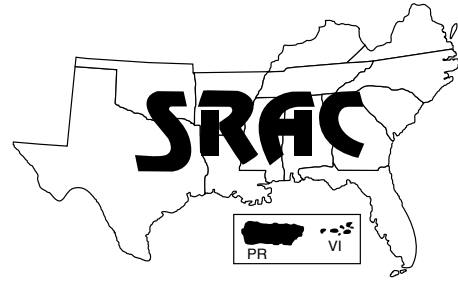


Southern Regional Aquaculture Center



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Australian Red Claw Crayfish

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When it was discovered that freshwater crayfish from the land “down under” grew to over a pound, aquaculturists in the United States got excited. Dubbed “freshwater lobsters,” these Australian crayfish have received a great deal of media attention. Today Australian crayfish are reportedly farmed not only in Australia but in New Zealand, Southeast Asia, Africa, Central and South America, and the United States.

Very little about the culture of Australian crayfish was known before 1975 when the selling of farm raised crayfish was first legalized in Australia. Once crayfish farming began, aquaculture enthusiasts in Australia began investigating several different species of crayfish for their culture potential.

There are more than 100 species of Australian crayfish, but only three species are presently being cultured. These are the “marron” (*Cherax tenuimanus*), the “yabbie” (*Cherax albidus-destroyer*), and the “red claw” (*Cherax quadricarinatus*). These three species are native to different regions of Australia

and have quite distinct natural histories (Figure 1).

Marron grow to be the largest and attracted considerable interest in the U.S. during the 1980s. Research with marron has not been encouraging, however. Research has shown that this species grows relatively slowly (1 to 2 ounces per year even though they may obtain a size of several pounds) and tolerates a very narrow range of environmental con-

ditions. It survives water temperatures between 55 and 85°F but appears to grow best between 70 and 75°F. In its natural habitat, marron live in cool streams and rivers of southwest Australia.

Summer water temperatures in most of the southeast U.S. remain at or above 85°F for two or more months each summer and may for short periods exceed 90°F. Marron are also sensitive to handling and water quality changes.

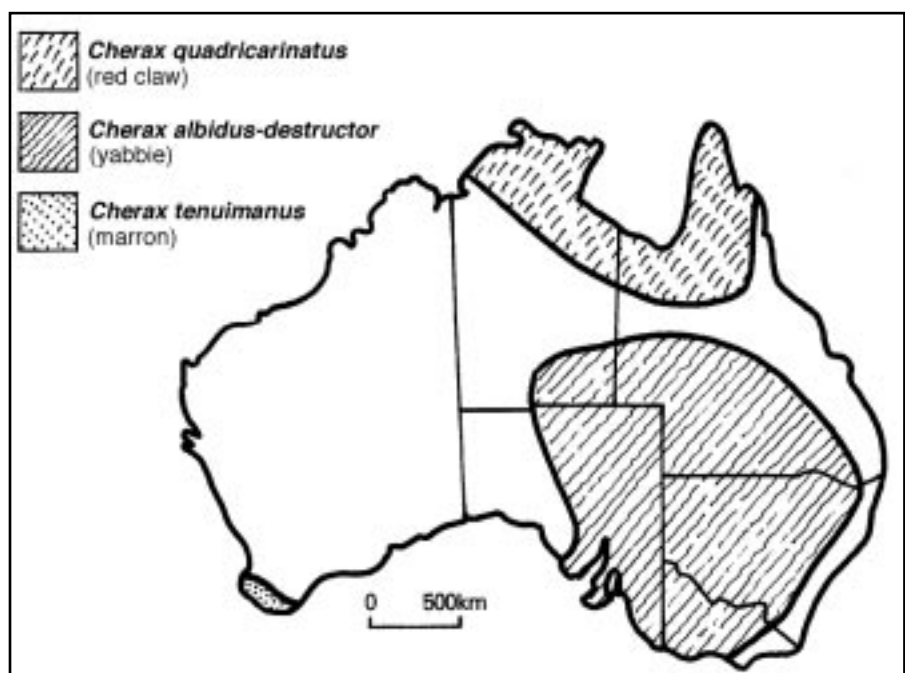


Figure 1. Natural distributions of cultured species of Australian crayfish.

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Low levels of salt (100 to 300 ppm) and moderate levels of alkalinity and hardness (50 to 100 ppm) were found to be necessary for successful growth/molting and survival. Other problems with marron are that they are difficult to breed in captivity, do not reproduce until two or three years of age, and are territorial. Considering these factors, marron appears to be a species with limited potential in the Southeast.

Yabbie, another cultured species, are native to the southeastern region of Australia. Yabbie are the smallest of the cultured Australian species, growing relatively slowly (1 1/2 to 2 ounces per year) and only attaining a size of 1/4 to 1/2 pound. Yabbie are able to tolerate a wide range of environmental conditions. The main problem with yabbie is their extensive burrowing habit. While burrowing is an important trait for crayfish that must survive extended dry periods, this trait creates problems in ponds. Yabbie have been known to cause ponds to leak or even drain by burrowing through the dam (as have native crayfish). Because of their burrowing habits and the fact that they do not grow much larger than native American crayfish, yabbie have received little attention from aquaculturists in the U.S.

Red claw, the third species, are native to remote areas of tropical northern Australia and hold the most promise for southeastern producers. Red claw have been cultured in Australia since 1985. Research on red claw began in the U.S. about 1989, and has shown positive results:

- Red claw tolerate higher temperatures and relatively low dissolved oxygen concentrations.
- They tolerate crowded culture conditions and are considered a nonburrowing crayfish.
- Red claw can grow to 2 to 4 ounces during the five to seven warmest months in the Southeast.

This publication summarizes available information on the life history, environmental requirements, techniques for spawning, hatching and production, and diseases of red claw based on research in both Australia and the United States. A brief discussion is included on potential markets for red claw.

General life history and environmental considerations

Red claw are similar to native American crayfish in their general anatomy, reproduction, and feeding habits. However, there are some important differences. These include:

1. larger potential size,
2. higher percentage of dress-out (meat),
3. multiple annual spawning and higher fecundity (fertility),
4. nonburrowing and nonaggressive behavior, and
5. growth at temperatures ranging from 70 to 90°F.

Red claw can reach a weight of 2 to 4 ounces (50 to 100+ grams) in a seven-month growing season while native crayfish normally grow to about 1 to 1 1/2 ounces (20 to 35 grams) during a growing season. Furthermore, about 30 percent of the total body weight of the red claw is edible tail meat compared to 15 to 20 percent for native crayfish.

Both red claw and native crayfish reach sexual maturity at less than one year of age. However, native crayfish are considered seasonal spawners. Day length and temperature changes are necessary to promote fall and spring mating activity. Red claw are multiple spawners capable of spawning several times (3 to 5 times) each year as long as water temperatures remain above 75°F.

Red claw do not excavate deep burrows like native crayfish. Red claw will occasionally dig shallow depressions or short burrows.

When burrowing does occur, it is usually in the deeper portions of the pond and does not damage dams or levees.

Another major difference between red claw and native crayfish is the water temperature requirement. Native crayfish are from a temperate climate and generally tolerate a wide range of temperatures. They are more active and grow during the cooler months and usually spend hot summer months in burrows underground.

Red claw are native to the tropical region of northern Australia. Therefore, red claw grow best in relatively warm water (75 to 85°F) and will not tolerate cold temperatures. Water temperatures below 70°F significantly reduce growth rates. Water temperatures below 50°F are lethal and will limit red claw production in outdoor ponds to a 5- to 7-month growing season in the Southeast. Much of the hatchery and juvenile production will need to be done indoors during the cooler months.

Red claw and native crayfish are both omnivorous detritivores, meaning that they prefer to eat decaying plant or animal matter. In their native habitat their diets consist mostly of decaying plant material. Under culture conditions both species have been found to readily accept a wide variety of foods including formulated diets.

Red claw, like native crayfish, seem to tolerate a wide range of water quality conditions including: dissolved oxygen (>1 ppm), hardness and alkalinity (20 to 300 ppm), and pH (6.5 to 9). Adult red claw have been shown to tolerate dissolved oxygen to as low as 1.0 ppm but young are more sensitive to low dissolved oxygen. Red claw have been known to tolerate unionized ammonia concentrations up to 1.0 ppm and nitrite as high as 0.5 ppm for short periods without noticeable adverse effects.

An important behavioral trait, from a culture standpoint, is that red claw are relatively gregarious and tolerate crowded conditions to an unprecedented degree for a

large-clawed crustacean. Even at densities greater than 50 per square yard, adults show limited cannibalism. This trait may reflect an adaptation to the environmental conditions this species experiences in tropical Australia, where pronounced wet and dry seasons cause them to congregate at relatively high densities in water holes during the dry season. Under these conditions nonaggressiveness is a critical adaptation to survival and repopulation. Once the rainy season begins they disperse by migrating into newly flooded areas. Juveniles are more aggressive and display a degree of cannibalistic behavior.

Reproduction and hatchery techniques

Red claw generally reach sexual maturity by the age of 6 to 12 months at which time they range from 2 to 3 ounces in weight. Mature male red claw develop a distinctive red or orange patch on the outside margin of the claws. Individuals of this same size without the reddish claw patch are usually females. The sexes are best identified, however, by examination of the genital openings on the underside of the cephalothorax at the base of the walking legs (Figure 2). Females have a pair of genital pores (counting from the head) of walking legs. Males have a pair of small genital papillae (small projections) at the base of the fifth pair of walking legs.

In a hatchery red claw can spawn almost continuously throughout the year if conditions are suitable. Individual females do not spawn when going through a growth phase (i.e., molting). Each female will produce 100 to 1,000 eggs per spawn depending on her size and general health. The first spawn of young females usually has fewer eggs than latter spawns. Newly spawned eggs average 10 eggs per gram of female. About 30 percent of the eggs are lost during incubation, resulting in an average of 7 eggs (that hatch) per gram of female. For example, a female weighing 3 ounces (85 grams) would produce about 600 eggs. Figure 3 can be used to estimate the number of eggs a female of a given size will produce.

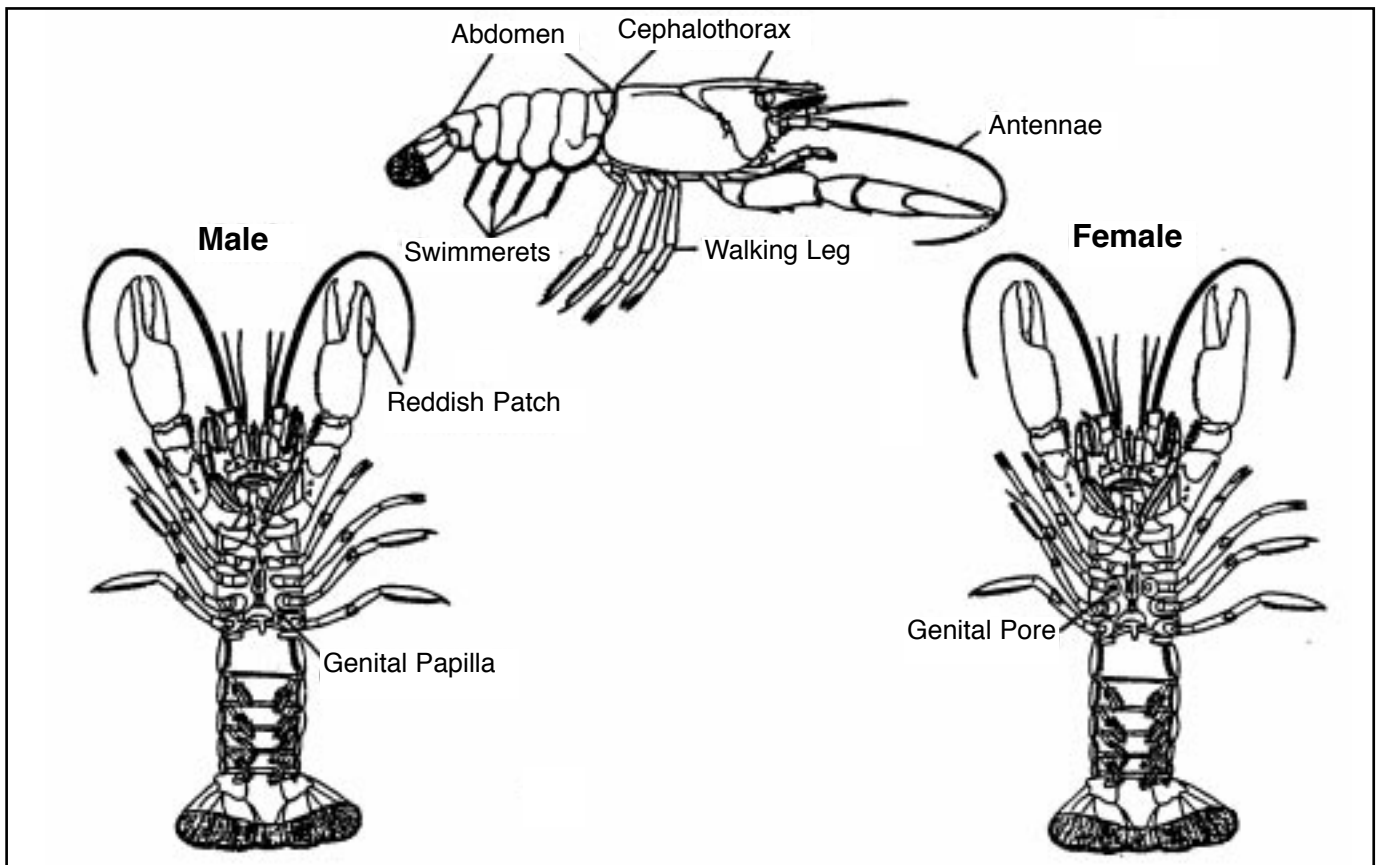


Figure 2. External anatomy of male and female red claw.

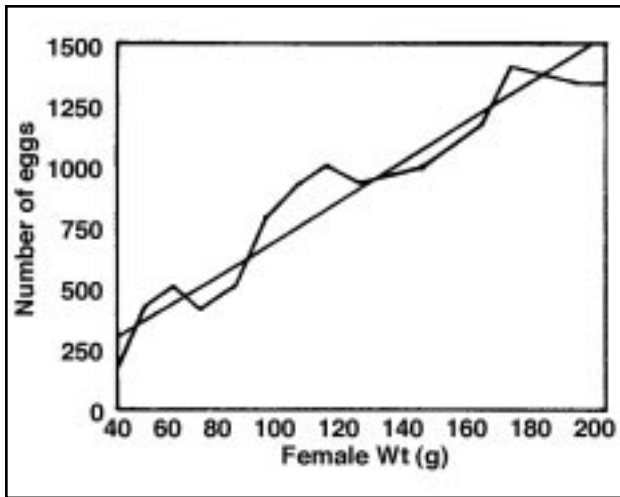


Figure 3. Relationship of female red claw body weight to number of eggs produced.

Natural reproduction will occur in ponds if the animals are mature and the water temperature is above 70°F. Most Australian producers simply collect juveniles from ponds stocked with mature red claw. Juveniles seek shelter in suspended substrate like burlap, shade cloth, onion bag mesh, or window screen mesh hung vertically from the surface to the bottom of the pond from floats. These collectors are periodically checked and juveniles carefully removed from the mesh. This method results in low returns/survival, only 5 to 10 percent. Juvenile growth and survival are limited because of lack of access to adequate food and to cannibalism which occurs among the juveniles.

Production of red claw outdoors in the southeastern U.S. is limited to five to seven of the warmest months. Therefore, outdoor spawning is not practical. The use of indoor hatcheries to spawn adults and rear juveniles during the winter months is the most practical and economical method in the U.S. Mature adults moved into hatcheries during late fall can be spawned during the winter. Young from these spawns can be reared indoors using natural and formulated feeds, then stocked into grow-out ponds the following spring. Stocking a one acre grow-out pond, at 10,000 to 12,000 juveniles per acre, will require approx-

imately 70 adult females and 25 adult males (considering spawning and survival rates).

The key points to successful maintenance and reproduction of broodstock in indoor holding systems include:

1. select healthy mature adults,
2. maintain warm temperatures (preferably 75 to 85°F),
3. maintain good water quality,
4. provide proper nutrition, and
5. isolate berried females to hatching tanks.

Broodstock should be selected based on size, vigor, and general health. It is important to select large, healthy animals. Before introducing broodstock into the hatchery it may be a good practice to treat them with a salt or formalin dip to eliminate potential external pathogens. Specific studies on prophylactic treatments for red claw have not been conducted but recommended fish treatments (e.g., a prolonged bath of 1,000 to 2,000 ppm salt or 15 to 25 ppm formalin) have been used experimentally. These treatments did not seem to harm the red claw and have appeared to be effective at preventing introduction of parasites. **At present, there are no approved therapeutics for red claw.**

Good water quality must be maintained in the holding tanks by using either a flow-through system utilizing warm water (e.g., geothermal) or a heated, recirculating system with particulate and biological filtration. Water temperature in the system should be maintained between 75 and 85°F. Warmer water temperatures (80°F) and a longer photoperiod (12 to 14 hours of light) in the hatchery will increase spawning rates. Research has shown that peak spawning

occurred at water temperatures of 82°F and 14 hours of light.

Light intensity should be low (just enough light for hatchery personnel to work). Dark colored tanks with partial covers can reduce stress associated with intense light and movement around the tanks. Also tanks with smooth surfaces, like fiberglass or stainless steel, minimize damage to the exoskeleton of the crayfish. Damage or abrasions of the exoskeleton can lead to disease problems.

Broodstock should be stocked into holding tanks at 1 to 3 animals per square foot of bottom area. Males should be of similar size (within an ounce of each other in weight), or spawning can be suppressed by nearly 50 percent. The ratio of females to males in each tank should be between 1 to 3 females for each male. Good spawning success has occurred using tanks with water depths of 1 to 3 feet. Small rectangular tanks of 15 to 20 square feet, as well as large circular tanks of 15 feet in diameter have been used successfully. Shallow rectangular tanks (8 to 10 feet long by 2 to 3 feet wide) with water 12 to 18 inches deep are commonly used.

Red claw are excellent climbers and escape from tanks if the water level is near the tank top or if equipment such as air line tubing or heater cords extends over the sides of the tank. To reduce escapes, equipment should be suspended from overhead so that it does not touch the sides of the tank.

Research has shown that red claw are most active in the evening between 6 p.m. and midnight (Figure 4). This should be the best time for daily feeding since the animals are actively foraging during this period.

Broodstock nutrition is extremely important. Broodstock should be fed a complete diet (with vitamin and mineral supplements). Sinking crayfish or shrimp feed (at least 28 percent protein) fed at 3 percent of body weight per day is recommended. Some hatchery



Figure 4. Typical hatchery tanks used in red claw production.

operators like to supplement formulated diets with fresh foods. These supplements have included frozen mixed vegetables, bird seeds, and chopped beef heart or liver. Care should be taken not to overfeed, especially with fresh food, because it may adversely affect water quality.

During mating the male red claw will attach a spermatophore (sack containing sperm) to the underside of the female between the third and fifth pair of legs. The spermatophore is white and about $\frac{1}{3}$ inch in diameter. Within 24

hours the female usually releases eggs from the pore on the base of the third pair of walking legs. These eggs are fertilized by the spermatophore as they are released.

Female red claw, like native crayfish, attach the eggs to the swimmerets under their tail or abdomen. The eggs remain attached through the incubation period (Figure 5). The incubation period may last 4 to 6 weeks depending on water temperature. At 82°F the incubation period averages 30 days. Individual eggs are oval and about $\frac{1}{10}$ of an inch in diameter. Females carrying eggs are called "berried" females. Berried females are easily recognized because they tightly curl their abdomen under the body for the first 10 to 14 days after spawning. They are also less active during this period. Berried females should be moved to separate spawning tanks so that the young hatchlings do not have to be captured from the broodstock tanks. Broodstock tanks should be checked for berried females at three to four week intervals. Berried females must be carefully netted and transferred to hatching tanks (to prevent egg loss). Keep the berried females with their abdomen curled around the eggs during transfer to prevent eggs from being dislodged by tail movements.

Hatching

Red claw eggs go through several identifiable stages during development (Figure 6). The length of development varies depending on water temperature. The stages are identified by color changes and appearance of body structures in the developing embryo. The sequence of development stages and approximate timing at 82°F is:

- stage 1** - light cream color (day 1-3),
- stage 2** - dark brown (day 12-14)
- stage 3** - eye spots (day 20-23)
- stage 4** - hatched, orange-red in color (day 28-35)
- stage 5** - released (day 35-40).

Hatching can occur within 30 days at 82°F but may take as many as 45 days at 75°F. Females in hatching tanks should be grouped according to similar egg development and should not be disturbed during early stages of egg development. Young remain attached to the females' swimmerets for about 7 to 10 days after hatching, becoming independent of the mother over a period of several days. This post-hatch period appears to be important to the survival of the young. Therefore, females should be removed from the hatching tanks only after the young are no longer observed

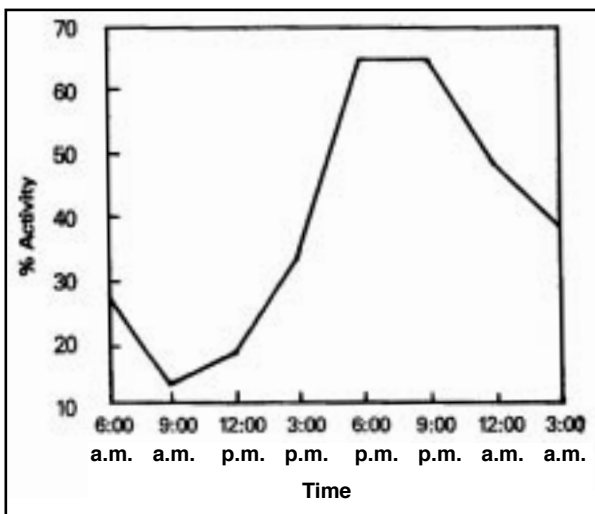


Figure 5. Daily activity level of red claw crayfish.



Figure 6. Eggs remain attached to the swimmerets through the incubation period.

clinging under her tail. One word of caution: females have been observed cannibalizing their young if crowded into small hatchery tanks or aquaria.

The keys to good juvenile survival in the hatchery are stocking density, size uniformity, cover, nutrition, and water quality. Stocking density of juvenile red claw should not exceed 25 per square foot of nursery tank bottom. At this density 50 to 75 percent survival should be expected. Again, juvenile numbers can be estimated from the females' size (see Figure 3). Many producers prefer shallow (6 to 12 inches deep) tanks for this phase. Handling the newly hatched juveniles during the first few weeks should be avoided as they are easily injured.

Research has shown that formulated feeds and adequate substrate in juvenile rearing tanks increase overall growth and survival. Juveniles 2 inches or longer (>1 gram) will have a much higher survival rate when stocked into ponds. Indoor hatcheries can improve the quantity and quality of juveniles available for stocking and could make larger juveniles available for differential stocking.

Older (i.e., larger) juveniles tend to cannibalize smaller ones, hence the need to group females together in the hatching tanks that have a similar egg stage or larval development. Juvenile red claw growth rates will vary. After four weeks a few individuals may be five times larger than others in the tank. Overall survival can be improved by grading or removing the larger juveniles. Netting or screening should be added to juvenile tanks, providing hiding places to reduce cannibalism. Any habitat that provides a large surface area, adequate water flow, and access to the bottom for feeding should improve survival. Some substrates which have been used effectively are fiberglass window screen, shade cloth, and mesh bags in which onions and citrus fruits are packaged.

Nutrition is also an important aspect in juvenile production. Newly hatched red claw occupy a very small territory (a few square inches). Therefore, feed must be distributed throughout the tank so that juveniles will have access to it both on the bottom and within the mesh. Several diets have been used to rear juveniles in the hatchery. At the present time, the best recommendation is to feed a high protein (>33 percent) commercial shrimp diet. Juveniles should be fed at 40 percent of estimated biomass per day, with the feed being fed over three to five feedings a day. Improved survival and growth have been obtained by feeding brine shrimp (*Artemia*) during the first week. Newly hatched brine shrimp nauplii are best but frozen adult brine shrimp have been used. Brine shrimp can be substituted for one of the daily feedings of formulated diet. Care should be taken to ensure young crayfish have all they can eat without overfeeding. Overfeeding can quickly cause deterioration of water quality. Excess food should be removed from tanks by siphoning daily. Feeding behavior and water quality should be closely monitored.

Maintaining good water quality is always important, especially with young crayfish (Table 1). Care should be taken to ensure that old feed and wastes do not accumulate and that proper aeration, filtration, and circulation are maintained.

Survival of juveniles in the hatchery should average 50 to 70 percent. Once the juveniles reach about 1 to 2 inches in length and weigh approximately $1/28$ of an ounce (1 gram) they can be stocked into grow-out or production ponds if pond water temperatures are above 68°F.

Pond production

Red claw are probably best produced in traditional fish production ponds 3 to 4 feet deep with sloping bottoms and a drainage system. Ponds ranging from $1/4$ to 2 acres have been used in red claw production, but ponds of 1 acre or less are recommended for ease of management and harvesting.

Research suggests the following production strategy:

1. Stock juveniles of 1 gram or larger in the spring when water temperatures stay above 68°F;
2. Stock at a density of 10,000 to 12,000 per surface acre of pond;
3. Feed hay at 500 pounds per acre per month and supplement with a commercial diet at 3 percent of estimated biomass;
4. Partial harvest using traps starting 3 to 4 months after the young crayfish were stocked;
5. Drain harvest when water temperatures drop below 60°F.

To reduce the chance of disease and competition, native crayfish should be eliminated from ponds

Parameter	Recommended Range
Temperature	80 to 85°F
Dissolved Oxygen	5.0 ppm (mg/L) or above
Total Ammonia	0.5 ppm (mg/L) or less
Nitrite	0.3 ppm (mg/L) or less
pH	between 7.5 and 8.0
Alkalinity	above 100 ppm (mg/L)
Total Hardness	above 50 ppm (mg/L)
Chloride	50 ppm (mg/L) or above

in which red claw will be stocked. Fill the ponds with well water if possible to eliminate introduction of other species and their diseases. Ponds should be filled only a few weeks before stocking to prevent the establishment of predaceous aquatic insects. Ponds should be limed if hardness is below 20 ppm and fertilized to establish a plankton bloom. Survival improves significantly if a 1 gram (28 to the ounce) or larger juvenile is stocked rather than newly-hatched juveniles. Stocking densities of 0.25 to 0.3 per square foot of pond surface area (10,000 to 12,000 per acre) appear to give the best overall survival and production of larger crayfish. Dried hay should be spread around the edges of the pond monthly at a rate of about 500 pounds per acre per month, divided into two or three applications. Commercial crayfish, shrimp, or fish feeds should be used in addition to the hay during the last half of the culture period. Total commercial feed input should be fed at 3 percent of estimated total crayfish weight per day but not to exceed 35 pounds per pond surface acre per day.

Water quality must be maintained if red claw are to survive and grow. Aeration should be used to maintain dissolved oxygen above 3 ppm. Remember that these animals live on the pond bottom; therefore, oxygen should be checked near the pond bottom and not at the surface. Ammonia and nitrite concentrations should be determined twice weekly toward the end of the growing season, but are not usually a problem at recommended feeding rates. If water quality declines, stop feeding and flush with clean water, if possible. Red claw may attempt to migrate from the pond if water quality is poor. Proper management should lead to the production of 1,000 to 1,500 pounds per acre after six months. Individual red claw should weigh about 2.5 ounces or six to the pound, although some individuals will weigh more than $\frac{1}{4}$ pound.

Harvesting

Red claw can be harvested by using baited crayfish traps, flow-traps, and by draining the pond. Crayfish traps used to catch native crayfish can be used for red claw. These traps are made of $\frac{3}{4}$ -inch plastic coated chicken wire mesh (Figure 7). Both stand-up and pyramid traps have been used effectively. Baits include formulated commercial crawfish baits and fish feed contained in small mesh bags. Final harvesting is done by partially draining the pond (to $\frac{1}{4}$ of original size) and setting up a flow-trap.

Flow-traps are traps through which water moves or flows. Red claw are strongly attracted to moving water, possibly an adaptive response to spring floods in their natural environment. Research suggests that flow-traps are very successful at capturing crayfish. Pumping rates in flow-traps should not exceed 8 gallons per minute, and water from another pond or a well appears to work better than water from the same pond.

One flow-trap design is the box-n-ramp trap. The box-n-ramp trap consists of an impervious box (e.g., plastic trash can or metal drum) into which water is pumped and a ramp which carries the out-flow water to the pond bottom (Figure 7). The crayfish move up the ramp against the flow and are trapped when they fall into the box. Adding fiberglass screen, vexar, or some other rough texture to the surface of the ramp will help the crayfish climb into the trap. Flow-traps must be checked often (every few hours) as they can fill with crayfish, causing those in the bottom of the trap to suffocate.

Diseases

Red claw are probably susceptible to most diseases that affect native crayfish. In addition, red claw are susceptible to the "crawfish plague" which is a fungal pathogen. Native North American crayfish carry the plague but are usually not adversely affected by it. The fungus was not known to be a problem until North American crayfish were introduced to Europe over 100 years



Figure 7. Commercial flow-trap design.

ago. European crayfish had no resistance or immunity to the North American pathogen and many natural populations were devastated. Research has shown that the red claw are susceptible to this fungus. The fungus grows best at temperatures below 65°F and does not appear to be active or pathogenic above 70°F. Since red claw need temperatures above 70°F for good growth, careful attention to stocking and harvesting temperatures may reduce potential problems. There are no known methods of prevention and treatment of the plague.

Legal and environmental constraints

Most states have restrictions on the introduction of exotic species. Before purchasing red claw or any other non-native species, state conservation departments should be contacted. There are no federal laws which prevent the introduction of invertebrates such as Australian crayfish, fresh water shrimp, etc. Permits for the importation or stocking of exotic crayfish are presently in effect in some states (e.g., Louisiana and Kentucky).

It is important that studies be conducted before any new species is introduced to ensure that there will not be negative impacts on our environment. In 1990,

research was started at Auburn University to look at possible interactions of red claw with native red swamp crawfish, the predominately cultured species in the U.S. Both species survived, grew, and reproduced in these interaction studies without any obvious negative impacts through a summer culture period. However, the red claw did not survive the winter. From these studies it would appear that if red claw were to escape there would be no impact on native red swamp crayfish populations and the red claw could not become established in natural waters.

Marketing

No one knows what price red claw crayfish will bring in the U.S. A market for red claw will have to be developed. If red claw have to compete in the native crayfish market their production will not be economically feasible. Because of its size (4 to 6 per pound), however, it should fall into a totally new market niche and not compete with native crayfish or large lobsters. Contacts with marketing specialists indicate that red claw should have high appeal and command a high price when sold as "small lobsters." Until large numbers are available, however, all marketing potential is speculative. One advantage of red claw will be the ability to market live,

whole animals without any need for processing. One disadvantage will be the development of a year-round supply since production cycles will be limited by cold weather from U.S. production.

Most juvenile red claw currently produced in the Southeast are being sold to the ornamental or aquarium market. The color (light blue) and uniqueness of the red claw have demanded high prices from aquarium enthusiasts. Again, even this market has to be developed by individual producers.

Financial considerations

Red claw farming, like any type of agricultural enterprise, is a risky venture. Red claw farming is even more risky since little is known about full scale commercial production problems, diseases, and potential markets.

Failures (to some degree) are still the rule and not the exception in aquaculture when it involves new species. All commercial ventures should be preceded by appropriate pilot scale operations. It is prudent that beginning producers be conservative. Start slowly, minimize capital investment, keep overhead low, and develop markets (i.e., start small and learn as you go).