 11 molts in their life cycles. Molting is more frequent in young crawfish, and in warm water. Rapidly growing young crawfish may molt every five to ten days, while older (but still immature) crawfish usually molt within 30 days.

FIGURE 3. There are three recognizable stages in the development of red swamp crawfish in the early and late premolt periods. The crawfish at the bottom still requires feeding and is 10 to 15 days from molting. The crawfish in the center is committed to molting, does not have to be fed, and normally molts within a week. The crawfish at the top is about three days from molting. Note its obvious dark coloration and gray patch.

Molting is required for crawfish growth. As the crawfish eats and grows, the space under its shell is filled. Once the shell is filled, no more growth can occur until the old shell is discarded.

Toward the end of the growth phase, a soft membrane forms beneath the shell and gradually thickens. It is destined to become the new exoskeleton, but at this stage it lacks calcium (the main substance that gives the shell its hardness).

Through a series of chemical processes, calcium is extracted from the old shell and stored as two half-spherical

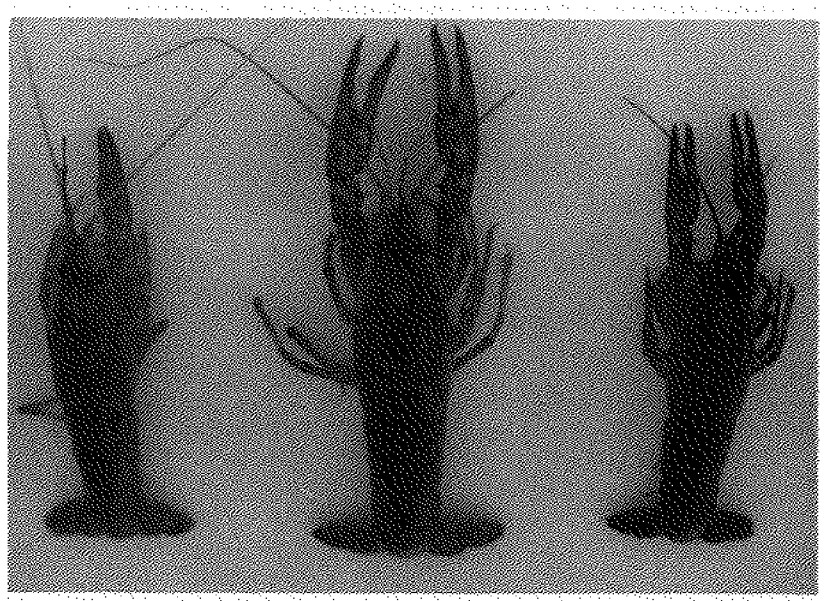


FIGURE 4. The darker crawfish at the right is in the late premolt stage. The coloration becomes evident within two to three days of molting. The shell becomes brittle and easily breaks if squeezed. The dark color is not actually from the shell but from the new, underlying skin that is highly pigmented.

stones, or *gastroliths*, just behind the eyes. This process weakens the shell and allows the crawfish to break it and escape. Following molting, the soft membrane (new exoskeleton) gradually hardens as it is impregnated with calcium. Water, absorbed by the crawfish, causes the new exoskeleton to swell, creating room for new tissue.

The calcium that initially hardens the soft exoskeleton is obtained from the dissolving gastroliths, the hepatopancreas, and the blood. Calcium is also taken from water and food when feeding resumes. The process is essentially complete in 72 hours. Soft crawfish for consumption must be collected every 12 hours to obtain the best quality. Collection every 24 hours is acceptable, but some crawfish will have rather "tough" shells.

FIGURE 5. Color is often a quick way to select immature crawfish, which are commonly referred to as "green" crawfish. A crawfish from muddy water, however, does not develop the intense color seen here on the mature red crawfish. Also, if a crawfish is red, it may still be immature, so additional characteristics must be examined. For example, in mature crawfish, the claw size is much larger in proportion to the body. In this figure, the immature red swamp crawfish exhibits the identifying green color. Immature white river crawfish, however, do not display intense coloration, and one must rely on sex-related structures to distinguish the immature crawfish from the mature ones.

In summary there are four recognizable phases to the crawfish molting cycle: (1) Intermolt—hard-shelled crawfish. (2) Premolt—the stage preceding the molt, in which the shell is still hard but is becoming brittle. (3) Molt—loss of old shell. (4) Postmolt—calcification of the new shell.

By recognizing the distinctive characteristics of the various stages in the molting cycle, the culturist can select appropriate crawfish for molting. Figures 3 through 6 illustrate the distinctive characteristics displayed by crawfish when they are approaching the molting phase. With experience, the culturist will be able to select crawfish that are within a few days, or even a few hours, of molting (late premolt).

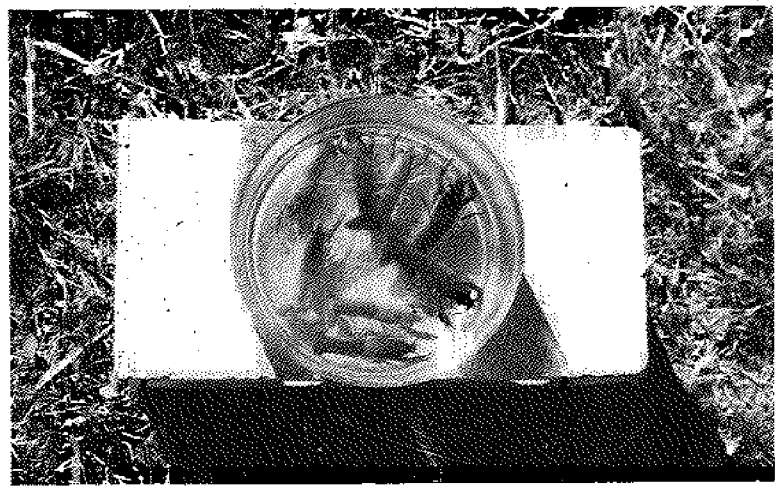


FIGURE 6. Small crawfish are of exceptionally high quality, as they are extremely tender. They are excellent for use as appetizers, and should demand a premium price in the marketplace.

It is more difficult to identify late premolt small crawfish, as their colors are not distinct. Several of the crawfish in the figure here have tails darker than their head regions, which is evident under proper light. Crawfish with darker tails are closer to molting than those with equal intensity of color on tail and carapace.

Recognizing Immature Crawfish

Because not all crawfish of a species can be used to produce soft crawfish, the key to success is knowing which crawfish to select. Sexually mature crawfish molt infrequently. Immature crawfish molt readily in captivity when given the proper care.

Some immature crawfish collected from traps are near the molting phase and molt without additional feeding. Others require feeding before they molt. Recognizing immature and mature male and female crawfish is critical to success. Figures 7 through 12 show the differences between mature and immature, male and female crawfish of both the red swamp and white river species. These characteristics can be easily seen with the naked eye and are accurate indicators for determining whether a crawfish is likely to molt within 30 days. With experience, the culturist can learn to quickly scan a group of crawfish and remove the nonmolters. Pointers to look for include claw size in relation to body size and general intensity of color. It is important, too, to understand how season of the year influences the number of molting crawfish in a typical catch.

Early in the year, most of the crawfish in Louisiana are mature, and frequently 100 percent of the crawfish in a catch will molt. From March through May, a minor breeding season occurs (depending on environmental conditions). These mature breeder crawfish that appear in the traps will not molt. Thus, selection becomes more critical as the season progresses.

From late June through October, most crawfish are mature and not suitable for molting. From November through January or February, many of the large crawfish are old breeders, or they may be stunted but mature. These are not suitable for molting. Small mature crawfish may seem to be immature because of their general appearance and claw size. Thus, one must rely on the characteristics shown in Figures 7 through 12, or obtain expert advice until sufficient experience has been achieved to detect these subtle differences.

Because crawfish release eggs throughout the year (peak egg hatching occurs in September and October and during a minor season from February through May), some immature crawfish can be obtained most of the year. In south Louisiana swamps and crawfish ponds, immature, moltable crawfish large enough to be edible are rarely present in sufficient numbers from July through January to warrant operating a soft crawfish system.

Occasionally, a pond containing crawfish may dry out or be drained before the crawfish season is over (for example, in April or May). If it is reflooded in July, the pond may have a population of immature crawfish during the "off-season." Considerable research is now underway by the authors to determine whether ponds can be routinely managed for off-season production. It may be possible to obtain a supply of immature crawfish throughout the year, or at least seven to eight months each year.

Fig. 7

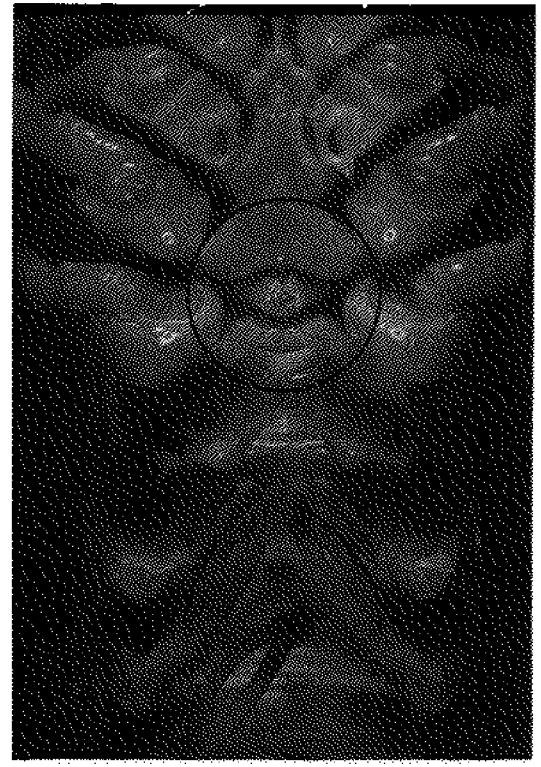


FIGURE 7. This is the typical appearance of a mature female red swamp crawfish. Normally, the annulus ventralis is rust-colored in the central area, but because of frequent mating the rust color may be scraped off.

FIGURE 8. This is a close view of the annulus ventralis of a mature female red swamp crawfish, as seen by the naked eye. The grooving can normally be seen without the aid of a magnifying glass.

FIGURE 9. In the immature female red swamp crawfish, the annulus ventralis shows only faint grooving and, to the naked eye, the grooves are often not evident. The surface appears to be rather smooth and cream-colored, and somewhat oval. This is the last stage before the female reaches maturity with the next molt.

FIGURE 10. In the mature female white river crawfish, the annulus ventralis groove is more pronounced than in the immature stage, but it is not as easily seen as in the mature female red swamp crawfish. The slight bulge that is barely evident in the immature white river crawfish can be clearly seen in the mature specimen. In addition to the expanded bulge, the surface of the mature annulus ventralis is very irregular and loses the smooth, pearl-like quality seen in the immature female.

Fig. 8

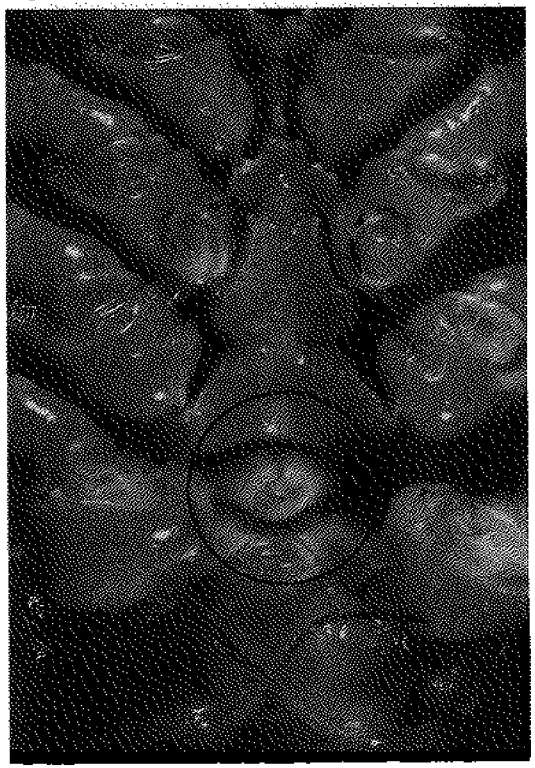


Fig. 9

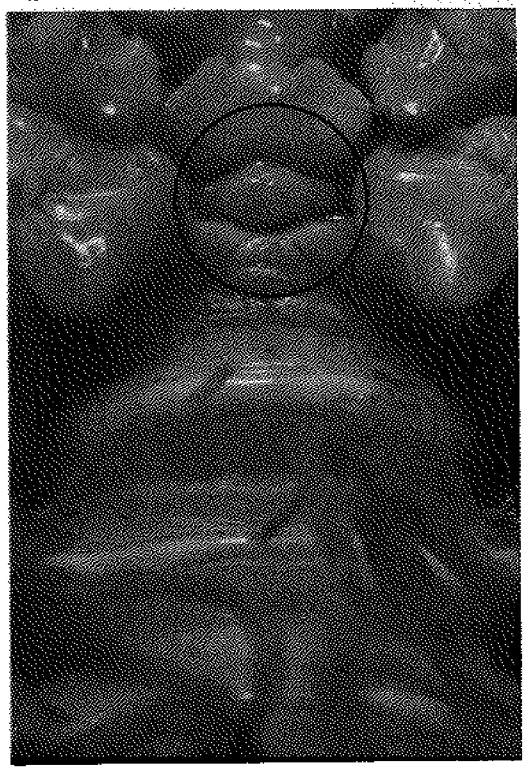
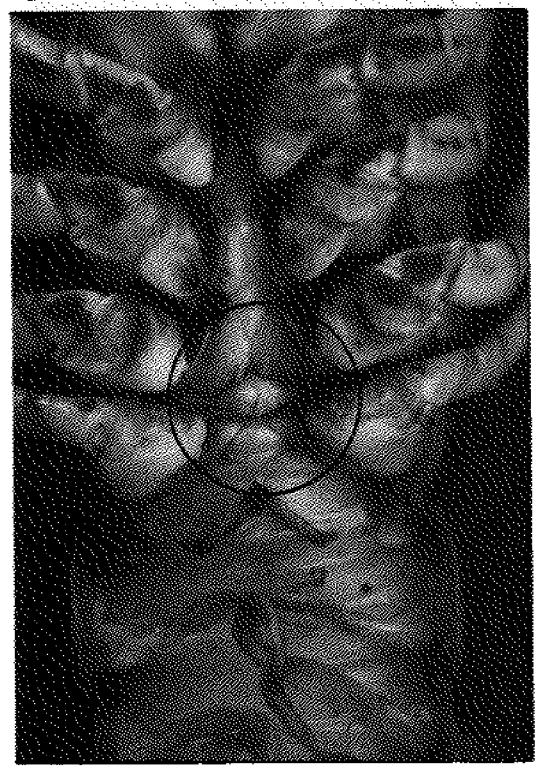


Fig. 10



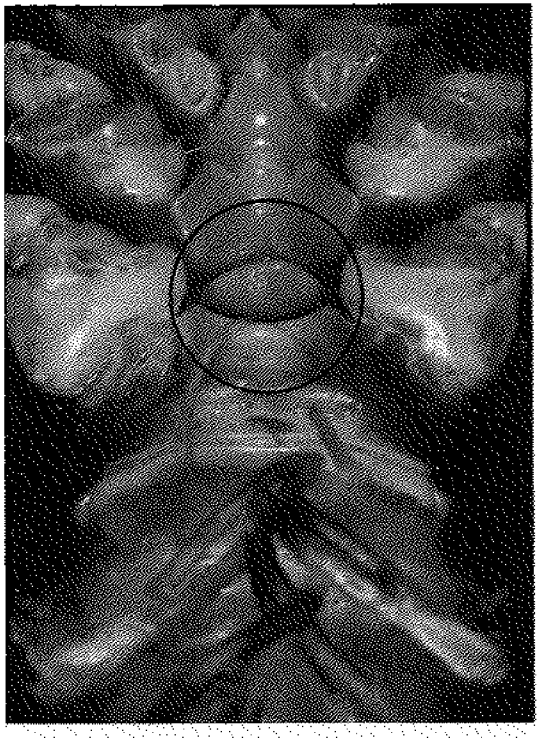


FIGURE 11. In the immature female white river crawfish, the annulus ventralis shows no clear grooving and a light bulge (upper right section) is often visible. To the naked eye, the surface appears smooth, oval, and cream- or pearl-colored. This is the last stage before maturity. At the next molt, the female will normally be mature.

FIGURE 12, A, B, and C. These figures show the hooks on the leg exoskeleton of the male red swamp crawfish. Size is not a factor in a male's reaching maturity. A very small crawfish (two inches) can be mature and show hook development. This is common in ponds where little food is available.

A. The hooks in the mature male crawfish are used to clasp the female during mating. The appearance of the male red swamp and white river crawfish is quite similar, but the shape of the hooks varies somewhat.

B. This male red swamp crawfish will molt once more before maturing.

C. This male crawfish will molt twice before maturing.

Fig. 12-A

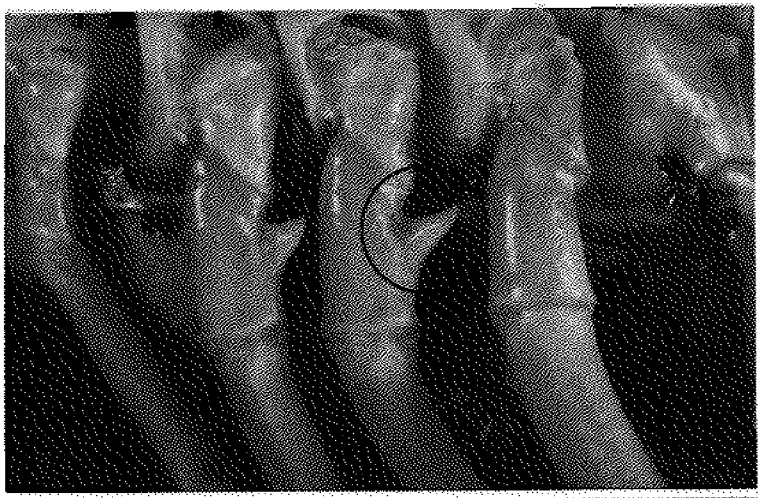


Fig. 12-B

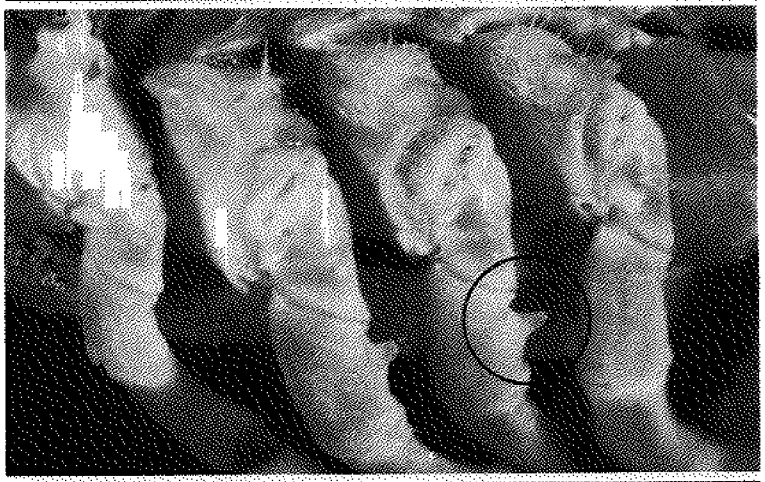


Fig. 12-C

SITE CONSIDERATIONS

A plant for producing soft crawfish should be located near the source of the crawfish. Access to more than one source is desirable; ponds and swamps are preferable, as these two combined may provide for a longer season in some years.

If the owner has land available, a few small ponds (about one or two acres each) could be useful in the production of crawfish "out of season." Small ponds are preferred, as aeration and water circulation may be required. Although techniques for off-season production have not been completely developed, evidence currently available indicates that small ponds can be managed to produce moltable crawfish from July through November. There is some evidence that deep ponds (three to four feet) are better than shallow ones during the summer.

Flat, cleared land is preferred if pond construction is required. Management of the ponds should follow current recommended procedures for crawfish production.

WATER SOURCE AND QUALITY

Well water or treated surface water (from which suspended matter has been removed) should be used. If a city water supply is available, the chlorine should be removed, either by aeration for 24 hours or by the installation of an activated charcoal filter. Crawfish can tolerate some chlorine (0.2-0.3 mg/1) but it is best to "play it safe."

Temperature

Ideally, water temperature should range from 70 to 75°F, but temperatures as high as 80°F are acceptable, with 85°F being the absolute maximum. Below 70°F the molting rate will decrease and thus reduce production.

Suspended Matter

Pond water can be used in the culture system, but algae, dead organic matter, silt, and aquatic organisms must be removed. Failure to do this increases the chance of introducing disease or parasites and makes cleaning and temperature control more difficult. Because waste feed and excrement accumulate, the tanks should be drained and cleaned weekly.

Water Chemistry

Water quality standards suitable for fish are also acceptable for crawfish: pH, 6.5-8.5: calcium hardness and total alkalinity (both as calcium carbonate), over 20 mg/1; and oxygen, above 3 mg/1.

These values can vary considerably in some cases; for example, calcium, alkalinity, and oxygen can be considerably higher, but high calcium causes the soft crawfish to harden faster. Less than 20 mg/1 of calcium is certainly not detrimental and may be beneficial by lengthening the time for calcification of the new shell.

The pH can be as low as 6.0 and probably as high as 9.5 without any difficulty. The effects of a rapidly fluctuating pH are not known at present.

The culturist should be cautious about substances such as ammonia (NH_3), hydrogen sulfide (H_2S), iron, saline water (above 0.8%), pesticides, sewage, industrial waste, and excess fertilizer (nitrogen compounds in particular). Water quality tests should be performed prior to facility development.

BUILDING REQUIREMENTS

Soft crawfish must be cultured within an enclosed shed, a greenhouse, or some other kind of structure that will: (1) provide protection from predators such as raccoons and birds, (2) offer personnel a reasonable work environment, (3) protect equipment and electrical circuits, and (4) provide reasonable environmental controls. The building need not be elaborate. A screened hatchery-type structure or a prefabricated greenhouse is acceptable.

The floor should have a hard surface with a drainage system and it must be washable. Electricity (110 and 220 v.) for lights, water and air pumps, and vent fans is required. Automated water and light timers are desirable.

Water flowing from the trays should be collected and not allowed to run over the floor. A small pond adjacent to the facility will provide for waste water discharge, a possible additional source of crawfish, or aquatic plants for supplemental feeding.

The piping should be large enough (four inches) to prevent clogging. The outlets of the drains should be covered with hardware cloth or similar material for rodent control. Periodically, this cover should be removed and cleaned and the floor drain flushed to remove crawfish and the buildup of organic sediment.

Processing, packaging, and refrigeration equipment should be housed separately from the culture system. Storage space is required for the culture and processing area. A workshop is necessary for meeting maintenance requirements.

Arrangements must be made for the removal of wastes, both solid and liquid. In most cases, a single or double lagoon system adjacent to the facility fulfills liquid waste-handling needs. If the system is properly planned and constructed, culture water from the crawfish tanks can be biologically treated and recycled through the system if a water source is limited.

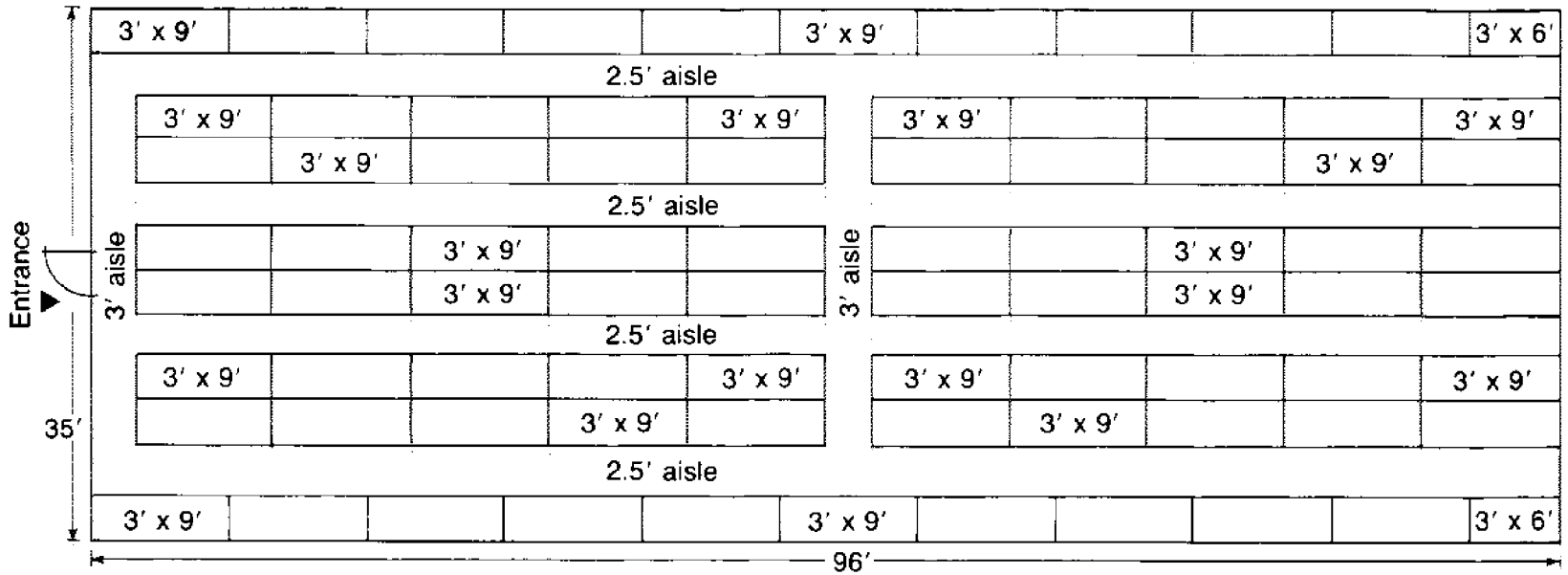


FIGURE 13. Suggested plan for the placement of crawfish culture trays.

SPACE REQUIREMENTS

A feasible size for a small-scale soft crawfish production system is that of a standard greenhouse—35 × 96 feet, or 3,360 square feet. Filling the greenhouse with single rows of trays and allowing 2.5-foot aisles, three feet of end spacing on one end, three-foot crosswalks, and 3 percent slack in culture space will give 1956 square feet of culture trays (Figure 13). This amounts to 65 percent of the available space. Although this is acceptable, increased use of the space is more desirable.

Stacking culture trays may be one answer, but the expense of adding tray support structures, plumbing, and, possibly, lighting must be compared with that of adding another greenhouse. A second possibility is to place the trays on support frames with rollers. Such frames are available from plant nursery supply companies. The use of these frames permits about 85 percent of the space to be used, leaving only one aisle. After the attendant completes checking one row of trays, that row is simply pulled over the aisle, creating a new aisle on the other side of the trays. Again, the cost of such a support system must be considered.

THE CULTURE SYSTEM

Several types of culture systems are possible, but all have certain common requirements: shallow water tanks containing water of good quality with a constant flow (for waste removal and aeration); a density of 10-20 animals per square foot of tank floor; the regular feeding and removal of premolt crawfish; and a water temperature of 70-80°F.

Tank Design

With the increasing interest in soft crawfish, culture systems have been developed. For example, a patented system for the culture of soft crawfish has been developed by James E. Bodker, Jr., of Baton Rouge. (The patent number is 4,475,480 granted 10/9/84. A copy can be obtained by sending 50 cents to the U.S. Patent Office, Washington, D.C. 20231.)

A simple shallow tray will suffice, though legal advice should be obtained to insure that there is no infringement on the patented system of Bodker. Multiple stacking of the trays may be possible, but the capital investment and complexity of management will increase. Culture tanks should be a light color and well lighted to insure that the crawfish can be easily seen. Dark containers and poor lighting will make it more difficult to locate the premolt or molted crawfish, and, thus, labor time is increased.

Figure 14 shows a simple design. The trays should have sides about six inches high to insure that the crawfish cannot escape. Corner covers prevent crawfish from stacking up and crawling out at the corners. Trays up to nine feet long and three feet wide may be used, with partitions every three feet, providing three compartments within a tray. The trays are compartmentalized so that the culturist can easily look over a reasonable number of crawfish to locate premolts quickly.

A row of trays can be quickly observed, and, if placed about 30 inches above the floor, there is little strain on the attendant. A tray width exceeding three feet can cause back strain for the attendant.

Each tray should be elevated slightly along the back side to allow for the rapid flushing of the tray during weekly cleaning (Figure 14). The lower end of the tray should have a 1½-inch standpipe that can slip down or be lifted out for draining. A plastic screen (⅛-inch mesh) sleeve should be placed over the standpipe to retain the crawfish and feed. Placing the drain in the tray floor in one corner will allow a maximum amount of water to be quickly removed, and the use of a squeegee or hand-held water sprayer will aid in cleaning the tray.

Water Supply

Each section of the tray should contain a sprayer head at the upper level. Water should be always flowing except when the attendant is observing the crawfish. A total flow rate of 1000 ml/minute (about one quart) is sufficient for each tray. A water depth of about two inches in each tray will give about 40 gallons (approximately 150 l) of water per tray (13 gallons in each tray section) and, thus, a water exchange every four to five hours. Adjustments in water flow can be made as needed, depending on the density of the crawfish and the quantity of feed.

Aeration

A proper sprayer head on the water supply eliminates the need for an aeration system. If greater aeration is necessary, it may be less expensive to increase the water flow, add another

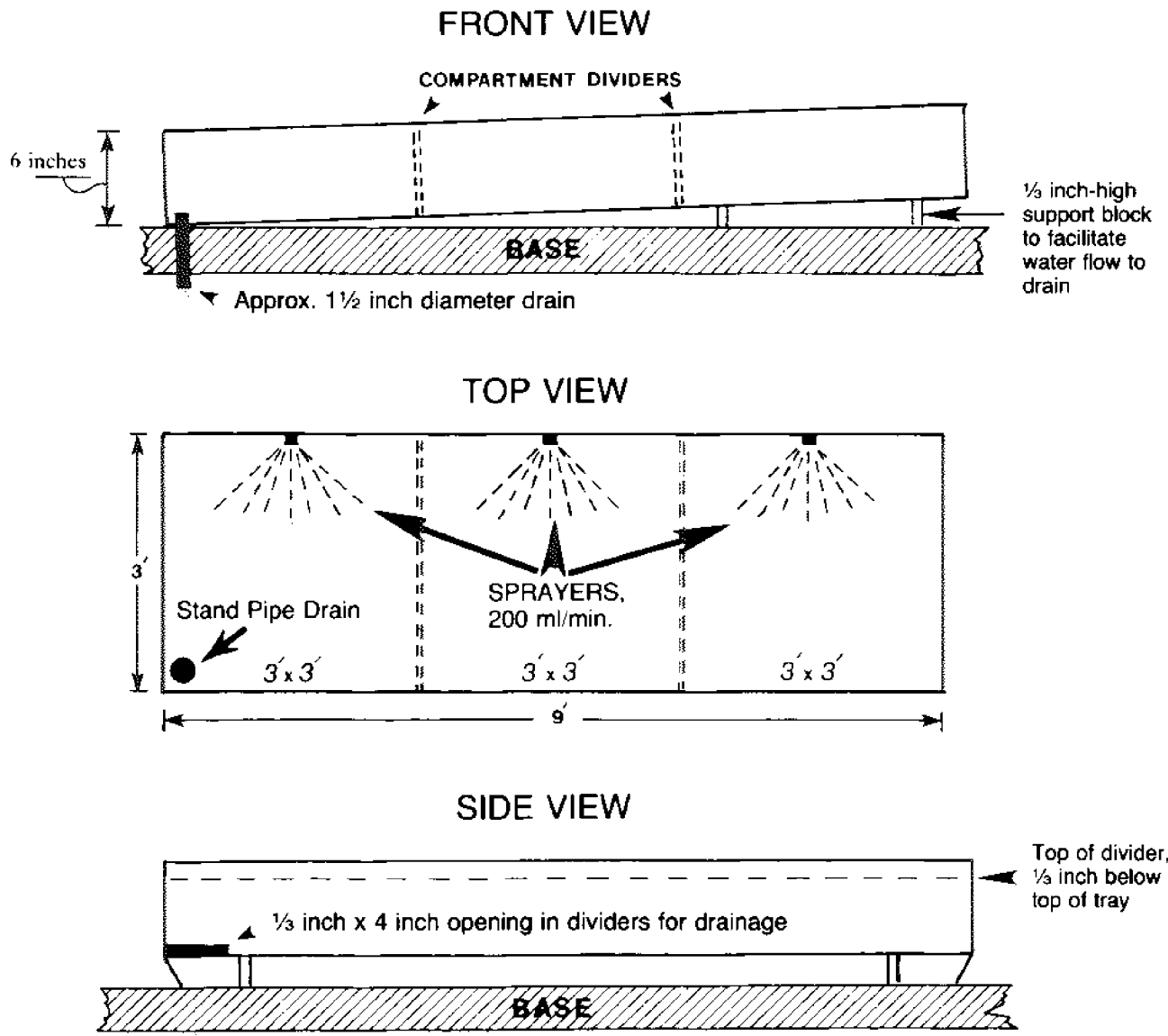


FIGURE 14. Crawfish culture trays.

sprayer head, or reduce the density of the crawfish rather than install an aeration system. Oxygen levels in the water should exceed 3 mg/l at all times.

In the case of a power failure, oxygen in the water may become depleted. Under such a condition, it is best to reduce the water level to no more than ½ inch so that the crawfish can stay wet but use atmospheric oxygen. Do not add feed during this time.

OPERATING PROCEDURES

As previously mentioned, soft crawfish are produced by intense culture within shallow trays with flowing water. During the crawfish season immature crawfish are collected from traps or purchased from commercial suppliers and placed in culture trays. Those that are in the premolt condition are isolated in separate molting trays until the molt occurs as they require no feed. Others are given food until the premolt stage can be identified. They are then removed from the culture tray and held until molting occurs. According to the results of research with trapped crawfish, the daily molting rate of the total population should approach 4 percent under proper management.

All culture trays are maintained at full crawfish density (10 to 20/ft^2). Premolt and dead crawfish are removed once each day. Thus, each morning, the tanks must be thoroughly inspected for premolt and dead crawfish, all of which are removed. Replacement crawfish and feed are then added to the tanks.

Feeding

Once each day the crawfish in the culture tray are provided with food. Feeding them a high-protein (40 percent) floating trout pellet, about 1/8 inch in diameter, gives an acceptable daily molting rate. Supplemental feeding with a high-protein (35 percent) duckweed (mixed species of *Lemna* and *Spirodela*) reduces the need for pellets and the buildup of waste feed. It is not difficult to produce duckweed in a small pond adjacent to the culture system, and it is a food preferred by crawfish. Commercial fish feeds such as floating or sinking catfish pellets break apart more quickly and, thus, cleaning and maintaining the tanks are more difficult. The use of duckweed may not be required, but it certainly provides a possible way of preventing the nutritional deficiencies frequently associated with commercial feeds.

The quantity of feed is determined in two ways. Three or four pellets per crawfish per day are usually sufficient. For example, if each culture section has 100 crawfish, 300 to 400 pellets are provided. The required number of pellets can be placed in a small container and the level marked on the side of the container. Filling to this level for each tank will give the approximate number of pellets needed. The second method is based on crawfish weight. Weigh all crawfish within a tank section and then take 3 to 5 percent of this weight for the amount of feed. For example, 500 grams of crawfish (1.1 pounds) require 15 to 25 grams of feed each day (.6 to .9 ounces).

To regulate the amount of feed, observe the buildup of waste feed. If the sediment is excessive, the tray should be drained and cleaned, and the amount of feed reduced. Duckweeds, if used, can be maintained in the trays at all times. Because the crawfish can reach the surface, all feed is readily obtained. Excess duckweed in a tray makes it difficult to see the crawfish; thus, the quantity should be adjusted to permit the rapid locating of premolt crawfish.

Controlling Mortality and Cannibalism

Contrary to current thinking, large crawfish under crowded conditions are not very cannibalistic if provided food, though if a crawfish molts in a tank with hard crawfish, it is usually eaten. Thus, checking the system frequently and removing premolt crawfish control cannibalism.

Mortality is usually highest when crawfish have been received in poor condition. They die in the trays or are cannibalized. If the crawfish are not injured or in weakened condition when placed in the culture tray, little mortality occurs (see section on collection, transport, and storage for crawfish care).

Premolt Separation and Holding

Premolt crawfish placed in molting trays with running water must be inspected every 12 hours. To insure the best quality, new molts must be removed. No feeding is required.

A simple system for holding premolt crawfish is the use of the standard culture tray (Figure 14) with more partitions. Compartments with areas of two square feet hold up to 40 premolt crawfish. The use of compartments to reduce the number of crawfish for the culturist to examine at a glance simplifies

locating the new molts. For example, if the attendant can look over 80 crawfish at a time as opposed to 240 in a tray *without* compartments, it is easier to locate the premolts or those that have molted.

In removing the molts from these sections, the number of molts can be determined by the number of empty exoskeletons. Newly molted crawfish can be recognized by their color and posture (they appear limp). With experience, the attendant can learn to quickly locate and remove the new molts.

As the attendant moves from tray to tray collecting new molts, he should place them in a shallow pan without water. Collection may take some time and, if the pan contains water, the crawfish may die from oxygen depletion. Packing the crawfish more than two deep while collecting can kill or disfigure those on the bottom.

Processing Care

Once collected, soft crawfish are taken to the processing area. There they are frozen whole; refrigerated temporarily for later delivery fresh; or processed (removal of gastroliths, internal organs, and carapace).

Whatever the process, the crawfish should be held in a chilled environment to prevent the gradual hardening of the soft exoskeleton. They can be placed in aerated water and chilled to about 40°F or placed in refrigerated trays. A thin layer of crushed ice can be added after the crawfish have been chilled for one hour. If the crawfish are not covered with ice, moist towels placed over the tray will prevent dehydration if the crawfish are to be maintained over 24 hours before shipping.

Processing

The culturist may or may not wish to process soft crawfish. If not, the fresh crawfish should be refrigerated, covered with crushed ice, and delivered fresh within three days.

The animals can also be placed immediately in containers, covered with water (or glazed with ice), and frozen. Frozen crawfish should be used in less than two months to insure that the fat does not become rancid.

Processing can be done by the purchaser (restaurant, seafood market) or by the culturist, but health codes must be followed. Figure 15 shows the various processed products. From left to right: unprocessed; rostrum and gastroliths removed (8

FIGURE 15. In the early stages of industry development, the processing of soft crawfish is likely to be done by the user. Thus, the crawfish on the left will simply be collected and delivered on ice or frozen.

In processing, three products can be produced, depending on intended use. The first, second from left, simply requires cutting through the head just behind the eyes, thus exposing two stones (gastroliths) that must be removed. If the carapace is pressed the stones pop out. A deeper cut can be made but another 5 to 7 percent of the product is then lost. With only the stones and the tip of the head removed, about 92 percent of the animal remains.

The second involves the removal of the stomach and fat (hepatopancreas) if the carapace is to be filled with a dressing (third from left). When cooked, however, these internal organs add a dimension to the flavor, and are often added to a sauce along with peeled tails. They can be easily removed by squeezing the sides of the carapace. Their removal extends the shelf life of the frozen product, as the fat becomes rancid in two to three months. Removal of the head, stones, and internal organs leaves about 82 percent of the animal for marketing.

In the third, all internal organs and the carapace are removed. The animal on the far right is fully processed. Processing to such a degree is usually done when the crawfish shows some hardening of the carapace (24 hours after molting), making the animal less suitable for

consumption as a soft product (except when fried). Processing to this extent leaves about 72 percent of the animal.

percent of the animal); rostrum, gastroliths, and internal organs removed (21 percent of the animal); rostrum, gastroliths, internal organs, and carapace removed (28 percent of the animal).

The type of processing depends on the desired use of the animal. For example, if the purchaser wishes to prepare soft crawfish with a stuffing in the carapace cavity, the internal organs should be removed. These include the eggs and the internal organs high in fat; both are used for flavoring crawfish dishes.

The *minimum* processing requires the removal of the two gastroliths behind the eye-stalks, as it is unpleasant to bite into a crawfish with the stones present.

CRAWFISH SIZE AND MARKETING

Normally, crawfish collected from traps average about 28 per pound, but can range from 15 to 30 per pound. All sizes are acceptable as the main source of meat in a crawfish dinner. At 28 soft crawfish per pound, ten crawfish provide a six-ounce serving of meat.

Smaller soft-shelled crawfish, 40 to 50 per pound, are more tender, delicate, and suitable for appetizers. They should command a premium price. In addition, the use of these crawfish will permit earlier harvesting in Louisiana, possibly as early as December. Efforts to use smaller crawfish and establish them in the marketplace are certainly worthwhile.

REVENUE POTENTIAL

Assuming that only 65 percent of the space is used (see section on space requirements), and with an average yield of 3.8 percent molting rate per day (the best is 4.3 percent per day) and a density of 10 crawfish per square foot, then 836 crawfish per day could be expected from a stock of 22,000. This would be about 30 pounds per day (27-28 crawfish per pound). A wholesale price of $6 to $7 per pound would yield as much as $210 per day. The producer may be able to sell to restaurants at current prices ranging from $9 to $11 per pound.

The LSU system has been in operation for two years at densities of 10 crawfish (collected from traps) per square foot. However, short-term studies (up to 30 days) have been successful at a density of 20 crawfish per square foot. If this density proves feasible for routine use, then the projection using only 65 percent of the greenhouse space would result in 60 pounds of soft crawfish per day. At a wholesale price of $7 per pound, the value would be $420 per day.

At this time, the costs of building, stocking, and operating a commercial system are unknown and should be determined before large systems are constructed. It is important to note that the crawfish taken from traps yield a lower daily rate of molting than crawfish taken by trawling or seining. The reason is that late premolt crawfish seldom go to traps. The collection of crawfish by trawling may increase the molting rate in a culture system, but the cost of collection must be taken into consideration in analyzing the whole economic picture.

RESEARCH NEEDS

Although soft crawfish can be produced under controlled conditions, additional information is needed to make the system more efficient. The following areas of research are most important.

1. A reliable source of crawfish must be secured over a longer period of time. A six- or seven-month season should be available at a minimum. Manipulating ponds to encourage breeding at times other than the normal fall and spring breeding periods needs further research. Producing females in berry, or young in a hatchery and releasing them into ponds is a second alternative. Obtaining crawfish from other parts of the country is also possible, and the cost may not be prohibitive.

2. The design of a culture system with a more efficient use of space is, economically, most important. The multiple stacking of trays certainly should be considered. Optimum crawfish density levels should be accurately determined.

3. Techniques for capturing premolt crawfish from ponds need immediate attention. The development of an effective technique could well double the molting rate within a culture system.

4. The processing of soft crawfish must be studied more closely. There is little doubt that bacteria are present in and on the soft crawfish, a factor that enhances spoilage. The best method of processing is yet to be determined—i.e., immediate freezing, refrigerated storage, iced for delivery in two or three days, or partial cooking and freezing.

5. Crawfish are found in the coastal marshes and can live in water with low salinity. The closed, recirculating system used for shedding blue crabs can also be used for crawfish. The dual use of the system in coastal areas could improve the economic efficiency of the soft crab production industry.

6. There is continued interest in inducing molting by the use of hormones and the removal of eye stalks or appendages. The effects of such techniques are inconclusive from a commercial point of view, but such research should continue.

7. There is an immediate need to determine the economics of constructing a soft crawfish system, and the costs of operation and processing.

As the industry develops, improvements will undoubtedly occur. Small-scale systems appear to function quite well at present, and may be economical, particularly if the producer sells directly to retail markets.

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A Status Report