Annual Report for FY 1971

THE INTERNATIONAL CENTER for AQUACULTURE

Agricultural Experiment Station
AUBURN UNIVERSITY
E.V. Smith, Director Auburn, Alabama

COVER PHOTO: Small Pond Research Area
Agricultural Experiment Station
Auburn University

This Report designed and produced by
DEPARTMENT OF PUBLICATIONS
AGRICULTURAL EXPERIMENT STATION
AUBURN UNIVERSITY
First Printing 1M, December 1971

Annual Report for FY 1971
Project: AID/csd 2780

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INTRODUCTION

The International Center for Aquaculture was established June 25, 1970, at the Auburn University Agricultural Experiment Station, under authority contained in Section 211 (d) of the Foreign Assistance Act of 1961. The grant (AID/csd 2780) was for the purpose of implementing the project "To Strengthen Specialized Competency in Aquaculture," under the agreement signed June 25, 1970 by Dr. John H. Hannah for USAID and President Harry M. Philpott for Auburn University.

The following objectives were considered of primary importance in strengthening the competence of the Center.

1. To add experts in selected fields to the faculty.
2. To develop a library of world-wide literature on aquaculture and more effective methods for dissemination of this information.
3. To provide educational opportunities in aquaculture for personnel of AID and other governmental agencies and private foundations, for students interested in international development, and for foreign participant training.
4. To develop a worldwide collection of data on food fishes and other aquatic organisms that appear suitable for culture.

ACCOMPLISHMENTS DURING THE FIRST YEAR

Technical Staff

The staff, percentage of time paid under AID/csd 2780 funds, together with their fields of specialization were as follows:

H. S. Swingle, Director, 57 per cent. Specialties: Aquacultures, Pond Construction, and Fish Population Dynamics.

E. W. Shell, Professor, 31 per cent. Specialties: Fish Populations, Fish Physiology, and Nutrition.

D. D. Moss, Assoc. Professor, 100 per cent July to Nov. 1, 1970. Subsequently shifted full-time to project AID/csd 2270. Specialties: Aquacultures, Pond Construction, and Planning Experimental Stations.

R. T. Lovell, Assoc. Professor, 100 per cent July to Feb. 4, 1971. Subsequently 30 per cent with remainder of time on Hatch project. Specialties: Fish Feeds and Fish Technology.

R. O. Smitherman, Assoc. Professor, 100 per cent. Specialties: Fish Breeding and Aquacultures.

C. E. Boyd, Assoc. Professor, 100 per cent beginning April 1, 1971. Specialties: Aquatic Ecology and Aquatic Plants.

Four graduate research assistants were supported. Their names and areas of research were:

Paul L. Smith: Aquaculture; Tilapias and catfishes.

Len L. Lovshin: Aquaculture; Role of water hyacinths in removing wastes from water.

Dan F. Leary: Fish Nutrition; Dietary fiber requirements in feeds for catfish.

Juim-Kuo Liang: Fish Nutrition; Use of water hyacinths in pelleted fish feeds.

Other staff members contributing to the expertise of the Center, but supported by other funds include:

J. S. Dendy, Professor. Limnology.

J. M. Lawrence, Professor. Aquatic Plant Control, Nutrient Relationships, and Water Quality.

E. E. Prather, Assoc. Professor. Aquacultures.

W. A. Rogers, Assoc. Professor. Aquaculture Parasites.

Ray Allison, Assoc. Professor. Fish Parasites.

John S. Ramsey, Assoc. Professor. Taxonomy and Ecology of Species.

H. R. Schmittou, Assist. Professor. Aquacultures.

N. B. Jeffrey, Assist. Professor. Aquacultures (Overseas).

W. B. Davies, Assist. Professor. Fish Population Dynamics (Overseas).

J. A. Plumb, Research Associate. Fish Diseases.

Library of World-Wide Literature on Aquacultures

In connection with surveys conducted during the past year at the request of AID Missions, a special effort was made in each country to secure all publications dealing with culture of fishes, shrimps, and other aquatic animals. These were obtained from Brazil, Costa Rica, Colombia, Ecuador, El Salvador, Panama, Peru, Philippines, and Thailand. The publications and reports are presently housed in the International Center for Aquaculture library for use by staff involved in the International program and by graduate students interested in working in these or other foreign countries. Copies are also available in the University Library.

A program was initiated during the year to increase the University Library's holdings in aquaculture and supporting subject matter areas. Emphasis was placed on obtaining books and periodicals about aquaculture and fisheries in other countries. Altogether, 42 new books were purchased during the year. Nineteen of these books concerned foreign countries. Subscriptions were purchased for three new periodicals.

A list of periodicals relevant to aquaculture and fisheries has been obtained from FAO. Those titles not already being received by the library will be purchased.

Abstracting Service of Publications Dealing with Aquacultures and Inland Fisheries

Publications coming to Auburn from all parts of the world are searched for articles related to aquacultures and to inland fisheries. Copies are made of the abstracts and occasionally of entire articles where they deal with important advances in these fields.

Copies of these abstracts and papers are being sent to fisheries departments in countries having cooperative AID fisheries projects, to AID Mission Agricultural Officers, and to other developing countries when AID-sponsored surveys have been made. Copies of these abstracts and papers are kept at the Auburn Center filed under species and/or subject for rapid reference. Copies of special articles on aquacultures are also made available to fisheries officials in cooperating countries upon their request.

A total of 242 official publications and scientific reprints dealing with aquacultures has been collected and filed under the country of origin to make assessment of the status of fishery development in each country more rapidly available. It is hoped a computerized program for information retrieval can be set up within the next year.

Survey of Aquacultural Developments in Japan, Taiwan, and Hawaii

To make recent advances in aquacultures more available to developing nations, Dr. H. R. Schmittou of our staff visited Japan, Taiwan, and Hawaii, all of which have highly-developed aquacultures. He made a survey of both inland and coastal aquacultures and will prepare a report on these cultural methods. A list of the areas that were visited follows:

Japan (May 16-26, 1971): Freshwater Fisheries Laboratory of Hina; Kanagawa Prefecture Fisheries Experimental Station; Fujinaga Shrimp Farm; Yamaguchi Prefecture Culture Center; Nansei Regional Fisheries Laboratory; Nichiro Gyogyo Oyster Plant; Pearl Research Laboratory; Marine Station, Kinki University; Shizuika Prefecture Fisheries Experimental Station; Privately owned eel and ayu farms and processing plants; Far Seas Fisheries Research Laboratory, Toka University.

Taiwan (June 2-11, 1971): Taoyuan Fish Propagation Administration Farm; Chupei Fish Culture Station; Tsengwen Tidal Land Milkfish Farm; Markets for Milkfish fry; Privately owned fish farms; Wushan Tou Fish Hatchery; Tungkang Marine Laboratory.

Hawaii (May 11-14, 1971): Oceanic Institute, Makapuu Oceanic Center.

Survey of International Fisheries Training and Assistance Available in Israel

Conferences were held with personnel of the Israeli Department of Fisheries at Tel Aviv, Hebrew University at Jerusalem, and the freshwater fisheries stations at Dor and Nir David, on the types of international fisheries training and assistance to developing countries that might be made available by Israel. A report[1] has been submitted to AID/Washington.

Israel has a program of training consisting of a 3- to 6-month period with participants working with fish culturists on various commercial fish farms, followed by 1 month at Dor working with the research staff, and 1 month at Nir David working on fish parasite and disease problems. This program is limited to 2 to 5 trainees per period because of a lack of dormitory and research facilities at Dor and Nir David. Cost of the training is approximately $500 per month plus travel expenses.

Israel has developed very productive and efficient techniques for pond culture of common carp, *Tilapia aurea*, and mullet. There are limited numbers of experienced fish farm managers and fishery research personnel who are familiar with these cultures and are available for work abroad under various international or national contracts.

Participation of Staff in International Surveys, Seminars, and International Publications

Five staff members took part in fisheries surveys in Ecuador, Peru, Panama, El Salvador, Haiti, and Thailand.

One staff member was the invited speaker at a seminar on utilization of indigenous vs. exotic fishes held in Bogota, Colombia.

Two staff members participated in writing sections for an "FAO Manual for Fishcultural Research", and one of these served as editor for the publication.

[1]Swingle H. S. and Ray Allison. Report on trip to Israel for discussion of international cooperation with AID in fisheries research and training. Feb. 1971, 13 pages.

RESEARCH REPORTS

A summary of the research conducted during the first year by the staff of the International Center and by graduate research assistants under this project follows.

Fish Breeding and Genetics

Blue, channel, and white catfish brood stock were maintained. Channel and white catfish fingerlings were reared for future experiments on breeding and commercial production.

Strains of channel catfish from different river systems in Georgia, Florida, Texas, and Alabama were obtained for studies on genetics and selective breeding. Young channel catfish of the same age were produced from stocks of Cahaba River, Marion Hatchery, cross of Cahaba x Marion, and Auburn University. When subjected to stress of fluctuating pH, high pH, and high water temperatures in rearing units, survival was consistently higher in the Cahaba x Marion cross.

A study of dress-out percentage from a deep-bodied, stubby type from the Auburn strain of channel catfish indicated that production of flesh was slightly greater in normally-shaped fish. Stubby fish had the same number of vertebrae as longer, normal fish but vertebrae were more compressed anterior to posterior.

F_2 hybrids of the crosses female redear x male bluegill and female bluegill x male redear reproduced successfully, producing 145 and 111 lb./A., respectively, of F_3 offspring in fertilized ponds. Production was similar to that of F_1 hybrids. Sex ratios of F_2 crosses indicated 46 and 70 per cent males, respectively, compared to 85 per cent males in the F_1 of female redear x male bluegill cross.

Brood channel catfish, such as this male, are being collected and tested for inherited variability. Brood fish from several states have been collected for this work.

Both reciprocal hybrids of Alabama redeye bass x Chattahoochee redeye bass were produced naturally in ponds. Young of both crosses grew at similar rates in a pond with insects and other aquatic animals as food.

The purpose of the fish selection and breeding program is to produce superior strains for culture and to develop methods for breeding and routine testing of the progeny which can be used here and abroad.

Methods for Increasing Fish Production

One technique tested to increase production was to reduce pond water wastes that resulted from growth and feeding of fish by use of aeration and by use of biological methods of waste disposal. Other techniques investigated were cage culture and pen culture as methods of intensive culture that may be useful in large bodies of water where intensive management of the entire area is impractical.

Aeration

Aeration by use of blowers made possible doubling the production of channel catfish, from 2,500 pounds to 5,000 pounds per acre. Maintenance of dissolved oxygen above 3 p.p.m. in bottom waters of ponds gave improved feed conversion and more rapid growth than in ponds where oxygen dropped to 1 p.p.m. near the pond bottom.

Biological Methods for Waste Disposal

What are wastes for one fish are often feed for another fish or aquatic animal. Both fish and aquatic plants were tested as methods for reduction of wastes in water where fish were being cultured. The goldfish and redhorse sucker were found to be without value for this purpose when added to ponds where catfish were being raised by feeding. However, *Tilapia aurea* was quite efficient in reducing wastes because it fed on feces, decaying organic matter, and plankton that resulted from wastes. Production with the combination of channel catfish and tilapia yielded approximately 5,000 pounds channel catfish and 2,000 pounds tilapia per acre, which is higher production than was obtained by channel catfish alone in aerated pond waters. During the current year, experiments combining biological waste reduction plus aeration using the above combination of fishes, are in progress.

Several species of freshwater mussels have been obtained for tests of their efficiency in removing wastes from pond waters.

Inclusion of *Tilapia aurea* (below) in intensive cultures of channel catfish (above) permitted higher feeding rates and increased production of pounds of fish per acre.

Part of the wastes are mineralized and these nutrients, together with the carbon dioxide resulting from decay, cause heavy growths of plankton in pond waters—a process called "eutrophication." Experiments at this Station have demonstrated that water hyacinths are very efficient in removing nutrients from eutrophic waters. Testing their efficiency in cultures of catfish where feeding, water purification, and recirculation are used is currently in progress. These plants appear suitable for reducing eutrophication when they are removed after they have absorbed large amounts of nutrients.

Cage Culture

Research on culture of fishes in cages is being continued. Past research demonstrated that 300 to 400 pounds of channel catfish or tilapia can be produced per cubic meter of cage. The wastes are dissipated by the pond, reservoir, or stream in which the cage is suspended. For this culture, it is necessary to develop nutritionally complete feeds and methods for control of parasites and disease. This research is currently in progress.

Tilapia culture in ponds is plagued by too frequent reproduction and too many small fish. Tilapia were found to grow rapidly, but not to reproduce, when confined in cages suspended in the top waters of ponds. Also, it was demonstrated that in ponds with heavy plankton growth, over 90 pounds of tilapia per cubic meter of cage could be produced in 10 weeks without feeding.

	Average pounds fish produced per cubic meter of cage	
Ponds	*With additional feed*	*Without additional feed*
Heavy plankton	114.7	94.0
Light plankton	86.7	25.6

Cage culture is a popular fish production method in the Orient. Several different types of cages have been tested at Auburn, and research has been conducted on some of the problems encountered in this production method.

The feed added was a high grade floating trout chow. The ponds with heavy plankton were those in which catfish were being raised by feeding sinking pelleted feed. The pond with light plankton received phosphate fertilization only. This type of cage culture appears suitable for use in developing countries wherever there is heavy plankton growth.

Pen Culture

The culture of fish in pens along the margin of lakes or impoundments has been used to an extremely limited extent and practically no research has been conducted to determine its possibilities. Research on this problem was set up in 1970-71 at several stations in Thailand and at the International Center. The pens at the International Center were made using a fencing of nylon netting and boards. In Asia, the fencing is expected to be made of bamboo as this is a common practice.

At Auburn, 30 pens are set in the marginal waters and extend out into water 1.5 meters deep. These pens are constructed singly and in sets of 3 and 5 contiguous pens

Research on pen culture was started at the International Center in 1970-71. In this picture scientists are harvesting fish from several of the pens to determine production.

to determine the effect of adjoining pens on production. One third of the pens are without feeding to evaluate the production possible from fertility of the pond waters and bottom muds. Two-thirds of the pens receive daily supplemental feeding with sinking pellets. Fish used in the tests are channel catfish plus *Tilapia aurea* or the common carp. Results will be determined in November, 1971.

The companion projects in Thailand are set up with pens constructed in irrigation reservoirs, using *Tilapia nilotica*, a plankton feeder, and a fish feeding on aquatic plants, either *Tilapia rendali (melanopleura)* or the grass carp. Aquatic weeds harvested from shallow areas of the reservoir will be fed to fish in the pens. The resulting fecal wastes and plankton will furnish feed for both species. This is to evaluate the usefulness of aquatic weeds as feeds and green manures where other fish feeds are not available.

This type of culture may be widely useful in developing countries where water has been impounded in reservoirs for irrigation.

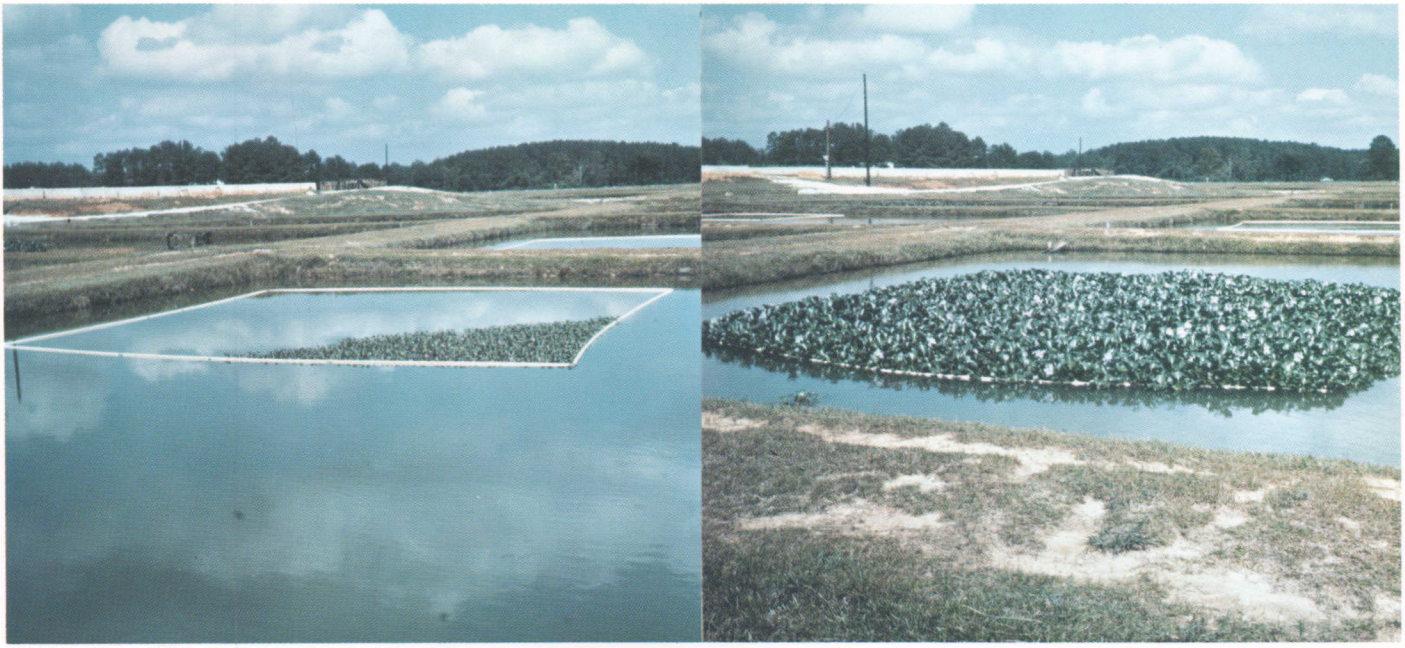
Fish Feeds and Feeding

Part of this research is cooperative with Thailand and Brazil. The Auburn staff devises feed formulations from products available in the cooperating countries and the rations are tested by personnel on location. This cooperative work will be extended in the coming year to the Philippines, Panama, and El Salvador as fisheries projects are finalized there.

Use of Water Hyacinths in Mixed Feeds for Fish

In East Pakistan and many other countries, water hyacinths are very abundant and interfere with water management. The fisheries specialist of the AID Mission at Dacca had suggested that the East Pakistan fisheries division use the protein from these plants in fish feeds. However, this research was considered too complicated and of doubtful value for a developing country to undertake, so the Auburn survey team brought the problem back for study at the Auburn center. Research has been conducted for the past 3 years on methods of protein extraction, its feed value, and the value of dried water hyacinth meal in fish feeds. During the past year, this work was continued under funds from the International Center.

Hyacinths in ponds have yielded up to 17 tons dry weight of plants per acre within 1 year. The crude protein content was 15.9 per cent on a dry weight basis. The amino acid content of the protein was also determined. Extraction of protein by the Village Press method, developed in England, was inefficient. The protein efficiency ratio for water hyacinth protein in fish feeds was only 7 per cent that of casein, which was used as a standard protein. Palatability of the dry plant meal fed as a major component of catfish feeds was low. However, the dried meal was a source of vitamins and when it was added to a vitamin-free diet, higher weight gains and higher survival of channel catfish were obtained. Addition of over 10 per cent hyacinth meal reduced palatability of the mixed feed to catfish.



The effects of water hyacinths on fish production and their use to remove excess nutrients from eutrophic waters were tested. The left picture shows hyacinth growth in water low in nutrients and the right shows hyacinth growth in water high in nutrients.

Vitamin Mixes and Minerals in Pelleted Feeds

The Auburn No. 2 fish feed is a simple mixture of peanut meal, soybean meal, fish meal, and distillers solubles which has been used extensively for the past 12 years in commercial fish production. It is a supplemental feed designed for use only in pond culture of fish, where natural feeds are also available. Tests were conducted to determine if additional vitamins were needed. It was found that addition of a standard vitamin premix to Auburn No. 2 yielded higher production, reduced the pounds of feed required per pound of gain from 1.7 to 1.2, and decreased costs by 1.5 cents per pound of catfish produced.

The value of phosphorus and calcium at approximately 1.3 per cent in the diet was indicated by feeding semi-purified diets. Phosphorus sources in the diet were more critical than calcium, since calcium is also apparently absorbed by fish from water.

Concentrated Fish Feeds

Use of concentrated fish feeds should theoretically result in less water pollution. Consequently, tests were run to determine the feasibility of eliminating most of the fiber in fish feeds.

Feed and nutrient conversions became poorer as fiber was increased from 2 per cent to 20 per cent in purified diets for channel catfish, indicating these fish can utilize a concentrated, low-fiber diet.

Striped Bass Culture

The striped bass *(Morone saxatilis)* is a large predatory fish native to the Atlantic and Gulf coasts of the United States. It has been introduced to the Pacific coast and to a few large reservoirs in several inland states. This species is important primarily because it is capable of converting relatively small, low quality forage fish into large, high quality fish and may also be grown on pelleted feeds.

Research at Auburn has been primarily concerned with factors affecting the survival and growth of early life history stages of the species. In experiments conducted in the spring of 1971, striped bass fry held in hatching jars survived and grew much better in water containing 1 part per thousand (1,000 p.p.m.) salt than in untreated water from a stream or in stream water to which had been added 150 p.p.m. calcium sulfate. There was no difference in the survival and growth of fry held in the untreated water and water treated with calcium sulfate.

Fry being grown in ponds where total hardness was 20 p.p.m. did not survive better or grow better when calcium sulfate was added to the pond water. In fact, it appeared that the addition of the chemical to the water at a concentration of 150 p.p.m. resulted in decreased survival.

In experiments to determine the effect of stocking density on the net production of 5- to 10-in. striped bass fingerlings in ponds, densities of 6,000, 10,000, and 30,000 per acre resulted in net productions of 169, 396, and 763 pounds of fish per acre, respectively, where they were fed pelleted feeds.

Use of Grass Carp for Aquatic Weed Control

Grass carp, stocked for aquatic weed control at 112 per acre in a bass-bluegill-redear pond that received feeding, removed algae and other aquatic weeds, and only 5 per cent of their stomach contents was fish feed. Stomach analysis also indicated minimal competition with bass, bluegill, or redear sunfishes for insects and other natural foods.

Grass carp stocked at 20 to 40 per acre effectively controlled *Chara*, midget sedge, and *Pithophora* in a first-year bass-bluegill pond, and had no apparent detrimental effect on the other fish species despite adding some 84 pounds per acre to the standing crop of fishes.

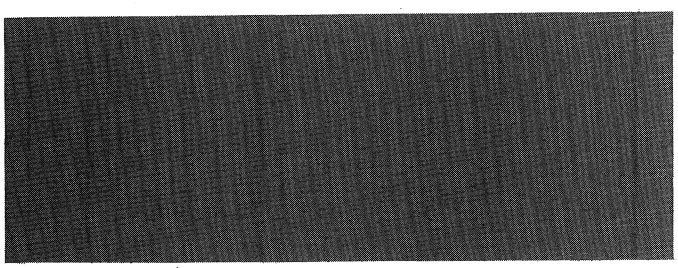
Grass carp at rates up to 160 per acre did not detrimentally affect growth and survival of channel catfish and striped bass nor did they eliminate within a 6-month period dense stands of water hyacinth from ponds. They did feed on the hyacinth roots, reducing growth of these plants. There was an apparent increase in standing crops of catfish and striped bass with the addition of grass carp, possibly a secondary effect from partial control of the hyacinth.

Experiments are also being conducted in northeast Thailand with varying numbers of grass carp per rai for control of mixed aquatic weeds in irrigation reservoirs. Their effect on abundance of aquatic weeds and their contribution to the fish catch is to be measured in 2 additional reservoirs.

Fish Technology

Off-flavors occasionally encountered in channel catfish have been attributed to actinomycetes (mycelial bacteria) and to algae residing in pond water. Chemical materials produced by actinomycetes and algae apparently are absorbed by fish independent of the diet. Approximately 15 days in flowing water was required to rid fish of the off-flavor. An expanded project supported by State Experiment Station and regional funds has been initiated to study causes and prevention of undesirable flavors in fish.

Fish sausages made from common carp and grass carp had moderate consumer appeal. A pressure cooked product (fish salad) made from grass carp was very well received.



PUBLICATIONS

A list of the publications from the Department of Fisheries and Allied Aquacultures and the International Center for Aquaculture follows, with asterisks beside those written by the Staff supported in part by Center funds. Since the Center has been in existence for only 1 year, there is no published information from research on this project.

ALLISON, RAY and W. A. ROGERS. 1970. Monogenetic Trematodes of Some Alabama Freshwater Fishes with Descriptions of Four New Species and Redescriptions of Two Species. Proc. Helm. Soc. Wash. 37(1): 17-23.

*BOYD, CLAUDE E. 1970. Seasonal Changes in the Proximate Composition of Some Common Aquatic Weeds. Hyacinth Control J. 8:42-44. (With Robert D. Blackburn).

———. 1970. Influence of Organic Matter on Some Characteristics of Aquatic Soils. Hydrobiologia. 36(1):17-21.

*CHIEN, SHIH MING. 1970. Four New Species of Monogenetic Trematodes, Genus *Pellucidhaptor* From Fishes of the Southeastern U.S. J. Parasit. 56(3):480-485. (With W. A. Rogers).

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FIJAN, N.K. 1969. Drug Sensitivity of *Chondrococcus columnaris*. Veterinarski Arhiv. Zagreb Knjiga XXXIX/1969, Svezak 9-10, pp 259-267. Urednistvo Primilo Rukopis 19 V. (With P. Voorhees).

———. 1970. An Acute Viral Disease of Channel Catfish. Tech. Paper FWS. 43.

GREENE, GEORGE N. 1970. Effects of Water Hardness on Fish Production in Plastic Pools. Proc. Southeastern Assoc. of Game and Fish Comm. 23(1969):455-461.

JEFFREY, NORRIS B. 1970. Some Aspects of the Ecology of Fish Ponds. Fish Farming Conference, Texas A & M University. p. 40-42.

JOHNSON, S.K. 1970. Sodium Hypochlorite: Use on Parasitic Copepoda for Identification. Trans. Amer. Microsc. Soc. 88(4): 591-592.

*LOVELL, R.T. 1970. Incidence and Growth of Some Health-Related Bacteria in Commercial Freshwater Crayfish (Genus *Procambarus*). J. Food Sci. 34:268-271. (With J. A. Barkate).

———. 1970. Nutrition in Catfish Culture. The American Fish Farmer 2(1):18.

PARDUE, G.B. 1970. Temperature Tolerance of *Clarias batrachus*. FAO Fishculture Bulletin 2(3):6.

PLUMB, J.A. 1971. Channel Catfish Virus Research at Auburn University. Auburn Univ. (Ala.) Agr. Exp. Sta. Prog. Rept. 95.

PRATHER, E.E. 1970. Fishing Success for Channel Catfish and White Catfish in Ponds With Daily Feeding. Proc. Southeastern Assoc. of Game and Fish Comm. 23(1969):480-490.

ROGERS, W.A. 1970. Summary of Fish Disease Cases Received Over a Five-Year Period at Southeastern Fish Disease Laboratory. Proc. Southeastern Assoc. of Game and Fish Comm. 23(1969):353-358.

SCHMITTOU, H.R. 1970. Cage Culture of Channel Catfish. Fish Farming Conf. p. 72-75.

_____. 1970. The Culture of Channel Catfish *(Ictalurus punctatus* Rafinesque) in Cages Suspended in Ponds. Proc. Southeastern Assoc. of Game and Fish Comm. 23 (1969): 226-244.

*SWINGLE, H.S. 1970. History of Warmwater Pond Culture in the United States. A Century of Fisheries in North America. Am. Fish Soc. Special Publ. 7:95-105.

The following publications were in press at the time this report was prepared.

DENDY, J.S., G.B. PARDUE, and LARRY AGGUS. Disposable Planchets for Weighing Macrobenthos. Progressive Fish Culturist.

DENDY, J.S. Phenology of Midges in Experimental Ponds. Internat'l Symposium on Chironomidae.

HILL, THOMAS K., G.B. PARDUE, and B.W. SMITH. An Evaluation of Several Marking Methods for Channel Catfish *(Ictalurus punctatus* Rafinesque). Southern Division Am. Fish. Soc.

*KILGEN, R.H. and R.O. SMITHERMAN. Food Habits of the White Amur *(Ctenopharyngodon idella)* Stocked in Ponds Alone and in Combination With Other Species. Progressive Fish-Culturist.

LAWRENCE, JOHN M. Fertility and Aquatic Biomass in Southeastern Impoundments. National Symposium on Hydrobiology.

*LIANG, J.K. and R.T. LOVELL. Nutritional Value of Water Hyacinth in Channel Catfish Feeds. Hyacinth Control Journal.

_____. Biological Evaluation of Aquatic Plants as Potential Ingredients in Supplement Feeds for Channel Catfish. Southern Division Amer. Fish. Soc.

*LOVELL, R.T. The Emergence of Cultured Catfish as a Consumer Food Item. Proc. Assoc. of South. Agr. Workers Ann. Convention. p. 110.

_____. Some Chemical and Sensory Aspects of Freshwater Catfish (Genus *Ictalurus).* Proc. Assoc. of South. Agr. Workers Ann. Convention. p. 110.

_____. Chemical Composition of Channel Catfish *(Ictalurus punctatus* Rafinesque) as a Food Fish. Presented at the 100th Annual Meeting of American Fisheries Society. New York City, September, 1970.

_____. Post-Mortem Degradation of Nucleotides in Gulf Shrimp *(Penaeus aztecus).* Proc. of Third Internat'l Congress of Food Science and Technology. p. 105.

MATHUR, DILIP. Food Habits and Feeding Chronology of Channel Catfish *(Ictalurus punctatus* Rafinesque) in Conowingo Reservoir. Proc. Southeastern Assoc. Game and Fish Comm. 24.

_____ and T. W. ROBBINS. Food Habits and Feeding Chronology of Young White Crappie *(Pomoxis annularis* Rafinesque) in Conowingo Reservoir. Trans. Amer. Fish. Soc.

_____. Seasonal Food Habits of Adult White Crappie *(Pomoxis annularis* Rafinesque) in Conowingo Reservoir. Amer. Midl. Nat.

PLUMB, J. A. A Virus-Caused Epizootic of Rainbow Trout *(Salmo gairdneri)* in Minnesota. Trans. American Fisheries Society.

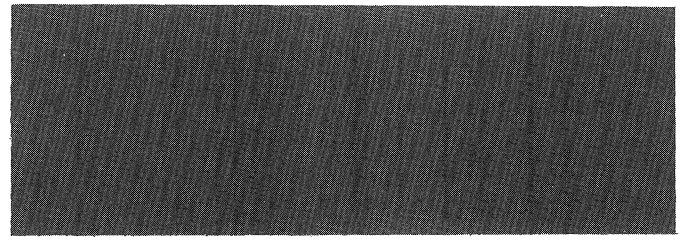
ROGERS, W. A. *Epistylis* (Ciliata:Pertricher) Epizootics of Fish in the Southeastern U. S. Proc. Southeastern Assoc. Game and Fish Comm.

SMITHERMAN, R. O. and T. E. CORLEY. Catfish Culture and the Agricultural Engineer. Agricultural Engineering. 1971.

SMITHERMAN, R. O. Research on Exotic Fish Species. Proceedings of the Primer Seminario Sobre Piscicultura En Colombia. Universidad de Caldas, Manizales, Colombia.

_____. Role of Research in the Development of the Catfish Industry. Proceedings of the Conference on Producing and Marketing Catfish in the Tennessee Valley.

*SWINGLE, H. S. Techniques for the Development of Systems of Aquaculture. FAO Handbook for Aquaculture Research. 77 pages.



TRAINING CONDUCTED AND DEGREES AWARDED

Seminars

Seminars were set up at Auburn for training participants under AID and FAO fellowships and for students specializing in Aquacultures. Following is a list of guest speakers.

January 15, 1971. Mr. Jack Snow, Director, Marion National Fish Hatchery, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Marion, Alabama. "Culture of Largemouth Bass".

February 12, 1971. Mr. Sam Chapman, Biologist, Soil Conservation Service, Athens, Georgia. "Raceway Culture with Channel Catfish".

February 19, 1971. Dr. James W. Avault, Jr., Associate Professor, School of Forestry and Wildlife Management, Louisiana State University, Baton Rouge, Louisiana. "L.S.U.'s Aquacultural Research Program".

March 5, 1971. Mr. I. B. Byrd, Chief, Division of Federal Aid, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, St. Petersburg, Florida. "Federal Programs Relating to Aquacultures".

April 6, 1971. Dr. Alan P. Jones, Marine Biologist, Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Suffolk, England. "Raceway and Cage Culture of Flatfishes".

May 18, 1971. Dr. David S. Mitchell, Director, Nuffield Lake Kariba Research Station, Division of Biological Sciences, University of Rhodesia, Salisbury, Rhodesia, Africa. "*Salvinia* on Lake Kariba—the Explosive Growth of an Aquatic Weed on a Man-Made Lake in Tropical Africa".

Students in Academic Fisheries Courses

Undergraduate Students

A total of 32 undergraduate students specializing in courses in Fisheries and Allied Aquacultures were working for the B.S. degree; none were foreign students.

A total of 10 B.S. degrees were awarded during the year.

Graduate Students

During the year there were 21 students enrolled and working for the M.S. degree in Fisheries and Allied Aquacultures of which 4 were foreign students with AID fellowships. Three M.S. degrees were awarded.

There were 14 graduate students working for the Ph.D. degree, specializing in Fisheries and Aquacultures. Of these, two were foreign students from Taiwan. Four Ph.D. degrees were awarded.

Special Training for Biologists from Cooperating Countries

Staff of the International Center for Aquaculture participated in the training at Auburn of biologists from the following countries:

Costa Rica. Mr. Bob Brown and Sr. Eddie Gomez of the Turrialba Fish Culture Project, Costa Rica, visited Auburn on June 29 and 30, 1971, for the purpose of discussing with appropriate staff members problems being encountered in their aquacultural project in Costa Rica. A tour of the field and laboratory facilities was arranged with discussions of various research projects underway at the Fisheries Research Unit.

Ecuador. An on-campus orientation program was carried out at the request of AID/Ecuador for Sr. Fausto-Silva Montenegro, Director of the Department of Fishculture, Ministry of Industry and Commerce, Quito, Ecuador, October 13-19, 1970. The primary purpose was to acquaint Sr. Fausto with the various research programs on inland waters at the International Center for Aquaculture and on estuarine waters at the Alabama Seafoods Research Station at Dauphin Island. Conferences were arranged with each staff member at the Center and the Station and a tour was made of pond and laboratory facilities. Conferences also were held for the purpose of reviewing recommendations for a possible cooperative aquacultural program in Ecuador, based on the fishculture survey carried out by staff of the International Center for Aquaculture in 1969.

Philippines. Professor Jose Carreon, Director of the Institute for Fisheries Development and Research, who will be Assistant Project Leader at the brackishwater station, and Mr. Melchior Lijauco, Project Leader for the proposed brackishwater station, at Leganes, (Iloilo), to be constructed under an AID project, were sent by AID/Philippines to the International Center for Aquaculture at Auburn University from September 18 to October 14, 1970. The major purpose of their visit was to observe field and laboratory facilities at the Center and to become as familiar as possible with research equipment, the general operation methods of our warmwater research station, and that of the estuarine Seafood Research Station of the Alabama Department of Conservation. A brief outline of the training program for these visitors is in the Appendix to this report.

NEW PROJECTS AND FUNDS FOR RESEARCH

Cooperative Project with Israel

A cooperative project with Dr. Moshe Shilo of Hebrew University was prepared and submitted to the National Science Foundation for support. The project titles were:

1. Ecological Factors Associated with the Development of Dense Blooms and Die-offs of Blue-green Algae. Dr. C. E. Boyd, Leader, International Center for Aquaculture, Auburn University Agr. Exp. Station.
2. Biological Agents and Physiological Conditions which Affect the Dynamics of Blue-green Algal Populations in Nature, Dr. Moshi Shilo, Leader, Hebrew University, Israel.

The level of support requested was $46,965 per year at the International Center and $40,000 at Hebrew University.

The problem of blue-green algal blooms and die-offs is a most important worldwide problem in aquacultures, and is the cause of a high percentage of the mortality occurring in fish and other cultured organisms.

Catfish Breeding, Production, and Marketing Project

Dr. Smitherman of the International Center worked with a committee from the Agricultural Experiment Stations in 12 states, U. S. Department of Agriculture, U. S. Department of Interior, U. S. Department of Commerce, and TVA in developing a regional research program on Catfish Culture, which has been approved for implementation by the Cooperative State Research Service, USDA. Regional Research Funds will be made available for this research in the Agricultural Experiment Stations of 12 states, which emphasizes that aquaculture is now recognized as an important phase of agriculture in the U.S.

An approved sub-project currently in operation under Dr. Lovell is entitled:

"Processing and Marketing Technology of Commercially Cultured Catfish", with financial support at $33,000 per year under funds to the Agricultural Experiment Station for regional and rural development research.

Additional projects dealing with breeding and cultural methods are in preparation for support from this source.

APPENDIX

Special Training Program Provided for Philippine Biologists at Request of AID/Philippines

Itinerary

Trainees: Mr. Jose A. Carreon and Mr. Melchor M. Lijauco of the University of the Philippines, Institute for Fisheries Research and Development.

September 18, 1970	Departed Manila, Philippines
September 19	Arrived Auburn at 5:20 PM
September 20	Preliminary discussions with Dr. Moss
September 21	Spent morning with Dr. Moss discussing layout of freshwater and brackishwater stations. Briefly visited ponds at the Fisheries Research Unit during mid-morning. Early afternoon—conference with Dr. Swingle on systematic record-keeping for research information. Late afternoon—discussion with Dr. Moss concerning library materials needed for Leganes library
September 22	Early morning—went over the reference files of the Department of Fisheries and Allied Aquacultures. Spent rest of the morning with Dr. Lovell in discussion on fish nutrition. Spent afternoon with Dr. Pardue discussing selective breeding techniques as applied to aquacultures.
September 23	Early morning—worked on library materials. Rest of day with Dr. Ramsey on the Alabama Cooperative Fishery Unit fish collection and survey trip to Halawakee Creek.
September 24	Morning—At Fisheries Research Unit with Messrs. Black and Ellington (pond construction). Early afternoon—conference with Dr. Moss on library materials. Late afternoon—discussion with Mr. Plumb on viral diseases of fish.
September 25	Spent entire day at the Fisheries Research Unit with Messrs. Black and Ellington. Took notes and specifications on equipment used in fisheries research; also notes and specifications on construction equipment.
September 29	Morning—Conferences with Mr. Black on pond construction at Fisheries Research Unit. Afternoon—Conference with Dr. Smitherman in the office on methods of maintaining records and files of research.
September 30	Spent the entire day working on the list of equipment needed for the proposed brackishwater station at Iloilo.
October 1	Conference with Dr. Dendy on natural fishfoods and Chironomids; From 10:00 AM until 11:00 AM—Sat in on Dr. Lovell's fish technology class. First part of afternoon—Conference with Dr. Rogers on fish parasites and diseases. Late afternoon—worked on list of equipment.
October 2	Morning—worked on list of equipment. First hour of afternoon—Seminar presentation by Mr. Barkuloo on Tektite II project. Late afternoon—Fisheries Research Unit observing pond construction.
October 5	Spent entire day with Dr. Moss at his residence working on list of equipment needed for brackishwater station.
October 6	Morning—Observed pond draining operations at Fisheries Research Unit. Afternoon—Participated in fish sorting and recording of data at end of the experiments.
October 7	Morning—Conference and visit to ponds at Fisheries Research Unit with Mr. Prather on cage culture and spawning of channel catfish. Afternoon—Conference with Dr. Lawrence on water chemistry and weed control.
October 8	Morning—Observed pond draining operations. Afternoon—Worked on list of equipment for brackishwater station.
October 9	Morning—Conference with Dr. Moss on water system of brackishwater station. Afternoon—Mr. Carreon gave seminar program on U. P. College of Fisheries and the inland fisheries program of the Philippines. Conference with Dr. Moss for rest of afternoon.
October 11-12	Departed Sunday afternoon with Dr. Moss and traveled to Dauphin Island, Alabama. Spent morning of October 12 observing facilities and research of the Seafood Laboratory, Seafoods Division, Alabama Department of Conservation, and conferring with Messrs. Hugh A. and Wayne E. Swingle, researchers at the laboratory. Afternoon—returned to Auburn.
October 13	Early morning—Worked on list of equipment needed for brackishwater station. Late morning—Conference with Dr. Allison on fish diseases and parasites. Afternoon—Final conference with Dr. Moss and Dr. Swingle concerning details of the brackishwater station layout, list of equipment, etc.
October 14	Departed Auburn, Alabama.