SUNFISH[6]

Project Termination Report for the Period
September 1, 1994 to August 31, 1999

NCRAC FUNDING LEVEL: $373,562 (September 1, 1994 to August 31, 1999)

PARTICIPANTS:

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Denzil Hughes	Farmland Industries, Inc., Kansas City	Kansas
IL Dept. of Conservation	Little Grassy State Fish Hatchery, Carbondale	Illinois
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Myron Kloubec	Kloubec Fish Farms, Amana	Iowa
MO Dept. of Conservation	Columbia	Missouri
Tribal Council	Red Lake Band Chippewa, Red Lake	Minnesota
National Biological Service	Midwest Science Center (formerly USFWS National Fisheries Contaminant Research Laboratory), Columbia	Missouri

U.S. Fish & Wild. Service	Gavins Point Nat'l. Fish Hatchery, Yankton	South Dakota

REASON FOR TERMINATION
The objectives were completed.

PROJECT OBJECTIVES
(1) Produce a production manual, accompanying videos, and other information as necessary to demonstrate the technology for culturing centrarchids.

(2) Determine the major nutritional requirements for centrarchids and compare their growth and performance using available commercial feeds in laboratory and field settings.

(3) Determine the best feeding management strategies for culturing centrarchids in laboratory and field settings.

(4) Compare feeding trials for grow out of locally available 5.1–10.2 cm (2–4 in) black crappie (*Pomoxis nigromaculatus*) and female green sunfish (*Lepomis cyanellus*) with a male bluegill (*L. macrochirus*) hybrids in:

(a) ponds at dissimilar latitudes in the region, and

(b) recirculating systems using compensatory feeding strategies.

(5) Establish baseline physiological measures for small 2.5–7.6 cm (1–3 in) black crappie subjected to handling stressors and test the effect of salt and temperature on stress reduction.

PRINCIPAL ACCOMPLISHMENTS
OBJECTIVE 1
Michigan State University (MSU) and Iowa State University (ISU) personnel have completed the 100-page Sunfish Culture Guide; it is now being proofed and should be available for distribution from the NCRAC Publications Office spring 2000. ISU personnel have produced a video addressing various production areas of male bluegill × female green sunfish (BG × GS) hybrids. The 8-minute video entitled "Sunfish (*Lepomis* spp.) Culture" is now available from the NCRAC Publications Office. This video depicts methods for determining the sex of brood stock, species identification, and out-of-season spawning techniques.

OBJECTIVE 2
Researchers at MSU have empirically determined the optimal energy level for growth and protein retention in 125 mm (4.9 in) BG × GS hybrids utilizing a saturation kinetics model for curve fitting. Results demonstrate the semi-purified diet developed for these trials is well accepted by these fish; this results in a

slightly lower but comparable growth to that obtained using a commercial control diet.

Studies at Purdue University (Purdue) were designed to quantify the dietary requirement for phosphorus (P) and optimum lipid to carbohydrate ratio. It appears the dietary requirement of BG × GS hybrids for P is #0.5% of the dry diet. Both pure bluegill and BG × GS hybrids grow best when fed diets containing no less than 10% dietary lipid in the form of fish oil.

Southern Illinois University-Carbondale (SIUC) researchers used practical diets containing crude protein levels of 32, 36, 40, and 44% for culturing BG × GS hybrids in two culture systems: recirculating culture system and culture ponds. Similar results were obtained regardless of culture system in regards to dietary protein levels. Increasing protein levels resulted in increasing growth rates with the optimum protein level of 40%. Dress-out analysis indicated a similar trend where increasing dietary protein levels resulted in increased percent gutted, headed, and fillet weight. Fillet composition also varied where increasing protein levels resulted in decreasing lipid content.

OBJECTIVE 3
ISU researchers have developed a procedure for tank-rearing larval bluegill and larval BG × GS hybrids in the laboratory. Results indicate that the protocol for tank-rearing larval bluegill and larval BG × GS hybrids should include using brine shrimp nauplii (*Artemia franciscna*) prior to using a commercial diet. It appeared that larval BG × GS hybrids could digest the commercial diet at the onset of exogenous feeding. However, without brine shrimp nauplii much lower survival rates resulted. Survival rates of about 25 and 37% can be expected for bluegill and BG × GS hybrids, respectively, by following this protocol.

The primary goal of the University of Wisconsin-Milwaukee (UW-Milwaukee) researchers was to utilize the early life stage feeding technology developed for yellow perch and apply this approach to centrarchids, specifically, black crappie. Young-of-the-year (YOY) black crappie were trained to accept commercial diets using a combination of adult frozen brine shrimp (*Artemia*); “green water” organisms, which included copepods, ostracods, and smaller cladocerans; and beef liver mixture.

Past efforts of UW-Milwaukee researchers to spawn adults in the laboratory or to collect wild adults have not been successful. The group of YOY black crappies acquired in October 1994 have been retained for use as captive brood stock; they have been maintained on a rearing regime that is intended to promote gonadal development.

Researchers at the University of Missouri (UM) have examined the potential to increase growth rates of BG × GS hybrids during grow out by using feeding schedules that bring out these fishes’ compensatory growth response (increased

growth following a period of fasting). Mealworms (*Tenebrio molitor*) were used as the food in these initial experiments so that daily consumption by individual fish could be accurately determined. Mean growth rates of BG × GS hybrids in the 2 and 14 day no feeding cycle groups were 2.1 and 1.5 times faster than the controls that were fed ad libitum every day. Growth improvements from compensatory growth appeared to result from increases in both consumption rate and growth efficiency.

UM researchers then evaluated the potential to increase growth rates of hybrid sunfish via compensatory growth under conditions closer to those used in aquaculture (use of commercial trout diet) than were used in their previous work. In contrast to their earlier studies, UM researchers found that while compensatory growth responses were indicated in all treatments by periods of hyperphagia (increased appetite) after no-feed periods, none of the treatment groups outgrew the controls (absolute growth rates ranged from 63–86% of the controls). UM researchers subsequently determined that the commercial diet was the cause for these contrasting findings. Because they were unable to duplicate the superior growth over controls as in earlier work, UM researchers reran the treatments as in a 1997 study done by them to ensure that their previous results were reproducible. Results of their earlier study were duplicated with both compensatory growth treatments outgrowing controls. UM research also determined that a significant effect of social interaction occurred upon growth variables and size variation in juvenile hybrid sunfish.

OBJECTIVE 4

Purdue researchers investigated three different diets, 32, 36 or 40% crude protein, for pond-reared hybrid sunfish; feed conversion ratios ranged from 1.3–1.5. Hybrid bluegill can be fed diets containing 32% crude protein without sacrificing weight gain or feed conversion. Further, it appears that hybrid bluegill fed dietary crude protein concentrations of 32% reproduce to the same extent as fish fed 36 or 40% crude protein.

Growth of black crappie and BG × GS hybrids were compared using common pond aquaculture techniques at SIUC. Hybrid sunfish were successfully cultured while black crappie were not. Net production for hybrid sunfish was 621.6 and 943.2 kg/ha (554.6 lb/acre and 841.5 lb/acre) in the 8,000 and 14,000 fish/ha (3,238 and 5,666 fish/acre) ponds, respectively. Black crappie net production was -111.0 kg/ha and -193.9 kg/ha (-99.0 lb/acre and -173.0 lb/acre), respectively, in ponds stocked at 8,000 and 14,000 fish/ha (3,238 and 5,666 fish/acre). The crappie did not appear to be using the prepared diet.

In response to their poor performance, black crappie were habituated to prepared diets prior to stocking in 1998 (hybrid sunfish were similarly treated) at SIUC. Hybrid sunfish accepted the production diet virtually immediately, whereas the crappie did not. Freeze-dried mysid shrimp and Biokiowa™ 2000 mini-pellets were then given to the black crappie as starter diets. Freeze-dried mysids were

eagerly taken the first time they were offered, and the Biokiowa™ diet was also readily accepted within a few days.

Researchers at ISU conducted two, 12-week feeding trials in 1997-1998 to compare growth and food conversion of fingerling hybrid sunfish derived from tank- and pond-spawning to a compensatory feeding strategy when raised in a recirculating aquaculture system. In both feeding trials, the restricted feeding group was fasted 2 days every week followed by 5 days of full feeding (2–5 day feeding regimen).

Although feed consumption in the restricted feeding group was greater than the daily feeding group for up to 3 days following resumption of daily feeding, overall, feed consumption was less in the restricted feeding group and compensatory growth did not occur. Food conversion in the restricted and daily feeding groups were similar. Most differences in growth between the restricted and daily feeding groups were not statistically significant, but when statistical significance was found in comparing the two groups, fish in the daily feeding regimen had faster growth than fish in the restricted feeding group. The restricted feeding strategy used here (2–5) is only one of many options on restricted feeding. Thus, these findings do not imply that other variations of restricted feeding will not produce more desirable results, or that the 2–5 system used here will not be successful with a different size group of hybrid sunfish, or with other species.

Although the parents of both groups of fingerlings were from the same stock of fish, they represented progeny of different families and of different numbers of parents; fewer brood stock were used to produce the tank-reared fish than the pond-reared fish. The most probable explanation for the results is the genetic differences among individual parental stocks.

Results from Pittsburg State University's (PSU) work indicate that compensatory feeding appeared to have little effect on biofilter performance at the loading densities of black crappie used for their study.

The compensatory feeding trial of 2, 3, and 4 day starvation periods were run for 50 days each and compared against a control group, which were fed daily to satiation on 2.5 mm (0.1 in) Biodiet™ grower. The best growth occurred during the control feeding. The next best was the 3-day; however, differences between the feeding trials were not statistically significant.

Individual trials were run on Biodiet™ at PSU using larger black crappie, 150–200 mm (5.9–7.9 in) size range. Comparisons of daily feeding to 2, 3, and 4 day starvation periods produced no differences in food consumption. Following concern about the commercial feed acceptability, individual trials were repeated using natural foods with 2, 4, and 8 day starvation periods. The best growth occurred in the control group fed daily.

OBJECTIVE 5

Juvenile black crappies were reared extensively at the Gavins Point National Fish Hacthery in Yankton, South Dakota and transported to the University of South Dakota (USD). Results from stress tests performed at USD and analyzed by USD and University of Wisconsin-Madison (UW-Madison) scientists indicate that black crappies are stressed from simple handling with the maximum corticosteroid response occurring at 0.5 h. Limited plasma chloride analysis shows that the crappies experienced an osmoregulatory imbalance from the stress, the effect of which was still apparent after 24 h. The results also indicate that routine handling, at least under these experimental conditions, was insufficient to cause significant mortality. The results show that using chilled water where fish were subjected to a rapid 6–7°C (42.8–44.6°F) temperature drop was more stressful to the fish than leaving them at ambient conditions. However, all fish appeared to recover partially from stress relatively quickly, although not completely by 24 h. Using an isotonic concentration of salt (NaCl), however, appeared to be beneficial to the fish by reducing or eliminating the decline in blood chloride levels caused by the osmoregulatory upset that usually accompanies a response to an acute stressor.

IMPACTS

The development of the Sunfish Culture Guide that incorporates information garnered from NCRAC-funded research will be a valuable resource for current and future sunfish producers.

Developing diets specifically for targeted species results in maximum performance at the lowest possible cost. Purdue research directed at minimizing costs of feeds will help to maximize profit to the producer.

It now appears that the intensive culture technology developed for yellow perch can be applied to black crappie. Also, YOY (30–60 day old) pond-produced black crappie can habituate to prepared diets within 26 days; YOY (100 day old) pond-produced black crappie can habituate to prepared diets within 14 days. The potential for the intensive culture of black crappie looks very promising.

UM's findings suggest that the compensatory growth response differs according to the type of food used; natural versus commercial diets. An exciting potential exists for using compensatory growth feeding schedules with sub-maximal feeds (e.g., mealworms), to achieve BG × GS hybrid growth rates approaching those obtained with commercial feeds.

Pond studies at SIUC showed that hybrid sunfish grow rapidly during the second year of the production cycle, but not fast enough when beginning with small (6 g; 0.2 oz) fingerlings to produce highly desirable, market-size 227–340 g (0.50–0.75 lb) fish by the end of year 2. This suggests a 3-year production cycle may be necessary to achieve 227–340 g (0.50–0.75 lb) fish.

The SIUC pond study also clearly showed that production methods suitable for hybrid sunfish are not suitable for black crappie. The latter showed poor growth and survival, and they appeared to be subsisting on the natural food supply rather than the production diet. However, great success was obtained with crappie with two starter diets, freeze-dried mysids and Biokiowa™. More work is needed to develop methods for weaning crappie from the starter to production diets.

Hybrid sunfish fed diets higher in crude protein yielded higher dress-out weights. Accordingly, a producer concerned about a processed product must consider the synergistic affects of production rates and dress out as a function of dietary protein levels when determining cost effectiveness of practical dietary formulations.

USD and UW-Madison results indicated that black crappies are stressed from simple handling, the effect of which was still apparent after 24 h. Their results also indicated that routine handling, at least under these experimental conditions, was insufficient to cause significant mortality. The use of chilled water to mitigate the stress response in crappies was actually more stressful to the fish than allowing them to recover at ambient temperature. The addition of salt (NaCl) may be useful in mitigating the effect of handling and transport stress in crappies.

RECOMMENDED FOLLOW-UP ACTIVITIES

Additional research on decreasing fish meal and continuing evaluations of optimal dietary crude protein should be pursued as these are the most expensive components in feeding of fish. It appears that the BG × GS hybrid will be more similar to the channel catfish than other species in that it will grow best when fed relatively low concentrations of dietary crude protein. This significantly aids in overall economics of bluegill culture, yet the hybrid remains a relatively slow growing candidate. Other members of this groups of fishes should be considered candidates for culture and those evaluations should be linked with nutritional evaluations.

ISU studies indicate that when carefully studied, family differences in performance characteristics are invariably observed. Thus, effort must be undertaken to avoid a culture program based on a limited gene pool.

Although not directly evaluated, the findings from UM's experiments in the fourth project, in combination with previous work, hinted that time-of-year may be a critical determinant of when compensatory growth feeding can improve growth. The three experiments involving compensatory growth that did not yield growth in excess of controls were begun prior to November, while the two that did began no earlier than December-February. Conceivably, better compensatory growth occurs only during late winter to early spring when control fish growth rates have been low despite summer-like temperature and photoperiods. If so, future efforts should evaluate the use of compensatory growth feeding to improve growth of

hybrid sunfish in recirculation tanks (where summer-like conditions can be maintained) during the months of January through April, as a means to reduce total grow-out times and to improve feed conversion.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See Appendix A for a cumulative output for all NCRAC-funded Sunfish Culture activities.

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
1994-96	$173,562	$177,300	$12,012[a]			$189,312	$362,874
1996-98	$200,000	$274,773				$274,773	$474,773
TOTAL	$373,562	$452,073	$12,012			$464,085	$837,647

[a]Farmland Industries, Inc.

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Publications in Print

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Miller, S. 1995. Tetraploid induction protocols for bluegill sunfish, *Lepomis macrochirus*, using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

Mischke, C.C. 1995. Larval bluegill culture in the laboratory. Master's thesis. Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 1997. Out-of-season spawning of sunfish *Lepomis* spp. in the laboratory. Progressive Fish-Culturist 59:297-302.

Mischke, C.C., and J.E. Morris. 1998. Growth and survival of larval bluegills in the laboratory under different feeding Progressive Fish-Culturist 60:206-213.

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Read, E.R. 1994. Cage culture of black, white and F_1 hybrid crappie (*Pomoxis* species). Master's thesis. Pittsburg State University, Pittsburg, Kansas.

Thomas, G.L. 1995. Culture of white crappie *(Pomoxis annularis)* in a Recirculating System. Master's thesis, Pittsburg State University, Pittsburg, Kansas.

Wang, N., R.S. Hayward, and D.B. Noltie. 1998. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid sunfish. Aquaculture 165:261-267.

Wang, N., R.S. Hayward, and D.B. Noltie 1998. Variation in food consumption, growth, and growth efficiency among juvenile hybrid sunfish held in isolation. Aquaculture 167:43-52.

Westmaas, A.R. 1992. Polyploidy induction in bluegill sunfish (*Lepomis macrochirus*) using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

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Wills, P.S., J.P. Paret, and R.J. Sheehan. 1994. Induced triploidy in *Lepomis* sunfish and hybrids. Journal of the World Aquaculture Society 25(4):47-60.

Manuscripts

Hayward, R.S., N. Wang, and D.B. Noltie. In press. Group holding impedes compensatory growth of hybrid sunfish. Aquaculture.

Mischke, C.C., and J.E. Morris, editors. In press. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Wang, N., R.S. Hayward, and D.B. Noltie. In press. Effects of social interaction on growth of juvenile hybrid sunfish held at two densities. North American Journal of Aquaculture.

Wills, P.S., R.J. Sheehan, and S.K. Allen, Jr. Submitted. Histology and DNA content in diploid and triploid hybrid sunfish. Transactions of the American Fisheries Society.

Papers Presented

Brown, P.B., and K. Wilson. 1994. Experimental and practical diet evaluations with hybrid bluegill. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Hayward, R.S. 1998. Strategies for increasing growth rates and reducing size variation in hybrid sunfish. Missouri Joint Aquaculture Conference. Springfield, Missouri, March 4-6, 1998.

Hayward, R.S. 1999. New feeding strategies for sunfish. North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Hayward, R.S., C.V. Bove, D.B. Noltie, and N. Wang. 1997. Does the compensatory growth response of hybrid sunfish reflect patterns of food availability in nature? 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-28, 1997.

Kohler, C.C., and J.E. Wetzel. 1997. Protein requirements of hybrid sunfish, *Lepomis cyanellus* × *L. macrochirus*, diets. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Kohler, C.C., and J.E. Wetzel. 1999. Sunfish nutrition. North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Mischke, C.C., and J.E. Morris. 1996. Growth and survival of larval bluegill (*Lepomis macrochirus*) and hybrid sunfish (green sunfish, *L. cyanellus* × bluegill) in the laboratory under different feeding regimes. Iowa-Nebraska American Fisheries Society Meeting, Council Bluffs, Iowa, January 29-31, 1996.

Mischke, C.C., and J.E. Morris. 1996. Early spawning of bluegill. Midcontinent Warmwater Fish Culture Workshop, Council Bluffs, Iowa, February 7, 1996.

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Morris, J.E. 1995. Hybrid bluegill culture update. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

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Sheehan, R.J., J.P. Paret, P.S. Wills, and J.E. Seeb. 1993. Induced triploidy and growth of *Lepomis* parental species, hybrid, and triploid hybrid at five temperatures, 8 to 28◦C. Prospects for Polyploid Fish in Fisheries Management Symposium, 123rd Annual Meeting of the American Fisheries Society, Portland, Oregon, August 29-September 2, 1993. (Invited paper)

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