



S-83 Annual Report 1979

Freshwater Food Animals

COOPERATING AGENCIES AND PRINCIPAL LEADERS

Station	Representative*
Agricultural Experiment Stations:	
Alabama	R. T. Lovell
Georgia	Kaine Bondari
Louisiana	J. W. Avault, Jr.
Mississippi	Roland Regan
Puerto Rico	R. C. Cortes- Maldonado
South Carolina	J. W. Foltz
Tennessee	J. L. Wilson
Texas	R. R. Stickney
Virgin Islands	R. L. Busch
Kerr Foundation	C. M. Collins
Memphis State University	B. A. Simco
Oak Ridge National Laboratory	Mike McGee
Tennessee Valley Authority	Carl Madewell
U.S. Department of Agriculture:	
Economics Research Service	Shelby Holder
Southern Utilization Laboratory ..	Don Freeman
U.S. Department of Commerce:	
National Marine Fisheries	
Station	Richard Raulerson
U.S. Department of the Interior:	
Fish Farming Experiment	
Station	Harry K. Dupree
University of Arkansas at	
Pine Bluff	Scott Newton
University of Southwestern	
Louisiana	Mark Konikoff
Catfish Farmers of America	R. T. Lovell
Administrative Advisor	
Southern Director	R. Dennis Rouse
SEA Representative	
SEA, USDA—	
Washington, D. C.	Clyde E. Richards

*Voting representatives. Other members of technical committee are listed in appendix 1.

S-83

FRESHWATER FOOD ANIMALS¹

Edited By R. T. LOVELL, Chairman
Technical Committee

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS

Objective I, Production

A. Nutrition

Alabama. High levels of vitamin C, four times the minimum requirement for growth, provided channel catfish fingerlings with increased resistance to the injected pathogenic bacterium *Edwardsiella tarda*.

Channel catfish, unlike carp, salmonids, and several other species, does not require dietary inositol for normal growth. Rate of inositol synthetase activity in liver of catfish was greater than the rate in livers of rats and chicks.

Freshwater prawns (*Macrobrachium species*) grew as well on a pelleted-crumbled diet as on an extruded-crumbled diet, but better than when fed a pelleted poultry diet in earthen-bottom plastic pools.

Golden shiners were fed a diet in meal (non-pelleted) form, in extruded and reground form, and in pelleted and crumbled form for 60 days in ponds stocked at 40,470 per ha. The assumption was that the extruded or pelleted diet particles would be more homogeneous (micro and macronutrients) than the meal and would provide a more nutritionally balanced diet; however, growth was not statistically different among the treatments.

Mississippi. Amino acid studies with channel catfish have shown that tyrosine can supply approximately 50 percent of the total aromatic amino acid requirement. In addition, the phenylalanine requirement per se was determined to be 0.49 percent of the diet or 2.04 percent of the dietary protein. Additional studies have demonstrated the apparent lack of an arginine-lysine antagonism in the channel catfish. Other in-

¹Supported by allotments of the Regional Research Fund Hatch Act as amended August, 1955.

teraction studies have demonstrated that excess dietary leucine (2 times the requirement) depressed growth when fed in diets marginal in isoleucine or valine. A reevaluation of the leucine requirement confirmed the previously reported value of 0.82 percent of the diet of 3.4 percent of the dietary protein.

Investigation of the methodology of conducting amino acid digestibility trials with channel catfish indicate that the dissection method of fecal collection is more reliable than collection by sedimentation.

Data pooled from 1978 to 1979 pond feeding trials indicated that catfish fed 1,075 kcal per pound of feed gained significantly less than fish fed either 1,150 or 1,000 kcal per pound of feed. The three trial feeds contained the same ratio of energy to the amino acids lysine, methionine and methionine plus cystine.

Texas. A feeding experiment demonstrated that the optimum protein-to-energy ratio for *Tilapia aurea* was similar to that for channel catfish. A study on the effects of stocking density on growth rate of *T. mossambica* showed that the fish elicit a chemical which causes an automimmune response which leads to self-limiting of the population. The finding was obtained first in 1978 and verified in a subsequent study in 1979.

South Carolina. Feeding tables which consider body size and water temperatures were prepared for channel catfish. Feeding regimes developed utilized only 85 percent of the food which existing feeding charts would dictate. Conversion was 1.18.

U.S. Fish and Wildlife Service (Fish Farming Experiment Station). Utilization of plant protein was 8 percent better when fed to channel catfish at 30 degrees then at 22 degrees or 26 degrees when compared with feeds containing a mixture of plant and animal proteins. The performance of catfish fed diets containing heat-treated, full-fat soybeans was less than that obtained in previous years. The cause was presumed to be reduced protein or specific amino acid availability due to overheating. Catfish fed diets containing both animal and plant protein in ponds from June 18—September 8 grew faster and had more visceral fat than fish fed all-plant diets.

A diet was developed that gave satisfactory growth and survival for catfish fry in tanks; however, other formulated diets, presumed to also be nutritionally adequate, did not give satisfactory response for reasons unknown. Feeding four times daily, compared with either once or twice daily, produced 16 percent and 9 percent more gain at 22 degrees C and 18 percent and 9 percent more gain at 33 degrees C. However, limited feed availability appeared to negate the benefit of multiple daily feeding.

B. Breeding and Genetics:

Alabama. Paternal influence was exhibited in reciprocal crosses between blue and channel catfishes; growth and development patterns including morphometric, meristic and behavioral characteristics were affected. Both hybrids were more easily caught by angling than the parent species, whereas, heterosis for catchability was 158 percent by number and 204 percent by weight. Reproductive performance was studied in crossbred and pure-line brood stock of 3-year old channel catfish. Cross-bred brood had more pronounced secondary sexual characters, spawned earlier, spawned at greater frequency, and had higher survival of young than pure-line stock.

Heritability estimates for length and weight for *Tilapia nilotica* were determined by half-sib analysis. Sire heritability estimates ranged from mass selection were small because of low heritabilities and small standard deviations.

Georgia. Bi-directional between and within family selection for 40-week body weight and growth uniformity of channel catfish was continued in 1979. First generation catfish selected upward for body weight gained an average of 5 grams per week more than their random-bred control. The line selected for multiple traits of importance to catfish breeders was also propagated. A recent trial, still in progress, indicates growth superiority of normal catfish over their albino full-sibs at 16 and 28 weeks of age.

Several inbred lines have been developed to study the effects of inbreeding on channel catfish growth. This experiment will be continued for several generations. Primary results indicate that large females produce spawns 22 percent

and 38 percent heavier than spawns produced by medium and small females, respectively. Spawns produced by large females hatched one day and one-half day earlier than spawns by small and medium females, respectively.

Louisiana. Six different families of channel catfish fry from a Yazoo City, Mississippi nursery were compared in the laboratory (30 degrees C) for their ability to withstand low levels of dissolved oxygen. Oxygen levels in test containers were manipulated by addition of nitrogen gas which displaced dissolved oxygen. The level of dissolved oxygen where fish began dying was 1.1 milligram per liter. The data indicate distinct differences of low dissolved oxygen tolerance among families.

Mississippi. Estimations of heritabilities in channel catfish have been completed. Studies have shown that heritabilities of growth is high to medium, head size is low, fat percent is zero, and dressout percentage is low.

Texas. Studies comparing four strains of channel catfish indicated that fish from populations as divergent geographically as northern Minnesota and the Rio Grande River, when managed under similar conditions, had similar characteristics such as growth rate, fecundity, and hatchability.

Studies comparing stocking densities of first year catfish fingerlings revealed that the fish stocked at 7,400 fish per hectare benefited more from natural pond foods and grew much more rapidly than fingerlings stocked at 123,500 per hectare. The study indicated that with a slightly longer growing season, possibly with earlier spawning, channel catfish can be grown to market size in ponds in one season in Texas.

C. Water Quality:

Alabama. Use of mechanical aerators may decrease instead of increase pond water oxygen level during periods of supersaturated concentration levels. Thus, a new paddlewheel has been designed and tested to provide stirring instead of splashing or spraying. Tests demonstrated that daytime circulation can increase dissolved oxygen content in the deeper portions of the pond during the following night. Circulation demands only a fraction of the power associated with most existing aerators. Three paddlewheels, adequate for a one-hectare

pond, require only 1.95 kilowatt per hour for day time operation.

Nighttime aeration of densely stocked catfish ponds for 2 hours (July 1-31), 4 hours (August 1-7), and 6 hours (August 8-October 16) per night resulted in an average yield of 5,264 kilograms per hectare and 92 percent survival, while unaerated ponds yielded only 1,400 kilograms per hectare and 40 percent survival.

Louisiana. Use of constant aeration to increase catfish production was determined in ponds stocked at rates per hectare of 18,532, 24,710, and 30,887. Ponds averaged 0.12 hectare in size and each contained one floating aerator with a capacity of 2,343 liters of water per minute. Controls without aeration were stocked at a rate of 4,942 per hectare. Production under constant aeration, in kilograms per hectare, ranged from 8,225 at the low stocking rate up to 14,325 at the high stocking rate. Controls averaged 2,516. Feed conversion ranged from 1.48 to 1.83 in aerated ponds and 1.19 to 1.34 in non-aerated ponds. Overall, fish averaged 0.57 kilogram each at harvest.

Memphis State University. The 24-hour LC₅₀ of total ammonia nitrogen to channel catfish at pH 7, 8 and 9 was found to be 263, 39 and 5 mg/liter, respectively. Unionized ammonia nitrogen LC₅₀ at these pH values varied only between 1.4 and 1.8 mg/liter. Enrichment of water from 40 to 440 mg/liter total hardness significantly increased the tolerance of catfish to ammonia. No differences in blood pH were found due to exposure to ammonia. Plasma sodium depletion is suggested as a contributing mechanism of ammonia toxicity.

Catfish exposed to 1, 2.5, and 5 mg/liter nitrite developed methemoglobin amounts of 21, 60, and 77 percent of total hemoglobin, respectively. However, an ionic ratio of 16 chloride to 1 nitrite monovalent ion completely suppressed methemoglobin formation. Fish with high amounts of methemoglobin recovered within 24 hours after transfer to nitrite-free water or the addition of salt to water containing nitrite.

U.S. Fish and Wildlife Service (Fish Farming Experiment Station). Methods for removal or neutralizing toxic metabolites in water reuse systems are being investigated. Addition of

1 percent and 2 percent of NaCl did not prevent or overcome nitrite toxicity in channel catfish. A filter system was installed to remove solid wastes and for nitrification of nitrogen wastes in reuse water. This system sustained a fish load of 40 grams per gallon. When nitrite nitrogen exceeded 2 milligrams per liter, the "brown blood syndrome", characteristic of nitrite toxicity, was found.

In reuse systems, a pump duty cycle of 7 minutes *on* and 3 minutes *off* was as effective as continuous operation, with a fish load of 0.63 pound per cubic foot.

D. Fish Health:

Alabama. Forty-five channel catfish brood stock were assayed for channel catfish virus (CCV) neutralization activity. Of these, 73 percent were positive for CCV antibody while 16 percent were questionable and 11 percent were negative. Hyperosmotic infiltration is a viable method for immunizing channel catfish against *Aeromonas hydrophila*, but the heteroantigenic nature of *A. hydrophila* may contraindicate its use in vaccination.

A protein assay for examining mitogen-induced blastogenesis in channel catfish peripheral blood lymphocytes resulted in significant stimulation to PhA, RWM, ConA, and LPS. Refinement work has improved the application of an indirect fluorescent antibody technique for the detection of CCV in cell cultures.

South Carolina. Acute 96-h toxicity tests were conducted to determine 96-h LC₅₀ values of 5 chemicals used in disease control for yellow phase eels. Tolerance of yellow eels to the 5 chemicals was determined by exposing yellow eels to recommended concentrations and exposure times of each chemical. Chemicals tested and calculated 96-h LC₅₀ values were: malachite green, 2.86 milligrams per liter; KMnO₄, 21.60 milligrams per liter; formalin, 329.65 milligrams per liter; Dylox, 8.57 milligrams per liter; and antimycin A, 304 ug/l. Eels appeared tolerant of application rates of KMnO₄, formalin and Dylox. Recommended application rates of malachite green and antimycin A caused substantial mortality.

U.S. Fish and Wildlife Service (Fish Farming Experiment Station). Results of research shows that feeds that contain di-n-butyl tin oxide, Tinostat^R or Yomesan^R (niclosamide, phenosal) did not eliminate all the tapeworms (*Bothriocephalus acheilognathi*). Probably the main cause for incomplete control is that all the fish did not eat the feed, and the solution to this problem is not apparent.

Five agricultural fungicides (Captan, Folpet, Maneb, Zineb, and Chlorothalonil) were tested *in vivo* on buffalo fish eggs. Excellent and repeatable results were obtained with Captan in controlling fungus. Unfortunately, information was obtained which showed Captan and Folpet to be mutagenic in *in-vitro* testing; thus, work on Captan as a candidate compound has ceased. Moderate success was obtained with Ro7-4481; *Saprolegnia diclina* was prevented in some tests at 20 ppm but was not effective in other tests. However, Duter^R suppressed all fungal growth at 1, 10, 25, and 50 ppm, and deformed fry were no greater than in the controls. A concentration of 100 ppm was toxic to the eggs. Thus a chemical for fungus control may be available to replace malachite green which was shown to be mutagenic.

Residue work is in progress on Ro5-0037 (Hoffman-LaRoche). This is a potentiated sulfonimide and has been shown to be a good drug in the control of certain bacterial disease of cold and warmwater fishes.

Lernaea, like *Ich*, is difficult to maintain in the laboratory on fish. We are attempting to develop a routine method of rearing the larvae to the first copepodite stage before exposing them in known numbers of fish. Older copepodites for therapeutant screening were tried but the controls died overnight; however, the first larval stages do remain alive 3 to 4 days and can be used for similar screening. The effectiveness of Masoten in controlling adult *Lernaea* was tested in aquaria. Masoten at 0.25 ppm did not kill adults, so it is presumed that the success of using Masoten is based on killing the larval stages; this will be tested.

Preliminary studies indicate that the "globs" in the epithelium of golden shiners are not parasites or algae, but are phagocytic cells containing an unidentified material. A

nematode, *Capillaria* sp., appears pathogenic. The Asian tapeworm, *Bothriocephalus acheilognathi* continues to cause major problems in golden shiners and white amur, but none has been found in goldfish or catfish. The parasite is found in high incidence in *Gambusia affinis*, and it is possible that it has become an important carrier.

E. Culture Systems:

Alabama. *Tilapia nilotica* males and females were grown separately and mixed in earthen ponds in cages at stock densities up 22,000 per hectare. Males grew 2-3 times faster than females. A maximum of 5,000 kilograms per hectare of marketable fish were produced in monosex male cultures.

Young-of-year *Tilapia aurea* were grown to marketable size in wire cages suspended in a catfish pond from July 2 to October 29, 1979. Average gain for mixed sexes stocked at 300-600 per m³ was 208 grams, and conversion of catfish feed was 1.5 to 1.

Rainbow trout produced 1,450 kilograms per hectare at a food conversion of 1.1 to 1 in earthen ponds with standing water November 1977—March 1978. Survival was 90 percent. Striped bass fry survival in well managed ponds average 43 percent, significantly greater than the commonly accepted norm of 33 percent. Rotifers were the principal food item for young striped bass.

Partial harvesting of channel catfish with 30 millimeter coral seines baited with feed was conducted in a 8.9 hectare pond. Thirty-one seine sets during September—December, 1978 and February—September, 1979 yielded 27,937 kilograms and 2,495 kilograms per hectare, respectively. From a 1-hectare pond, 12 seine sets removed 4,445 kilograms and 2,495 kilograms per hectare during the same period. An additional 21,818 kilograms from the large pond and 3,015 kilograms from the small pond were harvested at draining in October.

Silver carp and bighead carp fry were grown to 25 millimeters in pools, tanks and earthen ponds with survival 60 percent in pools and tanks and 73 percent in ponds.

Arkansas. Annual production of mosquitofish from 0.1-hectare ponds averaged 28-37 kilograms per hectare along with 92 kilograms per hectare of additional food fish. Average size of the mosquitofish, harvested at 30-day intervals, was 0.45 kilograms per 1,000 fish and sex ratio was 1 male per 20 females.

Average sizes of channel catfish after 1 year were nearly equal between monoculture ponds and polyculture ponds with various Chinese carps. Bigmouth buffalofish may be preferred over bighead carp in combination with grass carp in catfish ponds. Largemouth bass stocked 25-50 per hectare will control wild fishes in catfish ponds.

Georgia. A study on the effects of temperature on growth of *Tilapia aurea* revealed that *Tilapia* grown in well water heated to 27 degrees C were an average of 93 grams heavier and 23 millimeters longer after 16 weeks than *Tilapia* grown in 22 degrees C well water.

Louisiana. Crawfish production was highest in ponds planted early (June) in rice and left standing during flooding. Rice was a better forage than millet. Forage is best left standing. Another study showed rice was superior to delta duck potato, and poultry manure was highly beneficial. In another, rice stubble left standing was most productive, baling and adding back was next, and disking under was least productive, while flooding in September was slightly better than flooding in October.

The numbers of young crayfish consumed per day by *Cybis-ter finbriolatus*, *Belastoma latarium*, and *Anax junius* were 0.65, 0.5, and 0.

Giant Malaysian prawn post-larvae, stocked 24,710 per hectare, produced an average of 435 kilograms per hectare with 57 percent survival. Simultaneous stocking of channel catfish fry in the ponds did not affect prawn yield. Catfish production was 520 kilograms per hectare.

Tennessee. A study has been initiated in a flow-through culture system to evaluate yields of catfish (monoculture) and catfish with tilapia (polyculture). Optimum stocking ratio of catfish to tilapia will be based on fish yield and number of tilapia to clean up organic wastes.

Another study has been initiated to determine effects of fish anaesthetics (MS-222, quinaldine, salt) on blood glucose and cortisol in rainbow trout.

Texas. Tilapia culture studies with swine poultry manures as the primary nutrient source are in progress. Overwintering systems (outdoor and indoor) for tilapia have been designed and put into use.

U.S. Virgin Islands. A small, tilapia culture-hydroponic tomato production system was designed which consisted of a 3.7 millimeter diameter fish pool, 2 biofilters, 2 settling tanks, and 2 hydroponic beds. In 181 days of feeding, 125 male tilapia gained 449 grams each with 98 percent survival. Total yield of the system was 56.8 kilograms of fish and 77.7 kilograms of marketable fruit, and appears to be economical.

Tennessee Valley Authority. Using warmwater effluents and swine manure, it appears possible to produce the equivalent of 7,800 kilograms of fish (tilapia with silver, bighead and grass carps), 40 tons of water chestnuts and 7 tons of chestnut hay per hectare, and release water that meets federal discharge standards. During winter this effluent can maintain tilapia at the rate of 16 pound fish per gallon per minute of flow.

One crop of channel catfish was produced in raceways using power plant effluent from April-November, then rainbow trout were stocked. By maintaining constant 80 degrees F water temperature year round, a 3 to 5-fold increase in fish production could be realized. This will be considered in future work.

U.S. Fish and Wildlife Service (Fish Farming Experiment Station). Cultural practices have been developed to permit research in controlled containers on golden shiners. Factors evaluated were diet, density, flow-rate, temperature, and application of medications. Optimum temperature for golden shiners was found to be between 24 and 31 degrees C; growth and health were about equal at 24 and 27 degrees, but poorer at 31 degrees.

Objective II, Economics

South Carolina. Information is being collected on the quantity of inputs necessary for the operation of a *Macrobrachium*

hatchery. These data will be used to estimate the variable costs of production. The investment requirement for the building and equipment is being revised.

Tennessee Valley Authority. The cost of producing catfish in waste heat effluent raceways, using a one-crop-per-year system, was 65 cents per pound versus 49 cents per pound for traditional pond culture. Cost of producing rainbow trout will also probably be more than the traditional method. By using constant 80 degrees F year round temperature in the raceways, the annual yield of fish can be increased 3 to 5-fold which should be more economical and would provide a year round supply of fish.

Objective III, Product Development and Quality Assurance

Alabama. An enzyme hydrolysis method was used to liquify protein in catfish processing waste and separate the bones and lipids. On a moisture free basis, the yield was bone, 34.5 percent; lipids, 17.2 percent; and flesh, 34.5 percent. The flesh fraction, (dried) yielded a high quality protein (73) percent with an amino acid profile similar to fish meal.

“Warmed-over flavor” (WOF) develops quickly in cooked meats and poultry, due to oxidation of lipid components. Development of WOF in cooked, frozen-stored catfish was evaluated by sensory and TBA analysis, and found to be relatively lower than found in red meat or poultry. Dark muscle, which is in higher concentration in large fish, had a higher incidence of WOF than light muscle.

Canned pet foods were made from ground, catfish processing waste which contained 16, 24, and 33 percent waste. Those containing 24 and 33 percent waste had desirable texture and appearance; that containing 10 percent was mushy. Dog acceptance tests (with 6 animals) showed that the dogs preferred the product containing 24 or 33 percent catfish waste over a commercial canned dog food.

U.S. Department of Agriculture (Southern Regional Research Center). A silage-type process using natural visceral enzymes to liquefy catfish processing waste was developed. The process involves liquifying chopped waste with natural enzymes activated by formic acid, screening out the bones,

removing oil by centrifuging, and evaporating most of the water in a high-efficiency vacuum evaporator. Mixed offal (70% heads, 20% viscera, 10% skins), which is almost as viscous as ground beef, can be completely liquefied in 2 hours at 50° C (122° F). Processing waste can be upgraded into nutritious by-products such as oil, bonemeal, and high-protein concentrates (50% water removed) or meals for animal feeds or pet foods. This method not only shows potential for large-scale industrial processing plants, but it also could be used with minor modifications on the farm level with relatively simple equipment.

USEFULNESS OF FINDINGS

Information from this research is presented through journals, trade and Experiment Station literature, trade and technical meetings, and state and federal government extension agents. Four state-of-the-art cooperative bulletins have been prepared by the S-83 Technical Committee (Processing; Disease; Nutrition and Feeding; and Breeding and Genetics) and two are in preparation (Water Quality; Culture Systems) at this time. Scientific data provided during the 8 years of this project (S-83) will be useful to the industry and government in development of aquaculture in this county.

WORK PLANNED FOR NEXT YEAR

All participant stations except the Kerr Foundation will continue their research. It is anticipated that additional species of freshwater food animals will be included.

APPENDIX I

OTHER PARTICIPATING TECHNICAL COMMITTEE MEMBERS

Agricultural Experiment Stations

Alabama	R. O. Smitherman	C. E. Boyd
	J. A. Plumb	E. W. McCoy
	W. A. Rogers	Charles Busch
Arkansas	D. L. Gray	J. C. Dean
Georgia	E. E. Brown	E. B. Shotts
	J. B. Gratzek	J. L. Chessness
Louisiana	Ronnie Bean	Larry De la Bretonne
	J. V. Huner	
Mississippi	G. R. Ammerman	H. R. Robinette
	J. E. Waldrop	Edwin Robinson
	R. P. Wilson	W. E. Poe
South Carolina	A. G. Eversole	
	L. L. Bauer	
Tennessee	Tom K. Hill	
Texas	D. H. Lewis	R. K. Strawn
	R. W. Brick	W. Griffin
	M. Broussard	
Oak Ridge National Laboratory	M. Olszewski	H. Bigelow
	M. McGee	
Tennessee Valley Authority	J. J. Maddox	A. Smith
	R. Snipes	R. S. Pile
	B. G. Isom	J. S. Crossman
	B. Carroll	J. C. Roetheli
	L. Behrends	K. Granneman
U.S. Department of Agriculture	J. P. Cherry	D. M. Gadsby
	Shelby Holder	Billie Hougart
U.S. Department of Commerce	J. W. Ayers	
U.S. Department of the Interior	D. Greenland	Glenn Hoffman
	Mayo Martin	Thomas Brandt
	Drew Mitchell	Dewey Tackett
	Nick Parker	
University of Arkansas, Pine Bluff	Calvin Haskins	

APPENDIX 2

PUBLICATIONS

Alabama

- Boyd, C.E. 1979. Water quality in warm water fish ponds. Auburn University (Ala.) Agricultural Experiment Station, Auburn, Alabama 359 pp.
- Boyd, C.E., and R. P. Romaine and E. Johnston, 1979. Water quality in channel catfish production ponds. *J. Environ. Quality* 8: 423-429.
- Boyd, C.E. 1979. Determination of total ammonia nitrogen and chemical oxygen demand in fish culture systems. *Trans. Amer. Fish. Soc.* 108: 305-311.
- Boyd, C.E. 1979. Aluminum sulfate (alum) for precipitating clay turbidity from fish ponds. *Trans. Amer. Fish Soc.* 108: 305-311.
- Boyd, C.E. and C. S. Tucker. 1979. Emergency Aeration of Fish Ponds. *Trans. of the Am. Fisheries Soc.* 108: 299-306.
- Bowser, P.R. and J.A. Plumb. 1979. Fish cell lines: Establishment of a line from ovaries of channel catfish. *In Vitro*. (In press).
- Bowser, P.R. and J.A. Plumb. 1979. Channel catfish virus: Comparative replication and sensitivity of cell lines from channel catfish ovary and the brown bullhead. *J. Wildl. Dis.* (In press).
- Busch, C.D. and C.A. Flood, Jr. 1979. Water Movement for Water Quality in Catfish Production. *Transactions of the ASAE* (In press).
- Cremer, M.C. and R. O. Smitherman. 1979. Food habits and growth of silver and bighead carp in cages and ponds. *Aquaculture*. (In press).
- Hawke, J.P. 1979. A bacterium associated with disease of pond cultured channel catfish, *Ictalurus punctatus*. *J. Fish. Res. Bd. Can.* 36: 1508-1512.
- Hopkins, K.D., W.L. Shelton, and C.R. Engle. 1979. Estrogen sex reversal of *Tilapia aurea*. *Aquaculture* 18: 263-268.
- Jensen, G.L. and W.L. Shelton. 1979. Effect of estrogens on *Tipalia aurea*: Implications for production of monosex male tilapia. *Aquaculture* 16: 233-242.
- Lovell, R.T. 1979. Fish culture in the United States. *Science*, 206:1368.
- Lovell, R.T. 1979. Flavor problems in fish culture, *In Advances in Aquaculture* (Pillay and Dill ed.), Fishery News Books, Ltd., London. p. 186-190.
- Lovell, R.T. 1979. Nutritional diseases in channel catfish, *In Advances in Aquaculture* (Pillay and Dill, ed.), Fishing News Books, Ltd., London. p. 605-621.
- Lovell, R. T. 1979. Feeds for baitfishes. *Commercial Fish Farmer*, 5 (2): 35.
- Lovell, R. T. 1979. Phosphorus in fish feeds. *Commercial Fish Farmer*, 5(5): 34.
- Lovell, R. T. Brown Blood disease in pond-raised catfish. *Commercial Fish Farmer*, 5(3):33.
- Lovell, R. T. Factors affecting voluntary food consumption by channel catfish. *In Proc. World Symp. on Finfish Nutrition and Fish Feed Technology* (Halver/Tiews, ed.), Henneman Verlags-Gesellschaft, Berlin. p. 555-564.
- Lovell, R. T. 1979. formulating diets for aquaculture species. *Feedstuff*, 51:29.
- Lovell, R. T. 1979 Feeding and nutrition, *In ornamental, food, and biatfish handbook* (E. E. Brown, ed.) AVI Publishing Co., Inc., Westport, Conn. (In press).
- Lovell, R. T. 1979. Off-flavor in pond-raised catfish. *Highlights: Auburn University (Ala.) Agr. Exp. Sta.* 40:13.

- Lovell R. T. 1979. Nutritional value of catfish processing waste. *Commercial Fish farmer*, 5:31.
- Lovell, R. T. 1979. Diet and reproductive performance in brood catfish. *Aquaculture Magazine*. 5(6):38.
- Lovell, R. T. 1979. High levels of vitamin C. in fish feeds. *Aquaculture Magazine*, 6(1):39.
- Mitchell, A. J. and J. A. Plumb. 1980. Toxicity and efficacy of Furanace on channel catfish *Ictalurus punctatus* (Rafinesque) infested experimentally with *Aeromonas hydrophila*. *J. Fish. Dis.* 3:93-99.
- Plumb, J. A. 1979. Principal Diseases of Farm-Raised Catfish. South. Coop. Series Bulletin No. 225. Auburn University, Auburn, Alabama 92 pp.
- Plumb, J. A. and J. Chappell. 1978. Susceptibility of blue catfish to channel catfish virus. *Proc. 32nd Ann. Conf. Southe. Assoc. of Fish & Wildl. Agen.* 32:680-685.
- Shelton, W. L. and G. L. Jensen. 1979. Production of reproductively limited grass carp for biological control of aquatic weeds. Bulletin 39, Water Resources Research Institute, Auburn University, Auburn, Alabama 174 p.
- Smitherman, R. O., M. C. Mohead, W. G. Mustin, and R. K. Goodman. 1979. Trapping channel catfish from upland ponds, Highlights of Agricultural Research Auburn University (Ala.) Ag. Exp. Sta. Vol. 26(2):6.
- Tave, D. L. and R. O. Smitherman. 1979. Predicted response to selection in *Tilapia nilotica* Trans. Am. Fish. Soc. (In press).
- Walters, G. R. and J. A. Plumb. 1979. Environmental stress and bacterial infection in channel catfish. *J. Fish Biol.* (In press).
- Tucker, C. S. and C. E. Boyd. 1978. Effects of simazine treatment on channel catfish and bluegill production in ponds. *Aquaculture* 15: 345-352.

Arkansas

- Newton, S. H. 1980. Catfish farming with Chinese carps. *Ark. Farm Res. J. Vol. XXIX*, No. 1:8.
- Newton, S. H. and Calvin J. Haskins. 1979. Fisheries Research Program. State Report Section, Eighth Inland Commercial Fisheries Workshop. (In press).
- Newton, S. H., J. Mayo Martin, Joel Fergusson, and D. Leroy Gray. Grass Carp Aid Aquatic Weed Removal in Irrigation Canals and Reservoirs. *Arkansas Farm Research Journal*, 28(4). 12, 1979.

Louisiana

- Avault, J. W., R. A. Bean, H. M. El-Ibiary, R. E. Reagan, L. C. Skow, R. O. Smitherman, and G. W. Wohlfarth. (R. O. Smitherman *et al.* eds) 1978. Genetics and breeding of channel catfish. *So. Coop. Ser. Bull.* 223. 34 pp.
- Avault, J. W., Jr. 1979. Crawfish around the world. *Farm and Land Realtor*. 31(9):18-19.
- Bean, R. A., and J. V. Huner. 1978. An evaluation of selected crawfish traps and trapping methods. *In papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:141-152.
- Cheah, M. L., J. W. Avault, Jr., and J. B. Graves. 1979. Some effects of rice pesticides on crawfish. *Louisiana, Agr.* 23(2):8-9,11.
- Cheah, M. L., J. W. Avault, Jr., and J. B. Graves. 1978. Some effects of thirteen rice pesticides on crawfish. *In Papers from 4th Int'l Sym on Freshwater Crayfish.* 4:349-362.
- Chien, Y. H. and J. W. Avault, Jr. 1978. Double cropping rice, *Oryza sativa*, and red swamp crawfish *Procambarus clarkii*. *In Papers from 4th Int'l Sym on Freshwater Crayfish.* 4:263-276.

- Goyert, J. C. and J. W. Avault, Jr. 1978. Effects of container size on growth of crawfish (*Procambarus clarkii*) in a recirculating culture system. *In Papers from 4th Int'l Sys. on Freshwater Crayfish.* 4:277-286.
- Green, L. M., J. S. Tuten, and J. W. Avault, Jr. 1978. Polyculture of red swamp crawfish (*Procambarus clarkii*) and several North American fish species. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:287-298.
- Huner, J. V., and J. W. Avault, Jr. 1978. Introduction on *Procambarus* spp.—a report on the introductions committee of the International Association of Astacology. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:191-194.
- Huner, J. V., R. A. Bean, and J. W. Avault, Jr. 1979. New developments in crawfish culture. *The Commercial Fish Farmer & Aquaculture News.* 5(4):15-17.
- Huner, J. V. and R. P. Romaine. 1978. Size at maturity as a means of comparing populations of *Procambarus clarkii* (Girard) (Crustacea, Decapoda) from different habitats. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:53-64.
- Nolfi, J. R., and M. Miltner. 1978. Preliminary studies on a potential crayfish fishery in Vermont. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:313-322.
- Rivas, R., R. Romaine, J. W. Avault, Jr., and M. Giamalva. 1978. Agricultural forages and by-products as feed for crawfish, *Procambarus clarkii*. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:337-342.
- Romaine, R. P., J. S. Forester, and J. W. Avault, Jr. 1978. Growth and survival of stunted red swamp crawfish (*Procambarus clarkii*) in a feeding-stocking density experiment in pools. *In Papers from 4th Int'l Sym. on Freshwater Crayfish.* 4:331-336.

Memphis State University

- Tomasso, J. R., B. A. Simco, and K. B. Davis. 1979. Chloride inhibition of nitrite-induced methemoglobinemia in channel catfish (*Ictalurus punctatus*). *Journal of the Fisheries Research Board of Canada* 36: 1141-1144.
- Tomasso, J. R., B. A. Simco, and K. B. Davis. 1980. Inhibition of ammonia and nitrite toxicity to channel catfish. *Proc. Ann. Conf. S. E. Assoc. Fish & Wildl. Agencies* 33: (In press).
- Tomasso, J. R., C. A. Goudie, B. A. Simco, and K. B. Davis. 1980. Effects of environmental pH and calcium on ammonia toxicity in the channel catfish. *Transactions of the American Fisheries Society* 109: 229-234.
- Tomasso, J. R., M. I. Wright, B. A. Simco, and K. B. Davis. Inhibition of nitrite-induced toxicity in channel catfish (*Ictalurus punctatus*) by calcium chloride and sodium chloride. *Progressive Fish-Culturist* 42: (In press).

Mississippi

- Reagan, Roland E., Jr. 1980. Heritabilities and genetic correlations of desirable commercial traits in channel catfish. *MAFES Research Reports, Vol. V, No. 4.4* pp.
- Robinson, E. H., O. W. Allen, Jr., W. E. Poe, and R. P. Wilson. 1978. Utilization of dietary sulfur compounds by fingerling channel catfish: L-methionine, DL-methionine, methionine hydroxy analogue, taurine and inorganic sulfate. *J. Nutr.* 108: 1932-1936.
- Robinson, E. H., W. E. Poe, and R. P. Wilson. 1979. Phenylalanine requirement of channel catfish. *Fed. Proc.* 38:313.
- Wilson, R. P., O. W. Allen, Jr., E. H. Robinson, and W. E. Poe. 1978. Tryptophan and threonine requirements of fingerling channel catfish. *J. Nutr.* 108: 1595-1599.
- Wilson, R. P., W. E. Poe, and E. H. Robinson. 1980. Leucine, isoleucine, valine and histidine requirements of fingerling channel catfish. *J. Nutr.* 110, (In press).

Wilson, R. P., W. E. Poe, O. W. Allen, Jr., and E. H. Robinson. 1978. Tryptophan requirement of channel catfish. *Fed. Proc.* 37:3281.

South Carolina

Hinton, M. J. and A. G. Eversole. 1979. Toxicity of ten chemicals commonly used in aquaculture to the black eel stage of the American eel. *Proc. Tenth Ann. Meeting World Mariculture Soc.* 10: (In press).

Hinton, M. J. and H. A. Loyacano. 1978. Efficacy of quinaldine and MS-222 on American eel. *Proc. Ninth Ann. Meeting World Mariculture Soc.* 9: 647-652.

McCord, J. W., A. G. Eversole, AAS, C. A., J. S. Crane, R. A. Hansen, and M. J. Hinton. 1978. An annotated bibliography of *Anguilla rostrata* (Lesueur). *S. C. Wildlf. Mar. Dept. Publ.* 124 p.

Summer, S. E. and A. G. Eversole. 1978. Effects of water-borne mirex on the survival and production of *Macrobrachium rosenbergii* (deMan). *Proc. Ninth Ann. Meeting World Mariculture Soc.* 9: 47-54.

Texas

Brick, R. W., and R. R. Stickney. 1979. Polyculture of *Tilapia aurea* and *Macrobrachium rosenbergii* in Texas. *Proc. World Mariculture Society*, 10: (In press).

McGeachin, R. B., and R. R. Stickney. 1979. Culture of Chinese waterchestnuts in the southeastern United States. *Proc. S. E. Assoc. Fish and Wildlife Agencies.* 33: (In press).

Redner, B. D., and R. R. Stickney. 1979. Acclimation to ammonia by *Tilapia aurea*. *Trans. Am. Fish. Soc.* 108: 383-388.

Stickney, R. R., J. H. Hesby, R. B. McGeachin and W. A. Isbell. 1979. Growth of *Tilapia nilotica* in ponds with differing histories of organic fertilization. *Aquaculture*, 17:189-194.

U.S. Virgin Islands

Wattan, Barnaly J. 1980. A new approach to backyard tomato production. *Bull. 10th Ann. Agri. and Food Fair of the Virgin Islands*, pp. 33-39.

Tennessee Valley Authority

Behrends, L. L., J. J. Maddox, R. S. Pile, and J. C. Roetheli. 1979. Comparison of two methods of using liquid swine manure as an organic fertilizer in the production of filter-feeding fish. *Aquaculture* 19: (In press).

U.S. Fish and Wildlife Service (Fish Farming Experimental Station)

Dupree, H. K., E. J. Gauglitz, A. S. Hall and C. R. Haule. 1979. Effects of dietary lipids on the growth and acceptability (flavor) of channel catfish (*Ictalurus punctatus*). In: *Proceeding world symposium on finfish nutrition and fish feeding technology*, Hamburg 20-23 June, 1978. Volume II. Berlin. pp. 87-103.

Giudice, J. J. 1979. *Fish Farming Line*. *Commercial Fish Farmer and Aquaculture News.* 5(5): 33.

Greenland, D. C., R. R. Carter, R. R. Gill and D. L. Tackett. 1979. Harvesting monosex grass carp. *Prog. Fish.-Cult.* 41(1):50.

Greenland, D. C. and R. R. Gill. 1979. Multiple daily feedings with automatic feeders improve growth and feed conversion rates of channel catfish. *Prog. Fish.-Cult.* 41(3):151-153.

Hoffman, G. L. 1978. Recent parasitic problems in North American cultured fishes. *Proc. Fourth International Congress of Parasitology, Warsaw, Poland.* p. 185-186.

- Hoffman, G. L. 1979. Helminthic parasites. Chapter (pp. 40-58) in J. A. Plumb (ed), Principal Diseases of Farm-Raised Catfish, Auburn University, (Ala.) Agr. Exp. Sta. Auburn, Alabama, 92 pp.
- Hoffman, G. L., S. K. Kazubski, A. J. Mitchell, C. E. Smith. 1979. *Chilodonella hexasticha* (Kiernik, 1909). (Protozoa, Ciliata) from North American warmwater fish. J. Fish Diseases 2:153-157.
- Hoffman, G. L. and A. J. Mitchell. 1979. Diagnostic services available (annual list of fish disease diagnosticians). The Commercial Fish Farmer 5(3): 37-39.
- Martin, J. M. 1979. Aquaculture failures can be avoided. Commercial Fish Farmer and Aquaculture News. 5(1): 55-56.
- Martin, J. M. 1979. A new review of live hauling. Commercial Fish Farmer and Aquaculture News. 5(2): 38.
- Martin, J. M. 1979. Innovations for the fish farmer. Commercial Fish Farmer and Aquaculture News. 5(3):15.
- Martin, J. M. 1979. Fish and row crops rotation. Commercial Fish Farmer and Aquaculture News 5(5):24-25.
- Newton, S. H., J. M. Martin, J. N. Ferguson and D. L. Gray. 1979. Grass carp aid removal of weeds in irrigation canals and reservoirs. Arkansas Farm Research. 15(4):12.
- Raikova, E. V., V. Ch. Suppes and G. L. Hoffman. 1979. The parasitic coelenterate. *Polypodium hydriforme* Ussov, from the eggs of the American acipenseriform *Polydon spathula*. Parasitol. 65(5): (In press).
- Thomas, A. E., R. R. Carter and D. C. Greenland. 1979. Survival of one-and two-year-old monosex grass carp in small ponds. Prog. Fish.-Cult. 41(1):38.
- Tackett, D. L. and R. R. Carter. 1979. Discharge of solids from fish ponds, Prog. Fish.-Cult. 40(4):165-166.

Information contained herein is available to all persons without regard to race, color, sex, or national origin.