SRAC Publication No. 724

Southern Regional Aquaculture Center

August 2000

Species Profile
Sunfish

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The sunfish family (Centrarchidae) includes 30 species, and is found only in North America. This family includes the black basses (*Micropterus* spp.), crappies *(Pomoxis* spp.), and the bream *(Lepomis* spp.), as well as the genera *Amboplites, Elassoma, Enneacanthus, Centrarchus, Archoplifes* and *Acantharcus.* This family is one of the most popular and widely known gamefish groups in North America. Anglers like sunfish because of their fierce tenacity when caught by hook-and-line; their firm, white flesh; and their favored status as "bread and butter fish." In addition to their utility as sport and food fish, the lepomid sunfish species are generally stocked in impounded waters as forage fish for predators such as bass. Most anglers are familiar with these fish.

Bass, crappie and bream have been cultured for the past 50 years, primarily to provide fingerlings for stocking recreational ponds and lakes, or for use in research. There is increasing interest in culture of these fish for human consumption and for use in fee-fishing operations. This species profile will address only the culture of the genus *Lepomis,* commonly called bream, sunfish, sun perch or simply panfish. Refer to SRAC Publication 722 for information on largemouth bass.

Sunfish have been cultured almost exclusively to produce fingerlings for stocking recreational fishing waters. Bluegills and redear sunfish are stocked for forage, and with largemouth bass they also provide excellent sportfishing. Historically, most state and federal hatcheries produced large numbers of sunfish and distributed them to the public through various state and federal fish stocking programs. Now many private hatcheries are specializing in the production of gamefish for stocking, so public hatcheries and state agencies have reduced or eliminated their production of gamefish for the public.

Another production scenario is to stock fingerlings at high densities, feed them a manufactured feed, and grow them to adult sizes suitable for marketing as foodfish (225 to 340+g or 0.5 to 0.75+ pounds) or gamefish (110 g or 0.25 pound). These fishes seem to have potential for both food fish and fee-fishing markets. The culture of hybrids has been studied more than the culture of pure species, but consumer interest will likely stimulate additional research.

As interest grows in producing these fish for human consumption, producers will need to grow them to market size and ensure that they have the appearance, texture and flavor consumers desire. Bluegill and redear, as well as several sunfish hybrids, have good flavor and texture, low-fat flesh, and good storage qualities. Consumers recognize and accept them. In terms of temperature and water quality requirements, growth rates, trainability to manufactured feeds, and fecundity and ease of spawning in captivity, all lepomids, in general, are easy to grow. The bluegill and bluegill hybrids may be easiest to culture to adult sizes. The most common hybrid is the male bluegill X female green sunfish, which has a desirably high male:female sex ratio in the F1 generation. Other hybrids may also be successful, despite variable sex ratios, if techniques such as ploidy manipulation can be perfected.

Biology and natural history

The centrarchids are perciform fish with a spiny dorsal fin (with 6 to 13 spines) followed by a soft dorsal fin. The anal fin has at least three spiny rays at its origin, followed by numerous soft rays. The pelvic fins are located immediately beneath the pectoral fins and

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contain one spine and five soft rays. The caudal fin has 17 principal rays. Proper identification is critical to successful production, because the genus *Lepomis* readily hybridizes.

There are eleven species in the genus *Lepomis*, but only the bluegill *(L. macrochirus)*, redear sunfish *(L. microlophus)*, warmouth (*L. gulosus*), and green sunfish *(L. cyanellus)* and their various hybrids have been widely cultured as sportfish. Although other lepomids may have culture and market potential, these four have been the focus of research.

Bluegill

The bluegill may be the most well known of all the sunfish, and it is certainly the most popular with anglers and consumers. Originally distributed from the Great Lakes south to the Gulf of Mexico, it has been stocked throughout North America as a gamefish. It is equally at home in lakes or streams, but is most abundant in shallow, eutrophic lakes and ponds. The bluegill is identified by its deep, laterally compressed head and body and small mouth. The opercular flap is black, and individuals longer than 2 inches (51 mm) have a dark blotch at the posterior base of the dorsal fin. The sides usually have eight to ten sets of double vertical bars that are chain-like in appearance. Body colors range from olivaceous to purple, with a white to orange belly.

Redear

The redear, like the bluegill, has been widely introduced throughout much of the U.S. and North America as a gamefish and a companion to the bluegill in managed systems. Its common names are "shellcracker" and "chinquapin." The redear prefers sluggish waters. It is identified by its olive-yellow to straw-yellow body with gray or dusky spots. The breast is bright yellow to orange, and the opercular flap is short with a distinct scarlet outside margin or spot.

Warmouth

The warmouth, also called "goggle-eye," inhabits sluggish waters, preferring weeds or debris such as logs, stumps and brush piles. This species has not been widely stocked in recreational waters, but is popular with anglers where it is abundant. Its primary importance to aquaculture has been in the production of hybrids with the other primary species. It has a dark, olivaceous to brown body, with dark splotches on the sides and the fins. The cheeks and opercula have three to four dark bars radiating posteriorly from the eye, and the eye is often reddish. The mouth is larger than that of the bluegill and the redear, and the body is not as laterally compressed as in these species.

Green Sunfish

The green sunfish may be one of the most adaptable, abundant and environmentally tolerant of the sunfishes. It is found in a wide variety of habitats ranging from ponds and lakes to river systems. This hardiness makes it of interest as a "bait" fish, especially for setlines or trot-lines for catfish. In some states, however, this fish is classified as a game fish, and thus cannot be sold for this purpose. Characteristic colors of the green sunfish include a blue-green to dusky dorsum and sides, with a yellow to white belly. A dark basal spot is usually present on the posterior base of the dorsal fin. All fins are yellow to orange tinted, with occasional bright orange areas and white margins. The green sunfish is the species used most often to produce hybrids with either the bluegill or the redear sunfish.

Culture techniques

Broodstock

Broodstock selection is critical in the production of sunfish and their hybrids. Improper identification of the brood fish can lead to contaminated stocks of offspring, because these fish readily hybridize. Sunfish rely upon visual, auditory and behavioral cues for species recognition, but will hybridize readily if unable to locate a mate of the same species. Thus, proper identification of both sexes is vital to successfully producing the desired offspring. Bluegill and green sunfish males in breeding condition are easily distinguished from females, but redears and warmouth sexes are more difficult to differentiate. Experienced culturists can usually distinguish males from females on the basis of external characteristics such as color, body shape or size, and distention of the abdomen caused by enlarged ovaries or the size and shape of the urogenital sinus.

It is easy to express eggs or milt from ripe broodstock. However, broodstock often are not ripe at the time of stocking and identification. A simple method of probing for eggs involves using a 2- to 4-inch (5- to 10-cm) long capillary tube that is 0.04 to 0.05 inch (1.1 to 1.2 mm) in diameter. The tube is inserted into the urogenital sinus, then angled slightly back toward the tail and slightly to one side. With the application of light pressure, the tube passes through the oviduct into the ovary. A finger is then placed on the open end of the tube to seal it before it is removed for inspection. If no eggs are retrieved, the fish should be rejected as a brood fish. This is a simple procedure, but must be done with care to avoid damaging the fish.

Handling can be stressful to the fish and should be done with care. Broodstock should be handled in cool water, which is conveniently available during stocking season (late winter to early spring). Fish should be handled as little as possible, sedated when practical, and transported in well oxygenated tanks. Thermal shock should be avoided at all costs. Refer to SRAC Publications 390,392 and 393 for recommendations on handling and transporting fish.

Ideally, sexes should be kept separate until they are stocked into spawning ponds. This allows broodstock to be sexed in advance and held for a period of time in conditioning ponds to prepare

them for spawning. It eliminates, or at least minimizes, stressful handling, sexing and sorting immediately before the spawning season.

Bluegills and redears should be at least 2 years old and 0.25 to 0.5 pound (110 to 225 g) for maximum productivity, whereas warmouth and green sunfish will spawn at much smaller sizes. If smaller bluegills and redears are used for spawning, they should be stocked at higher rates to compensate for reduced fecundity and greater variability of spawn size, consistency and success. Most culturists agree that broodstock should be stocked in the winter, or at least by early spring, at the rate of 20 to 40 pairs per acre (50 to 100 pairs per hectare). Sex ratios of broodfish in spawning ponds are typically 1:1. Although sunfish can obtain much of their daily dietary need from organisms in the pond, supplemental feeding may increase fecundity. Feed broodstock with a 1/8- to 1/4-inch (3- to 6-mm) floating or sinking pellet (36% crude protein) as soon as the water temperature reaches a level that stimulates feeding activity. Feeding rate should be 2 to 3 percent of body weight per day.

Sunfish reproductive habits

To produce lepomid fingerlings for stocking or culture, one must understand the reproductive habits of these sunfishes. Sunfish are, in general, colonial nest-builders and multiple spawners. Spawning begins in early to mid-spring and continues to some degree until early fall, depending upon the species and the geographic location. Courtship and nesting behavior are similar for all lepomids, with slight variations by species.

The male typically prepares a nest in shallow water when the temperature reaches the preferred range for the respective species. The depth at which these nests are constructed depends upon water temperature, which in turn depends on the time of year. Nesting occurs first in warm shallows in early spring, and gradually moves into deeper waters (up to 6 feet or 2 m) as the water warms. To build the nest, the male sweeps the caudal peduncle across a sandy or gravelly substrate, forming a saucer-like depression from 2 to 6 inches (50 to 160 mm) deep and 4 to 12 inches (100 to 300 mm) in diameter. A single colony, often called a "bed," may contain as many as 60 nests and cover several hundred square feet.

Once nests are constructed, the courtship ritual begins. The males (more brightly colored than the females) circle the perimeter of the nest while making a series of grunt-like calls. This behavior attracts the females. A single female can produce as many as 80,000 eggs, in multiple spawns, during a spawning season. A female may deposit eggs in more than one nest, and more than one female may deposit eggs in a single nest. The males fertilize the eggs by releasing milt across the egg mass, and then aggressively defend the nest from invading predators, periodically fanning the nest to aerate the eggs. Incubation takes 1 to 6 days at temperatures above 70 °F (21 °C.)

Pond preparation

Sunfish can be produced in many types of facilities, and are often spawned in laboratory settings for research purposes. Most culture, however, is done in open ponds or cages. In general, spawning ponds should be 2 to 5 feet (0.6 to 1.5 m) deep with smooth, uniformly sloped bottoms to facilitate the harvest of fingerlings. Ponds should be less than 3 acres (1.2 ha), although larger ponds have been used successfully. Ponds should have drain pipes so that water levels can be controlled, and a water source (preferably ground water) for filling the ponds and replacing evaporative losses. Ponds should be filled with well water at least 2 to 4 weeks before spawning begins. Ponds should be completely free of other fish species. If other sunfish are present there is risk of hybridization, depredation and disease transmission; if other piscivorus species are present, they may prey on the fingerlings. Establish a plankton bloom before spawning begins, using inorganic or organic fertilizers, or a combination of the two. For information on fertilizing ponds and establishing and maintaining plankton blooms, see SRAC Publications 466 and 471.

Once water temperatures reach appropriate levels, spawning will begin. Warmouth and green sunfish are the first to spawn, with activity beginning at 70 °F (21 °C). Redear spawn when water temperature reaches 75 °F (24 °C), whereas bluegills do not spawn until temperature reaches 78 to 80 °F (26 to 27 °C). All species begin nest building and territorial behavior at temperatures several degrees cooler than the optimum spawning temperature.

Spawning techniques and fingerling production

Sunfish can be spawned in the laboratory by manually stripping gametes into petri dishes and then mixing milt and eggs with water. Fertilized eggs are placed in clean petri dishes containing aged tap water for water hardening, then in aerated aquaria. When larvae become free-swimming fry, they are transferred to rearing ponds. Spawning has also been induced in the laboratory or under simulated field conditions by manipulating temperature and photoperiod. Research to develop improved spawning and larval rearing techniques continues.

In pond spawning systems, broodstock are allowed to spawn freely. One hundred broodfish can produce up to 375,000 fry, with an average of about 100,000 fry per acre (247,000 / ha). With good water quality and optimum temperature, broodfish should produce offspring almost immediately. When fry are observed (which should be soon after hatching), begin a feeding program. A fry powder or a mash should be offered at first. As fry grow, the size of the feed can be matched to the size of the fish. With a feeding program, fry should grow as much as 1 inch per month.

Fingerlings should reach stocker size of 2 to 3 inches (51 to 76 mm) in 60 to 100 days.

Grow-out to adult size

Until recently, there has been little research on the grow-out of sunfish fingerlings to food size fish. Now, researchers are beginning to study the production of adult sunfish in ponds, cages and intensive / recirculating systems more thoroughly.

Ponds

Stocking rates for hybrid sunfish in grow-out ponds have ranged from 1,000 to 10,000 fingerlings per acre (2,471 to 24,710 /ha), but research in both the Southern Regional Aquaculture Center (SRAC) and the North Central Regional Aquaculture Center (NCRAC) indicates that the optimum stocking rate may be 5,000 to 7,000 fish per surface acre (12,355 to 17,297/ha). Hybrids can be grown to market size of 1/2 to 3/4 pound (230 to 340 g) in 18 to 30 months, depending upon stocking density, feeding practices, and water temperatures. Yields have ranged from 750 to 1,700 pounds per acre (837 to 1,926 kg/ ha), depending upon the size at stocking and the initial stocking density.

Definite nutritional requirements have not been determined, but the protein requirement of sunfish probably lies somewhere between that of rainbow trout and channel catfish. The dietary phosphorus requirement of one green sunfish X bluegill (GS X BG) hybrid is 0.5 percent or less of the dry diet. Both the bluegill and the GS X BG hybrids grow best when fed diets containing at least 10 percent dietary lipid in the form of fish oil. Research in recirculating systems and in ponds suggests that when natural food is not available (as in tanks, raceways or cages), optimum crude protein levels may be at least 40 percent. However, when fish are cultured in open ponds where natural food is available, crude protein requirements for formulated feeds are 35 to 40 percent.

Cages

Cage culture of sunfishes has been practiced where pond culture is not feasible. Cage culture has certain advantages. It is more flexible because many types of water bodies may be used. It is more convenient to observe and harvest fish, and the initial capital cost is relatively low if a suitable pond already exists. Sunfish meet the desired criteria for cage culture—rapid growth, tolerance of crowded conditions, good growth in regional environmental conditions, and potential market value. Cage culture requires larger fingerlings than pond culture, and they should be graded to ensure uniform initial size. It is recommended that 4-inch fingerlings be stocked into cages at the rate of six to eight fish per cubic foot (212 to 282 fish / m^3) of cage volume.

Sunfish cultured in cages must be fed a complete diet, because there is little or no natural food. A crude protein level of at least 40 percent is recommended.

Recirculating systems

Recirculating tank systems may be a good alternative where land and water resources are not adequate to support either pond or cage culture. Stocking rates and production techniques have not been documented, but it is relatively certain that the higher fixed costs and management inputs associated with tank systems would result in higher production costs. Like cage culture, recirculating systems will require a nutritionally complete, high protein feed.

Water quality requirements

The water quality requirements of sunfish vary with life stages and by species. Generally, eggs are more sensitive than fingerlings or adults. For example, bluegill eggs tolerate salinities up to 5 percent of seawater, but fingerling tolerance is as high as 30 percent of seawater.

Oxygen requirements are related to temperature. For example, the minimum dissolved oxygen level tolerated by bluegills at 95 °F (35 °C) is 0.75 mg/L, but this species tolerates only 1.40 mg/L at 77 °F (25 °C). Bluegills avoid areas where dissolved oxygen concentration is below 3.0 mg / L. Bluegill fry are reported to grow best at 30 °C.

Bluegills are not tolerant of high ammonia concentrations. Continuous exposure to as little as 0.006 mg / L unionized ammonia can significantly reduce their growth. Centrarchids, however, have a high tolerance for nitrite, and benefit from a physiology that prevents nitrite from entering the blood through the gills.

Diseases

Sunfish are hardy in the wild, but when stocked into high density culture conditions they can be susceptible to several bacterial and parasitic diseases. Columnaris is a common bacterial infection in centrarchids, especially when fish are stressed. External fungus (*Saprolegnia* spp.) can cause significant mortalities. Parasites such as black grub (*Uvulifer ambloplitis*), white grub (*Posthodiplostomum minimum*), and yellow grub (*Clinostomum marginatum*) are common in sunfish. Although these parasites usually pose no significant threat to the fish, they can affect appearance and marketability.

Harvest

Harvesting small (less than l-inch, 25-mm) sunfish is stressful to the fish, so most producers do not attempt harvest until the fish reach an average of 2 inches (50 mm). This is the most commonly stocked size for bluegills, redears and sunfish hybrids. Transporting fingerlings for stocking is usually delayed until the fall months when low water temperatures help minimize stress in handling and shipping. Fall is also the recommended time for stocking sunfish into small impoundments for recreational fishing.

Pond harvest is usually done by seining. A square mesh seine with 1/3-inch (8-mm) mesh will retain

sunfish 1.5 inches (37 mm) and larger, while a mesh size of 1/2 inch (12 mm) will retain sunfish 2 inches (50 mm) and longer. Harvest from cages and recirculating systems is easier and more convenient than from ponds, but large batch harvests are not as practical as in ponds, where larger numbers of fish can be corralled with a seine.

Marketing and economics

A recent survey conducted by the NCRAC estimates that there are 485 producers of sunfish in the U.S., most of them in the southern and north central regions (primarily Texas and Wisconsin). Bluegill is the most commonly produced species (45 percent of north central region producers), followed by various hybrids (26 percent of producers nationally) and redear (14 percent of producers).

There are two primary markets. Approximately 74 percent of producers produce sunfish for sport fish, and about 20 percent supply them to fee-fishing operations. Other production is split among food fish, bait fish, and supplying fish for scientific research.

There is no reliable economic data on the market for sunfish or the cost of production. Demand for sport fish has increased in recent years, and is expected to continue; the same is likely true for fee-fishing markets. Anecdotal evidence indicates a potential food fish market, but the breadth and long-term stability of that market are not known. For example, in the NCRAC survey, midwestern brokers, wholesalers, retailers and restaurants listed bluegill as one of the top three species they would like to purchase for their customers. In some states where the marketing of game fish for human consumption is illegal, there seems to be a significant black market for sunfish captured from the wild by commercial poachers. This would indicate some level of demand, but other than law enforcement efforts to stem illegal wild fish harvest, no attempt has been made to document or describe the economics and extent of that market.

Limitations and constraints

The two main limitations to further development of a sunfish aquaculture industry are legal issues and lack of research. The legal issues revolve around the "game fish" status of the sunfish in many states, and the prohibition on the sale of game fish for human consumption in some of those states. Many fear that the liberalization of the game fish laws to allow the sale of farmed game fish might result in increased poaching, the depletion of native fish stocks in streams and reservoirs, and severe or irreparable damage to our recreational fisheries resources. In at least three states, illegally harvested native game fish have, in fact, found their way into the legal supply of cultured fish. It is hoped that research will develop a way of quickly and easily distinguishing cultured fish from wild game fish. For now, it is critical that producers consult the wildlife and fisheries agencies and departments of agriculture in their states to determine the legality of culturing, processing, transporting and marketing game fish. Also know the laws in each state through which you plan to transport fish. In some cases, simply crossing a state line with game fish is a violation of the law.

Research is needed in nearly every area of sunfish culture—defining efficient and economical production techniques and identifying and quantifying markets and marketing strategies. Specifically, more information is needed on the costs of production at every life phase, larval and fry nutrition, alternative and more intensive methods of grow-out, processing, product form, packaging, and consumer priorities.

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 94-38500-0045 from the United States Department of Agriculture, Cooperative States Research, Education, and Extension Service.