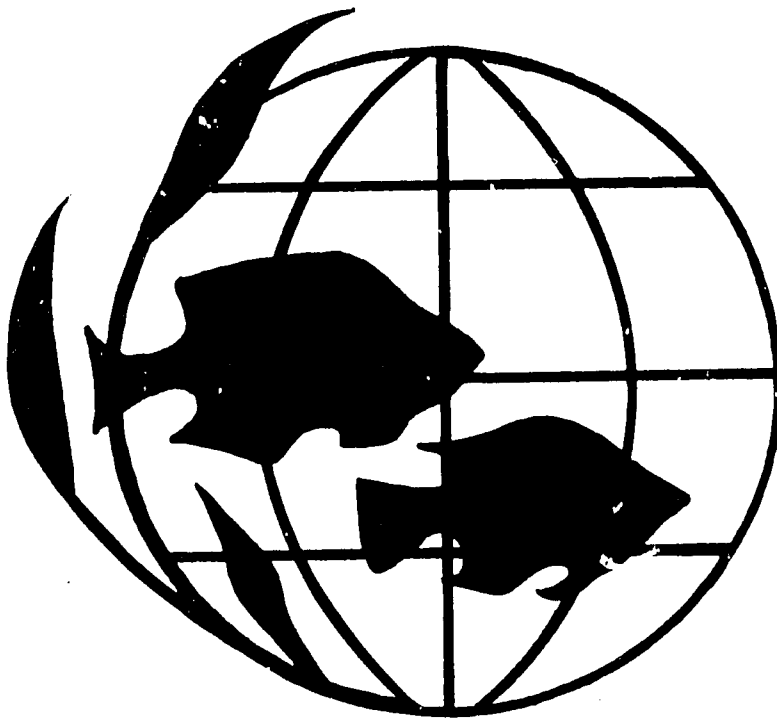


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TITLE XII
COLLABORATIVE RESEARCH SUPPORT PROGRAM
POND DYNAMICS / AQUACULTURE

FOURTH ANNUAL ADMINISTRATIVE REPORT



Pond Dynamics/Aquaculture CRSP
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FOURTH ANNUAL ADMINISTRATIVE REPORT

December 1986

This administrative report addresses the management and technical accomplishments of the Pond Dynamics/Aquaculture Collaborative Research Support Program during the reporting period from 1 September 1985 through 31 August 1986. Program activities are funded in part by AID Grant No.: DAN-4023-G-SS-2074-00.

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INTRODUCTION

The Pond Dynamics/Aquaculture Collaborative Research Support Program (CRSP) is a coordinated international effort to develop aquacultural technology as a means of confronting food and nutritional problems. The program is supported in part by a U.S. Agency for International Development (AID) grant awarded in 1982, under authority of the International Development and Food Assistance Act of 1975 (P.L. 94-161). Oregon State University is the Management Entity for the CRSP and has technical, administrative and fiscal responsibility for the performance of grant provisions.

The CRSP is a cohesive program of collaborative research carried out in selected developing countries and the U.S. by teams of U.S. and host country scientists. The U.S. institutions participating in the program are Auburn University, The University of California at Davis, and the Consortium for International Fisheries and Aquaculture Development (CIFAD). CIFAD members include the University of Arkansas at Pine Bluff, the University of Hawaii, the University of Michigan, Michigan State University, and Oregon State University. Active CRSP projects involve the participation of government agencies and educational institutions in six host countries: Honduras, Indonesia, Panama, the Philippines, Rwanda, and Thailand.

The CRSP activities were formally initiated on September 1, 1982. The purpose of this report is to summarize technical accomplishments, program organization and management during the period from September 1, 1985 through August 31, 1986, the fourth year of the CRSP.

In accordance with the provisions of the Collaborative Research Support Grant for this CRSP, the remainder of this report is presented in three chapters. Chapter 2 summarizes the administrative and technical accomplishments of the fourth operational year of the program. This chapter includes an overview of organization and management, and project summaries for the various research activities. In Chapter 3, the work locations and fields of specialization of CRSP participants are presented. The final chapter is a financial summary of CRSP budgets and expenditures, and identifies the financial contributions of U.S. and host country institutions.

PROGRAM ACCOMPLISHMENTS

The CRSP Global Experiment and the attendant analysis of data were the dominant theme during this reporting period. Notable progress also was made in the Host Country and U.S. Special Topics Research Projects, and in the area of institution building. Another area of major emphasis was the planning necessary to realize the CRSP's goals and objectives with the limited funding available. This activity will continue into the next year of the CRSP.

CRSP RESEARCH PROGRAM

The CRSP Research Program has three components: the global CRSP experiment; special topics research projects in host countries; and a U.S. research component composed of projects accomplished at the participating U.S. universities. These research activities, their purposes and their present status are described in this section.

The Global CRSP Experiment

The long-range goal of the CRSP is to increase the availability of animal protein in less developed countries through pond aquaculture. The strategy adopted by the CRSP in pursuit of this goal is to undertake the basic research required to improve the efficiency of pond culture systems. A technical plan consistent with this strategy was developed under a planning study funded by USAID (Specific Support Grant AID/DSAN-G-0264). The approach taken to the development of the CRSP technical plan was to accomplish a review and synthesis of the State-of-the-Art of pond aquaculture and to undertake overseas site visits to determine research needs in less developed countries. The findings from these surveys were then translated into planning guidelines.

In the course of the planning activities it became apparent that there are two important aspects of improving the efficiency of pond culture systems. First, there is a need to improve the technological reliability of pond production systems. Second, there is a need for economic optimization consistent with local cultures.

The need for improved production technologies is manifest in the extensive variation observed in the performance of pond aquaculture systems. Pond aquaculture has been practiced as a highly developed art form for a very long time and the literature is replete with reports about practices that have produced high yields. However, when the same practices are applied to other ponds the results are not reproducible. It is clear that there are subtle differences regulating productivity from pond to pond but the nature of this regulation remains obscure.

The need for rigorous economic analyses of pond aquaculture systems is typically encountered in attempting to formulate appropriate fisheries and aquaculture development strategies, both in developing countries and in the U.S., where it would be desirable to determine if contemporary pond management practices are the most efficient approach to fish production.

In order to answer this question, it is necessary to develop quantitative production functions to facilitate economic analyses of the various strategies or combinations thereof. It is not presently possible to develop these functions without making numerous and often tenuous assumptions because the dynamic mechanisms regulating the productivity of the ponds are poorly understood and the existing data base is consequently inadequate.

The common denominator in improving production technologies on the one hand and facilitating economic analyses on the other, is clearly related to understanding pond dynamics.

Experimental Design. During the planning of the CRSP it became apparent that the inadequacy of the existing pond aquaculture data base was a major constraint to improving the efficiency of pond culture systems. The abundant, technical literature about pond aquaculture can provide general guidelines for the operation of pond culture systems. However, because there is a lack of standardization in experimental design, data collection, and analysis, these reports can not be statistically compared to one another and consequently are of limited utility in predicting the performance of pond culture systems. The approach taken by the CRSP to develop quantitative expressions that can be used to improve production technology and facilitate economic analyses has been to develop a standardized data base that can be used to quantitatively evaluate pond performance over a broad range of environments.

The statistical design for the experiment involves monitoring several environmental and fish production variables at seven geographical locations. The different locations provide a spectrum of pond environments. Observations specified in annual work plans are made on 12 or more ponds at each location.

Observations at each location may be analyzed by the research team involved at that location. Additionally, data are filed in a centralized CRSP data base. Standard statistical methods can then be used to test statistical hypotheses about correlations between variables and evaluate the sources of variance within ponds, between ponds within locations, and between locations. Because of the relatively large number of locations and ponds at each location, the experimental design has substantial statistical power.

CRSP Work Plans. The CRSP technical plans are developed by the CRSP Technical Advisory Committee. Each work plan represents a detailed experimental protocol for one experimental cycle. A cycle involves two series of observations of four to five months duration. One set of observations is made during the dry season and the other during the wet season.

Three work plans have been developed to date. These work plans follow an orderly progression of investigating pond dynamics. The rationale has been to initially manage all ponds in exactly the same way and establish a detailed baseline of pond variables under this treatment. Then in

subsequent experiments, the pond environments have been manipulated in different ways and the responses observed.

The first work plan was developed at a meeting of CRSP participants in Davis, California on March 2-3, 1983. This plan specified standardized methods for pond preparation and monitoring. All ponds were prepared in the same way, fish were stocked at the same levels and specified variables observed during both the wet and dry seasons.

The plan for the second experimental cycle was developed at a meeting of CRSP participants in Atlanta, Georgia on April 10-12, 1984. At this meeting, participants reviewed accomplishments and discussed problems encountered during the first cycle of experiments. They then developed a detailed plan for the second experimental cycle. In this experiment, the responses of ponds receiving organic fertilizers were compared to that of ponds receiving inorganic fertilizers.

The third cycle of pond dynamics experiments was developed by the CRSP participants at their meeting in Honolulu, Hawaii on March 18-20, 1985. Based upon their experiences to date, they developed an experimental plan to compare the responses of ponds to varying levels of organic fertilizer addition.

Data Management. Consistent with its long-term goal, the CRSP proposes to develop practical pond management models to improve the efficiency of pond culture systems. The development of quantitative models will be dependent upon efficient management of standardized data resulting from the several projects.

Standardized data are tabulated at each research location for each experimental cycle in accordance with CRSP work plans. Each project team may accomplish independent analyses of their data and publish results if they so desire. However, in all cases, the data tabulations are filed in a centralized CRSP Data Base maintained by the Management Entity. In this way, the entire data set is available to all CRSP participants, but especially to the CRSP Data Synthesis Team. The latter body is appointed by the CRSP Board of Directors to accomplish data analysis, synthesis, and model development. The various activities of Team members are supported as part of the U.S. Research Component described below.

Status of CRSP Research

The CRSP presently supports projects in six countries. The six country projects, the Host Country and U.S. institutions, and the Principal Investigators and on-site Research Associates are listed in Table 4. Note that the Panama project is composed of two sub-projects; a brackish water project and a freshwater project.

Field Work. The present status of the six country projects is summarized in Table 1. Inspection of Table 1 reveals that each project is progressing towards completion of the existing work plans, and that several projects are progressing at different rates. This asynchrony resulted because of delays encountered in implementing the fresh water activities in Panama, in Rwanda, and in Thailand. Under the present CRSP operational plan, the projects should be essentially synchronized by the end of calendar year 1986.

The delay in implementing the fresh water project in Panama resulted because it was necessary to move the work from the originally intended Divisa Station to a new facility at Gualaca. This move was necessary because the ponds at the Divisa Station that were intended for CRSP use had to be diverted to fingerling production in order for the National Directorate of Aquaculture to satisfy the increasing demand for fingerlings by Panamanian farmers. The Gualaca Station offers a number of advantages to the CRSP and the move is mutually beneficial to the CRSP and the Host Country.

The Global Experiment is nearing completion at both the Panama stations (Aguadulce and Gualaca). The second experimental cycle at Gualaca, however, will be postponed indefinitely.

Initiation of the CRSP experiment in Rwanda had been delayed because of difficulties encountered in completing the new Fish Culture Station near the National University of Rwanda Campus in Butare. To bring the project back on schedule, the first and third experimental cycles were accomplished concurrently and the second cycle will be postponed indefinitely.

The CRSP experiment in Thailand began at the Nong Sua Fish Hatchery on schedule. However, this hatchery experienced a serious flood shortly after initiation of the work. The project was immediately moved to the Ayutthaya Fresh Water Fisheries Center in July 1984 and the first experimental cycle was repeated. The project is now back on schedule; the final experiments presently are in progress. Although unfortunate, the flooding at Nong Sua may have been fortuitous because the Ayutthaya site has proven to be an excellent research location.

In addition, the last phase (wet season) of the third cycle of the CRSP Global Experiment is nearing completion in Indonesia and in the Philippines. The expected date of completion for these projects is Winter 1986.

The third cycle, dry season experiment in Honduras is scheduled to begin in January, 1987 and will continue to July, 1987. The dry season experiment had to be postponed last year (January 1986) due to unforeseen difficulties with the water supply (i.e. pumping problems) and obtaining equipment through customs.

TABLE 1
STATUS OF THE CRSP GLOBAL EXPERIMENT

PROJECT	<u>First Experimental Cycle</u>		<u>Second Experimental Cycle</u>		<u>Third Experimental Cycle</u>	
	dry season	wet season	dry season	wet season	dry season	wet season
Honduras	completed	completed	completed	completed		in progress
Indonesia	completed	completed	completed	completed	completed	in progress
Panama - Aguadulce	completed	completed	completed	completed	completed	in progress
Panama - Gualaca	completed	completed			completed	in progress
Philippines	completed	completed	completed	completed	completed	in progress
Rwanda	completed	in progress			in progress	completed
Thailand	completed	completed	completed	completed	completed	in progress

Other Activities. A major contribution of the Honduras CRSP has been to help rejuvenate an interest in aquaculture. Meetings with various government officials and field days at the El Carao station have drawn attention to the Program and promoted an interest in aquaculture.

The CRSP has provided opportunities for university students to receive practical experience in aquaculture, as well as to conduct their thesis research (see Host Country Special Topics Research Reports).

In Indonesia, the construction of a deep well at the CRSP Research Site at the Fisheries Research Station of IPB began in August 1986. The pump, pipes and storage facility will be installed in the Fall/Winter of 1986/87. Indonesian students and professionals continued to participate in special research projects conducted at the CRSP Research Site. The potential of Michigan State University academic programs for graduate training of Indonesian fisheries professionals was evaluated and the identification of eligible graduate students was initiated.

CRSP personnel in Panama have participated with station staff (at Aguadulce and Gualaca) in the design and implementation of various experiments. The U.S. CRSP Research Associates developed a training program to assist Host Country participants in computer usage. David Hughes attended workshops, and with Dr. Richard Pretto, assisted CRSP and USAID consultants in their studies on shrimp culture and the shrimp industry in Panama. David Teichert-Coddington participated in a local meeting to discuss the use, management and maintenance of the Gualaca water supply.

CRSP personnel in the Philippines and from the University of Hawaii attended the First Asian Fisheries Forum held in May 1986 in Manila. CRSP researchers from the University of the Philippines in the Visayas and the University of Hawaii continued to study the culture techniques of the spotted scat, a project which was funded in late 1984 by a USAID PSTC grant.

The CRSP Research Team in Rwanda participated in planning activities for the Sixth Annual World Food Day (October 1986). They collaborated with the National Fish Culture Project in the preparation and presentation of displays and seminars to encourage the use of fish in the Rwandan diet.

The National University of Rwanda (UNR) received in June 1986 a grant for \$520,000 from the European Economic Community to fund expansion and maintenance of the UNR Fish Culture Research Station. Construction of ponds, a storage facility, offices, and expansion of the laboratory began in July 1986.

Dr. Kwei Lin, U.S. Research Associate in Thailand, attended the First Asian Fisheries Forum in Manila and presented papers on sulfate-acid-soil fishponds in Thailand and on the biological characteristics of Macrobrachium rosenbergii in relation to pond production and marketing.

CRSP Central Data Base. During the period of this report, the Program Management Office implemented an improved Data Base Management System. The new system provides for simplified data entry in the field using any one of several commercially available software packages. It provides numerous hardware options; the CRSP researchers are not limited to specific computers. Field data are entered on micro-computer diskettes at the work locations as specified in "The CRSP Data Base Instructions for Data Entry (ed. 1.1)," April, 1986.

The files are reviewed and, if necessary, electronically translated into a standardized format by the Program Management Office and transmitted into the central data base maintained on a mainframe computer at Oregon State University. Approved files are returned to the U.S. Project participants for verification. Verified files then are entered into the Data Base Management System for use by the Data Synthesis and Modeling Team. Specific data sets may be retrieved from the mainframe files in virtually any format desired. The data analysis can be accomplished with nearly any existing or future hardware or software.

During the past year, the data sets from completed experiments have been formatted, and are either undergoing verification, or filing in the data base is completed (Table 2). The completed files have been sent to the Data Synthesis and Modeling Team. Research results of the Data Synthesis and Modeling Team's activities are summarized under U.S. Special Topics Research Reports. (Refer to Chapter 3 for additional information on the Data Base Management System).

Special Topics

This component of the CRSP research program was developed to provide opportunities for host country and U.S. researchers to collaborate on original research directed towards the needs and priorities of the host country. The intent was to strengthen linkages within the host country institution and to contribute to the development of research capabilities within the institution by providing opportunities for scholarly involvement of faculty and advanced students. Additionally, this component provides the host country agencies and institutions with access to the personnel resources of the CRSP in seeking solutions to shorter term local problems.

Host Country Research Component

Proposals for these special topics research projects are developed collaboratively by the host country and U.S. participants. The proposals are reviewed by the CRSP Board of Directors but are not subject to outside peer review. The intent is to preserve the autonomy of the investigators. In reviewing the proposals the Board is satisfied with a statement of endorsement by the host country institution. Recently the Board has implemented the additional policy of requiring the investigators to discuss

TABLE 2
STATUS OF THE CENTRAL DATA BASE MANAGEMENT SYSTEM (1)

PROJECT	DATA FILES SUBMITTED TO THE CRSP PROGRAM MANAGEMENT OFFICE FOR INITIAL APPROVAL						DATA FILES VERIFIED BY EACH PROJECT AND RETURNED TO PMO FOR FINAL APPROVAL					
	CYCLE I		CYCLE II		CYCLE III		CYCLE I		CYCLE II		CYCLE III	
	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Indonesia	x	x		x			complete	complete		complete		
Thailand	x	x	x				complete	complete	complete			
Rwanda	x					x	complete					complete
Philippines	x	x	x				in progress	in progress	in progress			
Panama, Aguadulce												
Panama, Guaiaca												
Honduras												

(1) The Data Base Management System is maintained by the CRSP Program Management Office

the proposed project with U.S. AID Missions to assure that the projects are consistent with AID and host country development strategies and priorities.

Although the special topics research projects are an important part of the CRSP, they are not a major component in terms of funding support or time expenditures. Twenty to twenty-five percent of research associate time is typically devoted to this activity. Reports of Special Topics Research conducted in the Host Countries are presented in Appendix A.

The CRSP places highest priority on the longer term global research outlined above. However, it is noteworthy that it is politically expedient to place some emphasis on shorter term research needs. Host country agencies and institutions and U.S. AID Missions often consider basic research activities to be of low priority. Consequently, administrators sometimes have difficulty justifying participation in the CRSP. The CRSP support for the special topics research activities helps justify this participation. Thus, although the CRSP places highest priority on the longer term research goals, support for this component may be considered a cost of doing business in many countries.

U.S. Research Component

It is implicit throughout Title XII of the International Development and Food Assistance Act of 1975 that activities authorized under this Title should be mutually beneficial to developing countries and the United States. In planning this CRSP there was a consensus among the CRSP participants that improving the efficiency of pond culture systems through collaborative research involving both U.S. and developing country institutions would be "mutually beneficial." However, subsequent to awarding the CRSP grant the Agency interpreted "mutually beneficial" to mean that the CRSP should fund research activities both in the U.S. and in developing countries and instructed the CRSP to direct some proportion of its funds to support research activities at the U.S. institutions.

A U.S. research component was organized during the third year of the CRSP and several projects have now been funded. These projects address timely research problems that can not be addressed in the overseas component; consequently, the projects help to strengthen the overall effectiveness of the CRSP, even though funds have been diverted from the overseas activities to support them.

In organizing the U.S. research component the CRSP has endeavored to insure that the projects included in this activity are of high technical merit. Formal project proposals are subjected to critical peer review by outside reviewers not affiliated with institutions participating in the CRSP. The proposals and peer reviews are then submitted to the CRSP Board of Directors for consideration. In approving or rejecting proposals, the Board considers the relevance of the proposed work to CRSP goals as well as the technical merit and quality of the proposed work. Refer to Appendix B for the U.S. Special Topics Research Reports.

PROGRAM MANAGEMENT AND TECHNICAL GUIDANCE

The organization and management of the CRSP remained basically the same as previous years in this reporting period. One noteworthy exception was the reorganization of the former three member Technical Advisory Committee into an expanded Technical Committee composed of the Principal Investigators of the several research projects. Additionally, the membership of the External Evaluation Panel changed substantially.

During this period, the Management Entity continued to work with the Board of Directors, Technical Committee, External Evaluation Panel, and project participants in areas of policy, budget management, and technical performance.

Board of Directors

As the primary policy making body for the CRSP, The Board of Directors has taken an active role in program guidance. During this reporting period the Board was composed of three members:

Dr. Alfred M. Beeton
University of Michigan

Dr. Wallis H. Clark Jr.
University of California, Davis

Dr. Donovan D. Moss
Auburn University.

The Board has met periodically to provide guidance on policy, budgets, and technical performance. Board action has included:

- * Advisement of the Management Entity on matters of CRSP policy
- * Review of fiscal reports and advisement of the Management Entity regarding the apportionment of the limited funds available for program activities
- * Guidance of efforts to strengthen the CRSP within funding constraints by reducing the number of projects without technically compromising the research
- * Guidance of the centralized data management system, including appointment of a Data Synthesis Team
- * Review of the performance of the Program Director
- * Evaluation of the administrative and technical accomplishments of the several country and special topic research activities
- * Participation in the fourth annual meeting in March, 1986.

Technical Committee

The former three member CRSP Technical Advisory Committee was reorganized during this reporting period. Technical guidance is now provided by a Technical Committee composed of the Principal Investigators of the CRSP research projects and at-large members appointed by the Board of Directors. This change in CRSP organization was implemented to expand the disciplines represented on the committee, and to bring the CRSP organization into consistency with the BIFAD Guidelines issued after the CRSP was implemented.

The membership of the Technical Committee during this reporting period is presented in Table 3. The Committee is composed of four standing subcommittees: Work Plans, Budgets, Materials and Methods, and Technical Progress. The subcommittee assignments are also presented in Table 3.

During the past year, the Technical Committee has drafted a technical plan for the next phase of the CRSP global experiment. This plan is based upon specific research needs identified in earlier CRSP research activities, and includes a compendium of materials and methods required for completion of the identified objectives. The plan is ready for formalization into a biennial work plan pending decisions regarding project locations and funding.

Program Management Office

The Program Management Office (PMO) provides executive linkage between the Management Entity and operations under the CRSP. During the reporting period, the Office staff included:

Dr. James E. Lannan, Program Director (0.5 FTE)
Ms. Nancy Brown, Assistant Program Director (1.0 FTE)
Dr. Kevin Hopkins, Assistant Program Director (0.5 FTE)
Ms. Carman McBride, Secretary (0.5 FTE).

Mr. Bruce Sorte of the Oregon State University Office of Business Affairs served as Fiscal Officer in support of the PMO during this reporting period.

During the reporting period, the PMO continued to facilitate and coordinate interactions between collaborating institutions, monitor research activities, and prepare summary and fiscal reports. Specific accomplishments include:

* Preparation of CRSP budgets and subcontract modifications extending funding and performance periods

* Continued assistance in processing travel clearances for CRSP personnel and approvals for purchases of restricted goods for country projects

TABLE 3
THE CRSP TECHNICAL COMMITTEE

Name	Institution	Subcommittee (1)
Members-at-Large		
Dr. Donald Garling (Chairman, 1985-86)	Michigan State University	W
Dr. William Chang	University of Michigan	T
Dr. Raul Piedrahita	University of California	W
Dr. R.O. Smitherman	Auburn University	T (2)
Dr. George Tchobanoglous	University of California	T
Principal Investigators		
Dr. Ted Batterson	Michigan State University	M (2)
Dr. Thiraphan Bhukaswan	National Inland Fisheries Institute, Thailand	B
Dr. Jose Carreon	University of the Philippines in the Visayas	M
Dr. James Diana	University of Michigan	W (2)
Dr. Muhammed Eidman	Institute Pertanian Bogor, Indonesia	T
Dr. Jonathan Espinoza O.	Directorate of Renewable Natural Resources, Honduras	B
Dr. Arlo Fast	University of Hawaii	W
Dr. Philip Helfrich	University of Hawaii	B
Dr. C.D. McNabb	Michigan State University	B
Dr. Valens Ndoreyaho	National University of Rwanda	T
Dr. Ronald Phelps	Auburn University	M
Dr. Richard Pretto M.	National Directorate of Aquaculture, Panama	W
Mr. Wayne Seim	Oregon State University	M
Dr. Richard Tubb	Oregon State University	B (2)

(1) W=Work Plans; B= Budgets; T= Technical Progress; M= Materials and Methods

(2) Denotes subcommittee Rapporteur

* Continuation of a technical information service for overseas research staff

* Held a fourth annual CRSP research meeting to plan continuation of CRSP research activities under reduced funding

* Completion of the first CRSP Triennial Review and received approval for continuation to 1990

* Compilation of the standardized data sets from the three Work Plans completed at the seven overseas locations

* Participation in the BIFAD meeting on CRSPs on June 23-24, 1986

* Completion and implementation of an improved data base management system for analysis and synthesis of data resulting from the CRSP global experiment

* Coordination of activities for the newly appointed CRSP Data Synthesis Team

* Assistance to S&T/AGR through participation in its Committee for International Fisheries Research and Assistance Institutions (CIFRAI) and by participation in a congressional briefing on CRSPs.

In support of this list of accomplishments, additional detail is provided on reports and documents issued by the CRSP and on the CRSP Data Base Management System.

CRSP Reports and Documents

A number of reports and documents were prepared and disseminated during the period of this report. These are briefly described below. Reports of CRSP research that were not processed by the Program Management Office are listed in Appendix C.

Triennial Review. Pond Dynamics/Aquaculture CRSP, Program Management Office, December 1986. Triennial Review. Oregon State University, Hatfield Marine Science Center, Newport, Oregon.

This report contains a three-year summary of CRSP activities, results of the External Evaluation and the Continuation Proposal.

CRSP Data Base. Pond Dynamics/Aquaculture CRSP, Program Management Office, April 1986. CRSP Data Base: Instructions for Data Entry (Edition 1.1). Office of International Agriculture, Oregon State University, Corvallis, Oregon.

This document gives instructions for entering standardized field data from the CRSP Global Experiment into the central Data Base Management System maintained by the Program Management Office. Edition 1.1 replaces version 1.0; it reflects the changes requested by CRSP participants at the 1986 CRSP Annual Meeting.

Updated CRSP Directory. Pond Dynamics/Aquaculture CRSP, Program Management Office, August 1986. CRSP Directory. Office of International Agriculture, Oregon State University, Corvallis, Oregon.

The CRSP Directory originally was published during the first operational year of the program. The updated versions account for subsequent changes in program personnel.

CRSP Newsletter. Pond Dynamics/Aquaculture CRSP, Program Management Office, Fall 1985, Winter 1986, Spring 1986, and Summer 1986. Aquanews. Office of International Agriculture, Oregon State University, Corvallis, Oregon.

During the reporting period, four issues of the quarterly CRSP newsletter, Aquanews, were published. Each issue included a brief informative article on a particular Pond Dynamics/Aquaculture CRSP Project, a message from the Director, short articles and notes on the program and its participants. The newsletters were distributed to CRSP participants, AID and BIFAD representatives, other CRSP's, and interested persons upon request.

Principles and Practices of Pond Aquaculture. J.E. Lannan, R.O. Smitherman and G. Tchobanoglous, eds. 1986. Principles and Practices of Pond Aquaculture. Oregon State University Press, Corvallis, Oregon, 272 pp.

This book had its origin as a report prepared for USAID by the Pond Dynamics/Aquaculture CRSP and distributed through AID to pond researchers and managers in developing countries. Principles and Practices of Pond Aquaculture is a state-of-the-art synthesis of the principles and practices of pond aquaculture, providing original insights into the mechanisms which regulate productivity of these systems. The purpose of publishing this document was to make the information available to the sectors of the world aquaculture community that were not eligible to receive it through AID distribution.

Third Annual Administrative Report. Pond Dynamics/Aquaculture CRSP, Program Management Office, December 1985. Third Annual Administrative Report. Oregon State University, Marine Science Center, Newport, OR.

This report summarizes the technical and management accomplishments for the third operational year of the CRSP (1 Sept. 1984 to 31 Aug. 1985). Included are a statement of program objectives, a description of research activities, a staff summary, and a financial statement.

A Data Base Management System for Research in Pond Dynamics. K.D. Hopkins, J.E. Lannan, and J.R. Bowman. Submitted December 1985 to Journal of the World Aquaculture Society.

This paper provides a description of the data base management system used in the analysis and synthesis of data from the CRSP global experiment. The data synthesis is directed toward the development of comprehensive farm-pond management models.

External Evaluation Panel

The External Evaluation Panel (EEP) is composed of impartial senior aquaculture scientists selected on a world-wide basis. During the past year, the CRSP lost two of the three members of the EEP. Dr. James Avault and Dr. Ziad Shehadeh found it necessary to resign from the Panel because of conflicting commitments on their time. During this reporting period, the CRSP conducted an international search for replacements, and recently received approval for the appointment of two distinguished scientists to fill the vacancies on the panel. The present membership is:

Dr. Homer Buck
Illinois Natural History Survey

Dr. Kenneth Chew
University of Washington

Dr. Peter Edwards
Asian Institute of Technology.

During the year, Dr. Chew attended the annual meeting, reviewed various documents and provided input on policy matters.

STAFF SUMMARY

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 50 professionals and a number of support personnel. As shown in Table 4, four major fields of specialization were represented during the reporting period: Research Administration, Limnology/Water Quality, Fisheries/Aquaculture, and Data Management.

In addition to staff with formal CRSP assignments, numerous individuals have participated in the development of host country projects. The CRSP team in the Philippines reported that over 15 professors, instructors and research assistants at the University of the Philippines in the Visayas played a major role in the accomplishment of the research program at the Iloilo site. CRSP research in Indonesia benefited from the participation of a number of undergraduate and graduate students carrying out pond dynamics experiments at the Bogor site. The Thailand, Panama, Honduras, and Rwanda CRSP projects also have added many host country research assistants and technicians to their staffs, so that over 70 host country participants presently are involved in the Collaborative Research Support Program.

TABLE 4
STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
BOARD OF DIRECTORS						
Dr. Philip Helfrich	Chairman	x		x		Kaneohe, HI
Dr. Alfred Beeton	Interim Chairman	x	x			Ann Arbor, MI
Dr. Wallis Clark, Jr.	Member	x		x		Davis, CA
Dr. Donovan D. Moss	Member	x		x		Auburn, AL
TECHNICAL COMMITTEE						
Dr. Donald Garling	Member			x		East Lansing, MI
Dr. R. Oneal Smitherman	Member			x		Auburn, AL
Dr. G. Tchobanoglous	Member			x		Davis, CA
MANAGEMENT ENTITY						
Dr. James Lannan	Director	x		x	x	Corvallis, OR
Ms. Hillary Egna	Assistant Director	x	x	x	x	Corvallis, OR
Dr. Kevin Hopkins	Assistant Program Director	x		x	x	Corvallis, OR
Mr. James Bowman	Graduate Research Assistant			x	x	Corvallis, OR
Mr. Bruce Sorte	Fiscal Officer	x				Corvallis, OR

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
HONDURAS - AUBURN UNIVERSITY PROJECT						
Dr. Ronald P. Phelps (2)	U.S. Principal Investigator			x		Auburn, AL
Lic. Jonathan Espinoza	H.C. Principal Investigator			x		Teguicigalpa, Honduras
Mr. Bartholomew Green	U.S. Research Associate		x	x		Comayagua, Honduras
Ing. Hermes Alvarenga	H.C. Research Associate		x	x		Comayagua, Honduras
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Ricardo Gomez	H.C. Lab Assistant			x		Comayagua, Honduras
Mr. Cesar Salinas	H.C. Research Assistant			x		Comayagua, Honduras
Mr. Miguel Zeianya	H.C. Lab Technician			x		Comayagua, Honduras
Mr. J. Ludovico Ayala	H.C. Lab Assistant		x	x		Comayagua, Honduras
Ms. Catalina Sherman	H.C. Student			x		Comayagua, Honduras
Mr. Jaime Berrios	H.C. Student			x		Comayagua, Honduras
INDONESIA - MICHIGAN STATE UNIVERSITY PROJECT						
Dr. Clarence McNabb	U.S. Co-Principal Investigator		x	x		East Lansing, MI
Dr. Ted Batterson	U.S. Co-Principal Investigator			x		East Lansing, MI
Dr. Muhammed Eidman	H.C. Principal Investigator			x		Institut Pertanian Bogor, Indonesia
Dr. Chris Knud-Hansen	U.S. Research Associate			x		Institut Pertanian Bogor, Indonesia
Mr. Komar Sumantadinata	H.C. Co-Research Associate			x		Institut Pertanian Bogor, Indonesia
Mr. Darnas Dana	H.C. Co-Research Associate			x		Institut Pertanian Bogor, Indonesia
Mr. Gerald Jacobs	Fiscal Officer	x				Indonesia East Lansing, MI

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
PANAMA, AGUADULCE - AUBURN UNIVERSITY PROJECT						
Dr. Ronald P Phelps (2)	U.S. Principal Investigator			x		Auburn, AL
Dr. Richard Pretto Malca (2)	H.C. Principal Investigator	x		x		Santiago de Veraguas, Panama
Dr. David Hughes	U.S. Research Associate		x	x		Aguadulce, Panama
Mr. Ameth de Leon	H.C. Research Associate			x		Aguadulce, Panama
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Ismael Wong	H.C. Station Chief			x		Aguadulce, Panama
Mr. Jorge Garcia	H.C. Station Chief			x		Aguadulce, Panama
Ms. Graciela de Gomez	H.C. Chemistry Lab Director		x			Aguadulce, Panama
Mr. Ernesto Lasso de la Vega	H.C. Field Biologist			x		Aguadulce, Panama
Ms. Cenobia Quintero	H.C. Field Biologist			x		Aguadulce, Panama
Mrs. Marquisela Arreve de Friedman	H.C. Field Biologist			x		Aguadulce, Panama
Ms. Ilenia de Zapata	H.C. Technician			x		Aguadulce, Panama
Mr. Modablo Bonilla	H.C. Technician			x		Aguadulce, Panama
Mr. Rugierre del Valle	H.C. Data Processor				x	Aguadulce, Panama
Mr. Lenin Santamaria	H.C. Field Biologist		x	x		Aguadulce, Panama
Mrs. Dora Hernandez de Santamaria	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Hipolito Chavez	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Miguel de Leon	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Amed Tunon	H.C. Field Biologist			x		Aguadulce, Panama

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
PANAMA, GUALACA - AUBURN UNIVERSITY PROJECT						
Dr. Ronald Phelps (2)	U.S. Principal Investigator			x		Auburn, AL
Dr. Richard Pretto Malca (2)	H.C. Principal Investigator	x		x		Santiago de Veraguas, Panama
Dr. David Teichert-Coddington	U.S. Research Associate			x		Gualaca, Panama
Mr. Medardo Peralta	H.C. Research Associate			x		Gualaca, Panama
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Nelly Serano	H.C. Technician		x			Gualaca, Panama
Mr. Ricardo Rios	H.C. Technician			x		Gualaca, Panama
Ms. Itozela Davis	H.C. Technician			x		Gualaca, Panama
PHILIPPINES - UNIVERSITY OF HAWAII PROJECT						
Dr. Arlo Fast	U.S. Co-Principal Investigator	x		x		Univ. of Hawaii
Dr. Philip Helfrich	U.S. Co-Principal Investigator	x		x		Univ. of Hawaii
Dr. Rogelio Juliano	H.C. Co-Principal Investigator	x		x		Univ. Philippines in the Visayas
Dr. Jose Carreon	H.C. Co-Principal Investigator	x		x		Univ. Philippines in the Visayas
Dr. Kent Carpenter	U. S. Research Associate			x		Brackish Water Aquaculture Center, Philippines
Dr. James Woessner	U.S. Research Associate			x		Brackish Water Aquaculture Center, Philippines
Dr. Romeo Fortes	H.C. Research Associate			x		Brackish Water Aquaculture Center, Philippines
Mr. William Coops	Fiscal Officer	x				Univ. of Hawaii
Dr. Yvonne Chiu	Special Project Leader			x		Univ. Philippines in the Visayas
Ms. Cecilia Minsalan	Special Project Leader			x		Univ. Philippines in the Visayas
Ms. Lea Ver	Special Project Leader			x		Univ. Philippines in the Visayas

TABLE 4. (Continued)
STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
PHILIPPINES (CONTINUED) - UNIVERSITY OF HAWAII PROJECT						
Prof. V.L. Corre	H.C. Research Coordinator			x		Brackish Water Aquaculture Center, Philippines
Mr. V. Estilo	H.C. Data Manager			x	x	Brackish Water Aquaculture Center, Philippines
Ms. E. Pudadera	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. G.T. Aaron	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. P.J. Carpio	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. Z. Feliciano	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. I.G. Pahila	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. E. Naret	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Mr. H. Gonzales	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Mr. R. Sanares	H.C. Technician				x	Brackish Water Aquaculture Center, Philippines
Mr. G. Domingo	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. R.L. Janeo	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. Mary Sastrillo	Special Project			x		Brackish Water Aquaculture Center, Philippines
RWANDA - OREGON STATE UNIVERSITY PROJECT						
Dr. Richard Tubb	U.S. Co-Principal Investigator	x		x		Corvallis, OR
Mr. Wayne Seim	U.S. Co-Principal Investigator	x	x			Corvallis, OR
Dr. Valens Ndoreyaho	H.C. Principal Investigator		x			Rwanda
Dr. Boyd Hanson	U.S. Research Associate		x	x		Corvallis, OR
Mr. Felicien Rwangano	H.C. Research Associate			x		Rwanda
Mr. Eugene Rurangwa	H.C. Research Associate			x		Rwanda
Mr. Bruce Sorte	Fiscal Officer	x				Corvallis, OR
Mr. Marijke Van Speybroeck	H.C. Participant			x		Rwanda

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
THAILAND - UNIVERSITY OF MICHIGAN PROJECT						
Dr. James Diana	U.S. Principal Investigator			x		Ann Arbor, MI
Dr. Thiraphan Bhukaswan	H.C. Principal Investigator			x		NIFI, Thailand
Dr. C. Kwei Lin	U.S. Research Associate		x	x		NIFI, Thailand
Dr. Sompong Hiranywat	H.C. Research Associate			x		NIFI, Thailand
Dr. Sompotte Ukatawewat	H.C. Research Associate			x		Ayuthaya, Thailand
Mr. Nelson Nevarre	Fiscal Officer	x				Ann Arbor, MI
Dr. Philip Schneeberger	U.S. Research Assistant			x		Ann Arbor, MI
Mr. Viniij Tansakul	H.C. Data Processor			x	x	NIFI, Thailand
Mr. Somlek Auworatham	H.C. Research Assistant			x		NIFI, Thailand
Mr. Worathep Muthuwana	H.C. Research Assistant		x			Ayuthaya, Thailand
Mr. Wirawan Chinaksorn	H.C. Research Assistant			x		Ayuthaya, Thailand
Mr. Agaluck Saloaw	H.C. Research Assistant			x		Chacheongsao, Thailand
Mr. Tongasuk Saelee	H.C. Research Assistant			x		Chacheongsao, Thailand
Mr. Supranee Chinabut	H.C. Scientific Collaborator			x		NIFI, Thailand
Mr. Chalor Limsuwan	H.C. Scientific Collaborator			x		Kasetsart Univ., Thailand

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization				Location of Work (1)
		Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	
U.S. SPECIAL TOPIC RESEARCH PROJECTS						
Dr. William Chang	Data Synthesis Team Member		x	x	x	Ann Arbor, MI
Dr. Raoul Piedrahita	Data Synthesis Team Member		x	x	x	Davis, CA
Mr. Steven Francis	Data Synthesis Assistant				x	Davis, CA
Ms. Cory Pannaionni	Data Synthesis Assistant				x	Davis, CA
Mr. Phillip Giovannini	Data Synthesis Assistant				x	Davis, CA
Dr. Lawrence Curtis	U.S. Principal Investigator		x	x		Corvallis, OR
Dr. Richard Tubb	U.S. Project Head	x		x		Corvallis, OR
Mr. L.K. Siddens	U.S. Research Assistant		x			Corvallis, OR
Mr. F.T. Diren	U.S. Technician			x		Corvallis, OR
Mr. M.D. Hurley	U.S. Technician			x		Corvallis, OR
Dr. Rex Dunham	U. S. P.I., Special Topics			x		Auburn, AL
Dr. James Diana	U.S. Principal Investigator			x		Ann Arbor, MI
Dr. Arlo Fast	U.S. Principal Investigator		x	x		Kaneohe, HI
Dr. Philip Schneeberger	U.S. Principal Investigator			x		Ann Arbor, MI

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.
 (2) Researchers involved in two projects

FINANCIAL SUMMARY

This section summarizes the expenditure of AID and non-federal funds for CRSP research activities and program management. This unaudited summary is intended to provide an overview of CRSP progress relative to program budgets.

The AID funds budgeted and expended for various program activities are presented in columns A and B of Table 5. The amounts in column A include AID obligations received prior to this reporting period and a pro-rated fraction of the current obligation. This budgeting assumption is necessary because the periods of funding obligation are not congruent with the anniversary of the CRSP.

The data on expenditures for research projects were provided by the Principal Investigators of the several projects. Because there is typically a time lag between the time that expenses are incurred and posted, it is likely that the expenditures reported for the research activities underestimate the true account status. It is probable that the accounts are in fact either fully expended or over-expended.

The information on Program Management expenses was taken from Program Management Office monthly account status reports. Through its first four years, the CRSP has expended 15 percent of its AID funds on program management, including supporting a Management Office, a Board of Directors, Technical Committees, an External Evaluation Panel, and conducting a Triennial Review. This expenditure reflects the philosophy of the CRSP to minimize overhead costs and expend the major share of limited funds on research activities. However, compliance with AID and BIFAD guidelines that have evolved since implementation of the CRSP continues to strain the CRSP budget. The minimum management costs for a CRSP are fixed and independent of total funding. We note that the management costs of some of the CRSPs nearly equal the entire budget of this CRSP.

During this reporting period, the CRSP funding was reduced by 18 percent relative to the previous obligation. In order to insure completion of work in progress, projects were level funded from the new obligation. Thus the monthly rate of expenditure for the final three months of the fourth year exceed the pro rata. The deficit will have to be absorbed during the fifth year.

Cost sharing contributions from the U.S. institutions are presented in column C of Table 5. These data reflect continuing commitments to participation in the CRSP. It appears that the amounts reported satisfy or exceed the 25 percent cost sharing requirement. However, confirmation of this requires further accounting because the amounts shown in column B to be excluded in calculating cost sharing requirements in accordance with BIFAD guidelines must be determined after the fact.

Host country contributions (in U.S. dollars) are presented in column E. The data were provided by the Principal Investigators of the projects. Although host country cost sharing is not required, these data indicate a continuing commitment to participation in the CRSP.

Table 5. Financial Summary

	AID Funds		Cost Sharing	Total Expended	Host Country
	Budgeted	Expended			
Collaborative Research Projects					
Honduras - Auburn University	349,140	338,526	79,723	418,249	270,800
Indonesia - Michigan State University	568,496	538,053	171,907	709,960	180,290
Panama - Auburn University	496,003	502,920	123,269	626,189	359,090
Philippines - University of Hawaii	539,720	523,528	140,300	663,828	90,300
Rwanda - Oregon State University	494,426	484,537	66,059	550,596	252,672
Thailand - University of Michigan	462,915	475,223	23,715	498,938	135,450
Subtotal	2,910,700	2,862,788	604,973	3,467,761	1,288,602
Special Topics					
Auburn University	6,305	4,981	4,632	9,613	
Oregon State University	24,993	20,959	8,322	29,281	
University of California, Davis	24,966	27,595	7,100	34,695	
University of Hawaii	16,688	15,687	3,922	19,608	
University of Michigan	31,271	30,020	11,102	41,122	
Subtotal	104,223	99,242	35,078	134,320	
Program Management					
Management Office	434,891	441,250		441,250	
Boards, Committees, and Panels	105,873	106,975		106,975	
Subtotal	540,764	548,225		548,225	
Total	3,555,687	3,510,255	640,051	4,150,306	1,288,602

APPENDIX A

Host Country Special Topics Research Reports

Host Country Special Topics Research Project Reports

HONDURAS

Studies regarding increased production of hybrid (Tilapia nilotica x Tilapia hornorum) fingerlings

H.R. Alvarenga, Direccion General de Recursos Naturales Renovables, Honduras and B.W. Green, Department of Fisheries and Allied Aquaculture, Auburn University, Alabama

Introduction. The value of all male populations of tilapia is widely recognized in aquaculture. Such populations can be obtained by separating the males from the females by morphological differences, altering the sex ratio by administering hormones to sexually undifferentiated fish, and by hybridization with other tilapia species when an aberrant sex ratio results. One of the common hybrid crosses that gives a high percentage of males is the cross of Tilapia nilotica females with Tilapia hornorum males.

The system of hybridization has been adopted at the El Carao Aquaculture station to produce all male populations for its fingerling distribution program. Past practices have been to stock female T. nilotica and male T. hornorum at a density of 1 fish/5-10 m² and a sex ratio of 4 females to 1 male, then to collect fry over a 90-day period via partial harvest for restocking into nursery ponds. This report presents information on two trials regarding the relationship between brood stock density and fingerling production.

Materials and Methods. Both trials were conducted in three 500-m² ponds fertilized with 144 kg/ha of chicken litter. Brood stock were fed corn gluten daily at 30% of their body weight. Partial harvests were made at 25-day intervals. Brood stock were stocked at a sex ratio of 4 females per male.

In the first trial, brood stock were stocked at 1 fish/2 m² and held 114 days. Female brood stock had a mean initial weight of 464.2 g and males 402.5 g. In the second trial, brood stock were stocked at 1 fish/4 m². The mean initial weight of females and males was 125 g and 442 g, respectively.

Results and Discussion. In the first trial, the mean number of fingerlings collected was 49,027 while in the second trial, the mean number was 2,132. The lower number in the second trial could be due to several factors: lower densities; smaller size of the female brood stock; or the difference in size between males and females.

Growth and survival of hybrid (Tilapia nilotica x Tilapia hornorum) fingerlings in nursery ponds

J.M. Berrios, National University of Honduras

Introduction. Nursery ponds are important in fish culture. They enable the producer to increase the efficiency of his grow-out ponds by stocking larger

fingerlings. This results in a higher biomass and greater survival of the initial stock.

Nursery ponds are particularly important for the production of hybrid tilapia fingerlings at the "El Carao" station. The reproduction ponds are stocked with female T. nilotica and male T. hornorum. Fry and fingerlings are harvested. The ponds are most productive when fry are collected weekly with partial harvests. When small fish are stocked into nursery ponds, they can be stocked at much higher densities and will result in larger fingerlings before carrying capacity is reached.

The value of nursery ponds is appreciated at the "El Carao" station but the proper management techniques for such ponds are still being developed. The following experiment was part of a student thesis to improve management techniques by studying the effect of stocking density on growth and survival.

Materials and Methods. Hybrid tilapia fry (T. nilotica x T. hornorum) were collected from reproduction ponds and stocked into two blocks of ponds. In the first phase of the study, one block of six 1000-m² ponds were stocked at 50,000 fry/ha. Another block of four 2000-m² ponds were stocked at densities of 60,000, 89,750, 100,000 and 141,245 fry/ha. The culture period varied from 30 to 40 days. The 1000- and the 2000-m² ponds were fertilized with chicken litter at 45.5 and 100 kg/ha/week, respectively.

In the second phase of the study, the stocking densities in the six 1000-m² ponds were 50,000, 71,660, 72,500, and 83,570 fry/ha. The four 2000-m² ponds were stocked at 65,875, 101,735, 106,445 and 114,060 fry/ha. The fertilization rates were the same as in the first phase.

In both phases, fish stocked in the 2000-m² ponds were fed a ground fish feed at a rate of 10 times their biomass, once a day, seven days a week. The quantity of feed added was adjusted every two weeks. At harvest, the sex ratio of the fingerlings was determined.

Results and Discussion. In the first phase, the mean size at harvest ranged from 9.3 to 19.5 g with survival ranging from 71.4 to 97.0% at a stocking density of 50,000 fry/ha. Daily individual growth ranged from 0.2-0.5 g/day. Biomass at harvest (day 40) ranged from 335 to 711 kg/ha. The percentage of males varied from 76 to 85%.

In the 2000-m² ponds, at initial densities of 60,000 to 141,245 fry/ha, individual daily growth rates ranged from 0.3 to 0.4 g/day. Survival ranged from 50.7 to 90.0% and did not appear to be correlated to stocking density. Average weights at harvest varied from 10.0 to 18.1 g and final biomass varied from 350 to 550 kg/ha. The percentage of males ranged from 75 to 86.4%. Feed conversions ranged from 1:1 to 4:1.

In the second phase, individual daily growth rates ranged from 0.2 to 0.4 g over a 38-day period in the 1000-m² ponds; final average weight varied from 7.7 to 9.0 g. Final biomass varied from 475 to 958 kg/ha. Survival ranged from 74.3 to 82.9%. The percentage of males varied from 88.6 to 94.8%.

In the 2000-m² ponds, after a 38-day culture period, final individual weights varied from 9.0 to 18.0 g with daily gains of 0.2 to 0.4 g/day. Survival ranged from 75.7 to 96.7% with final biomass ranging from 275 to 596.5 kg/ha. Feed conversion ranged from 1.1:1 to 1.9:1. The percentage of males ranged from 74.2 to 91.7%.

The results indicate that daily growth rates of 0.2 to 0.4 g/day can be supported at initial densities ranging from 50,000 to 83,000 fry/ha in ponds

treated with a nutrient application of chicken litter at 45 kg/ha/week. Average weights can be expected to range from 7.5 to 15 g.

When fertilizer is added at 100 kg/ha/week and supplemental feed is given daily, growth rates of 0.2 to 0.4 g/day can be supported when the initial densities range from 60 to 140,000/ha. Final mean weights for such conditions can be expected to range from 8 to 18 grams.

The sex ratios at harvest indicate that the cross of T. nilotica and T. hornorum is resulting in a significant proportion of females and that sexing of fingerlings at harvest is necessary to minimize reproduction during the grow-out phase.

Pelleted fish feed versus corn gluten as feed for Tilapia and Chinese Carp polyculture in ponds

H.R. Alvarenga¹, B.W. Green², and M.I. Rodriguez¹

¹Estacion Acuicola Experimental "El Carao," Recursos Naturales Renovables, Honduras.

²International Center for Aquaculture, Auburn University, Alabama

Introduction. Fish culture in Honduras recently has experienced rapid growth as evidenced by the 600% increase in demand for fingerlings. Appropriate production systems information presently is unavailable for Honduran fish farmers. They have had to rely on information developed in other countries in the same geographical region but, whose local climate, resource and economic conditions are different from those of Honduras.

A wide variety of animal feeds are available in Honduras including one pelleted fish feed, two pelleted shrimp feeds, and a number of agricultural by-products whose prices range from \$5.50 to \$8 per hundred weight (45.4 kg).

Corn gluten, a by-product of the corn starch process, contains 21% protein and costs approximately \$8/100 lb. The pelleted fish feed contains 23% protein and costs \$15/100 lb. The present study was designed to test the value of each feed for producing tilapia and chinese carp in organically fertilized earthen ponds.

Materials and Methods. Six earthen ponds were used in this study: three 500-m² ponds and three 2000-m² ponds. Each pond was stocked with hybrid tilapia (Tilapia nilotica x Tilapia hornorum) at the rate of 20,000 fish/ha, silver carp (Hypophthalmichthys molitrix) and grass carp (Ctenopharyngodon idella), the latter two at a rate of 1000/ha. The mean initial weight of the tilapia was 21.3 g, while that of the silver and grass carp were 23.5 g and 16.3 g, respectively.

Fish in the 500-m² ponds were fed with pelleted fish feed at 3% of the tilapia biomass 5 days per week. Fish in the 2000-m² ponds were fed 5 days per week with corn gluten at 3% of the tilapia biomass. All ponds were fertilized with 500 kg/ha of fresh cow manure five days per week. The experiment was terminated after 150 days.

Results. Mean total fish production was 4596 kg/ha when pelleted fish feed was used and 3670 kg/ha when corn gluten was used. The pelleted feed treatment resulted in mean weights at harvest of: tilapia, 221.8 g; grass carp, 267.0 g; and silver carp, 497.4 g. In the corn gluten treatment, the mean weights were: tilapia, 184.3 g; grass carp 153.1 g; and silver carp,

414.9 g. Mean survival of pellet-fed fish was: tilapia, 95.0%; grass carp, 65.3%; and silver carp, 28.7%. In the corn gluten treatment, the mean survival was: tilapia, 94.0%, grass carp, 46.2%; and silver carp, 18.2%. Feed conversions were 1.8:1 for the pelleted feed and 2.2:1 for the corn gluten.

In an economic evaluation where only the input costs of fingerlings, fertilizer, feed, and the value of the fish produced were considered (other input costs were the same for both treatments), the use of corn gluten appears attractive. The net gains in U.S. dollars were \$4,633.96 for pelleted feed and \$4,402.21 for corn gluten. However, the cost of corn gluten was less than half of that of the pelleted feed.

Production of hybrid Tilapia (Tilapia nilotica x Tilapia hornorum) fingerlings using two different brood stock densities

H.R. Alvarenga¹, B.W. Green², and M.I. Rodriguez¹

¹Estacion Acuicola Experimental "El Carao", Recursos Naturales Renovables, Honduras.

²International Center for Aquaculture, Auburn University, Alabama

Introduction. The "El Carao" station is responsible for producing the majority of the tilapia fingerlings used in fish culture in Honduras. Demand for fingerlings has been increasing steadily over the past several years. Distribution of fingerlings to producers has risen from 39,000 in 1980 to more than 600,000 in 1986. Thus far, the station has been able to keep abreast with demand but this has required intensification of the fingerling production system. Improvements in fingerling production systems have concentrated on manipulation of broodstock density in reproduction ponds and on the nursery phase. Earlier work indicated that 1 brood fish per 2 m² of pond area was very productive. In the present study, two stocking rates for brood fish were tested in an attempt to develop an efficient production system.

Materials and Methods. Six 500-m² earthen ponds were stocked with female Tilapia nilotica and male Tilapia hornorum for the production of hybrid fingerlings. Two treatments, 1 brood fish/2 m² and 1 brood fish/2.5 m², were randomly assigned to the ponds. The former treatment was terminated after 96 days while the latter was terminated after 88 days. Four females were stocked for each male. Females in each treatment had similar mean weights (376.6 g), as did males (485.7 g).

Beginning at 24 days and continuing thereafter at approximately 7-day intervals, fingerlings were harvested from the brood ponds using a 15.4-m seine with a 6.35-mm mesh. Any brood fish captured were immediately returned to the brood ponds while the fingerlings were transferred to nursery ponds.

Fingerling: from the brood ponds were stocked into 2000-m² nursery ponds at densities ranging from 75,000 fish/ha to 120,000 fish/ha. Ponds were harvested about every 25 days.

Brood ponds were fertilized with fresh cow manure at a rate of 244 kg/ha/day and the brood fish were fed 5 days per week with corn gluten at 3% of their biomass. Nursery ponds were fertilized with chicken litter (250 kg/ha/wk), and the fingerlings were fed at 10% of their biomass 5 days/wk with pelleted fish feed.

Results. After 90 days, a mean total of 88,900 fingerlings per 500-m² pond had been produced at a density of 1 brood fish per 2 m² of pond area, while a mean total of 74,700 fingerlings/500 m² pond were produced at a density of 1 brood fish per 2.5 m². The number of fingerlings obtained per weekly harvest varied from 192 to 27,200 in the 1 fish/2 m² treatment and from 328 to 36,000 in the 1 fish/2.5 m² treatment. Daily production averaged 1096 fingerlings in the low density treatment, whereas in the high density treatment, 849 fingerlings were produced per day; a mean of 520 fingerlings were produced per female in the former treatment, and 467 fingerlings per female were produced in the latter treatment. The mean individual weight of fingerlings harvested were 1.0 g and 2.0 g for the 1 fish/2 m² and 1 fish/2.5 m² treatments, respectively.

Nursery ponds were harvested on the average of every 25 days, at which time they were ready for distribution to fish farmers. Nursery pond harvest data is summarized as follows:

Stocking Rate (#/ha)	Mean Weight (g)	Mean Growth Rate (g/d)	Mean Survival (%)
75,000	10.3	0.41	80.4
80,000	11.6	0.41	87.7
85,000	18.5	0.65	69.0
100,000	13.8	0.49	73.0
110,000	10.4	0.42	67.9
120,000	10.0	0.31	93.0

Production of female Tilapia nilotica in ponds fertilized with chicken manure

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Introduction. Tilapia are one of the most widely cultured fish in the world. They are capable of reproducing naturally in ponds, which facilitates the production of fingerlings. However, this characteristic of being able to naturally reproduce in ponds can result in uncontrolled reproduction in the production ponds. Such production increases competition for available food and suppresses the growth of the initial stock. Often, this results in high biomass at harvest but few fish of marketable size.

To control the reproduction of tilapia several techniques have been developed. One technique is to separate the sexes and culture only the male tilapia. This is an effective procedure but 50% of the fingerling production, i.e. the females, are of little use and generally are discarded. Male tilapia generally grow faster than females and consequently are the preferred sex for culture. Females, in the presence of males, use much of their energy for reproduction and less for growth. In the absence of males, females will have a greater growth rate. Whether this growth rate is acceptable and justifies the saving of female tilapia fingerlings is a question that needs further study. The following study was conducted as a

part of a student thesis to provide additional information regarding the culture of female tilapia.

Materials and Methods. Six 1000-m² earthen ponds of the "El Carao" Aquaculture Station were stocked with "hand-sexed" female Tilapia nilotica at a density of 5000 fish per hectare and cultured 91 days. The average weight of the females at stocking was 32.6 g. The ponds were fertilized weekly with chicken litter at a rate of 45.3 kg/week.

Results and Discussion. The total production averaged 750.2 kg/ha for a net production of 587.2 kg/ha. Mean individual weight at harvest averaged 161.6 g. The individual growth rate was 1.42 g/day. The survival averaged 91%.

The results of this study indicate that the culture of female tilapia may be an acceptable alternative to discarding them. Additional studies need to be conducted at higher densities and for longer culture periods before more definitive conclusions can be made.

PANAMA - Freshwater Station at Gualaca

Relationships between liming, phosphorus absorption and pond soils at the Gualaca Aquaculture Research Station

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Introduction. The Gualaca Aquaculture Station is characterized by acidic, nutrient poor soils and a water supply that is low in alkalinity and nutrients. Few nutrients are available in the water column for plankton production. The lack of phosphorus in the water column often occurs in the presence of acidic soils where aluminum and iron ions bind free phosphorus. The addition of lime to such soils can raise the pH, transform aluminum into an insoluble state and make phosphorus more available to primary producers.

The relationships between phosphorus, lime and acidic pond soils have been studied in depth in the U.S. but such relationships are not well understood. In particular, the rate at which phosphorus is taken out of solution by the soils, the quantity of lime required per unit area to raise soil pH, and the relationship between lime and orthophosphate need to be better understood. These three areas were addressed in a series of studies conducted at the Gualaca Freshwater Aquaculture Research Center.

Materials and Methods. Three studies were conducted: (1) the effect of liming on the phosphorus levels in the water column; (2) the effect of limed soils on levels of soluble orthophosphates; and (3) the rate of phosphorus uptake by soils of the region having different hydrogen ion concentrations. The basic units of the study were 18.9 l (5 gal) plastic buckets with 14.2 l (15 quarts) of water with or without 3 kg of soil. Each treatment was repeated four times.

In Study One, the treatments were water only, water-and-soil only, water with lime added to the soil to meet a calculated lime requirement, and water and soil treated with lime at 3 times the lime requirement. Triple

superphosphate (TSP=42% P₂O₅) was added to all buckets as a slurry at a rate of 16 kg/ha (55 mg/bucket). Soluble orthophosphate, pH and total alkalinity were monitored regularly over a 14-day period.

In Study Two, the buckets from Study One containing water-and-soil only and water with lime added to the soil to meet the calculated lime requirement were drained. The soil was allowed to dry and then was returned to the buckets along with 14.2 l of new water. In addition, eight other buckets were filled with water only, of which four had lime added. Four days after the buckets had been set up and allowed to equilibrate, initial measurements of soluble orthophosphate, total hardness, total alkalinity and pH were taken. Then, 55 mg of ground TSP were added to each bucket as a slurry. Two weeks later, 20 g of ground limestone were added to all buckets except the four containing water only. The study continued for an additional week. During the four-week study, levels of soluble orthophosphorus (SOP), total alkalinity (TA), total hardness (TH), and pH were monitored.

Study Three was conducted using soils from seven of the station ponds, some of which had received lime. Two kg of soil from each pond were placed in two buckets (replicates); 14.2 l of water were added to each bucket. In two other buckets, only water was added. All buckets were allowed to stand for one week, after which a water sample was taken on day one. The sample was analyzed for total alkalinity, total hardness, soluble orthophosphate and pH. Then, 55 mg of TSP were added to each bucket. On days 15 and 22, 55 mg of phosphorus were added. Between and after fertilizer applications until day 26, SOP, TA, TH, and pH were monitored.

Results and Discussion. In Study One, phosphorus disappeared rapidly in all treatments with soil and most rapidly in the soil treatment where lime was not added. Maximum soluble orthophosphate (SOP) concentrations at any one time was less for the heavily "limed" treatment but the overall rate of disappearance of SOP was slowest. Total alkalinity and the pH of the water were lowest in the soil treatment where lime was not added.

In Study Two, initial orthophosphate levels were low. With the addition of TSP, concentrations of SOP increased sharply and were greatest in the water-only treatment. The addition of limestone resulted in a drop of SOP levels in all treatments. The SOP levels were consistently lower in the treatment which had soils that had previously received lime. The addition of limestone to this treatment did not affect the alkalinity of the water.

In Study Three, SOP levels in the water/soil treatments increased then decreased rapidly after fertilization. In the water only treatments, SOP levels rose after fertilization and remained high.

Regression analysis of the data from the treatments with water of differing H⁺ soil concentrations indicates that SOP levels were significantly higher when H⁺ concentrations were higher. There were no significant relationships between SOP, TA and TH.

Data from these three studies indicate that for conditions such as those at Gualaca an excess of lime would reduce soluble orthophosphate levels. This may be due to the formation of calcium phosphate by the complexing of phosphorus. However, lime is required to minimize the amount of phosphorus that is complexed to the low pH soils. Further work is needed to establish a proper rate for adding lime to acidic soils that are high in aluminum and iron.

PANAMA - Brackish Water Station at Aguadulce

Effect of experimental diets on the production, growth, survival and feed conversion efficiency of Penaeus vannamei juveniles in brackish water ponds during the 1985 rainy season.

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Introduction. The shrimp culture industry in Panama uses a feeding and water exchange system that is semi-intensive. The commercial feeds currently used are heavily dependent on imported raw materials. This results in an expensive feed, which in turn contributes to the country's balance-of-payments problems. Therefore, it would be desirable to develop a suitable shrimp feed based on locally produced ingredients. Such a diet would reduce the need to import feedstuffs and would stimulate the local production of feedstuffs. In this study, four diets composed of locally available feedstuffs were compared with a commercially available shrimp feed.

Materials and Methods. Fifteen earthen ponds were stocked with Penaeus vannamei juveniles at 4 fish/m². The daily water exchange rate was 5%. The shrimp were cultured 140 days on one of five rations. The fish were fed once a day in decreasing amounts, beginning at 25% of their body weight and ending at 2%. The three diets tested were composed of local ingredients; they were pelleted feeds containing different percentages of protein: 25%, 32.5% and 40%. In addition, a diet of fresh coconut meat and a commercial feed containing 25% protein were tested.

Water quality data following the CRSP experimental protocol was also collected for these treatments.

Results. Shrimp production was the greatest with the 40.0% protein diet composed of local materials (530 kg shrimp/ha) followed by the 25% commercial feed (525 kg shrimp/ha). The fresh coconut resulted in the poorest production (436 kg shrimp/ha). The feed conversion was best with the commercial diet (2.95:1) and poorest with the coconut (3.74:1).

Effect of mullet, Mugil curema, stocked at varying densities with Penaeus vannamei, on production and water quality in brackish water ponds.

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Introduction. An aquaculture pond contains a variety of niches. A proper combination of animals often can improve both the stability of the system and the efficiency of nutrient recycling.

Mullet such as Mugil curema are common inhabitants of estuaries. They are benthic grazers that also feed on phytoplankton. They are used in polyculture systems in various parts of the world. In Panama, they offer one

of the best hopes for a fish species that can be used in polyculture with shrimp.

Materials and Methods. In the rainy seasons of 1985 and 1986, mullet were stocked at varying densities in combination with Penaeus vannamei. In 1985, brackish water, 600-m² ponds receiving a 5% water exchange per day were stocked with juvenile P. vannamei at 4 shrimp/m². The shrimp were fed a 25% protein commercial ration daily at a decreasing percentage of their body weight (from 25-2%) and cultured 150 days. M. curema were stocked 18 days later at one of four densities. The four densities were 1,2,4, and 6 fish per 10 m². Each density was replicated three times. The initial weights of mullet ranged from a mean of 10.7 to 35.0 g. In another three ponds, P. vannamei were cultured without mullet (in monoculture).

Results. Shrimp production was slightly less in the polyculture treatments. Mean production ranged from 476 to 521 kg shrimp/ha and there was no clear effect of mullet density on shrimp production. The monoculture of shrimp resulted in a mean production of 525.3 kg shrimp/ha. In monoculture, shrimp feed conversion was 2.58:1. Shrimp feed conversion improved with increasing density of mullet. At a density of 1 mullet/10 m², feed conversion was 2.62:1; at 2 mullet/10 m², feed conversion was 2.53:1; at 4 mullet/10 m², it was 2.27:1; and at 6 mullet/10 m², feed conversion was 2.18:1. Mean sizes of shrimp produced were similar irrespective of the density of mullet.

Mullet production increased as density increased, with the greatest being 423.58 kg fish/ha at the 6 fish/10 m² density. Mean weight gains per individual ranged from 25.3 to 34.0 g for the 122-day period. The differences in weight gain were more a reflection of survival rates than of initial stocking rates. Survival rates ranged from 21.3 to 99% and were not influenced by treatment.

The results of this study indicate that Mugil curema stocked at densities of 6 fish/10 m² or less do not significantly reduce shrimp production. The mullet may contribute to improved feed conversion. This study is currently being repeated in larger ponds to determine whether these results will hold true.

The relative value of three commercial rations developed for nursery culture of Penaeus vannamei post-larvae

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Introduction. The use of nursery ponds is becoming more important in shrimp culture. Nursery ponds enable hatchery-produced larvae or small wild-caught larvae to be stocked at high densities. The larvae then are cultured to a large size before stocking into the grow-out ponds.

Although the value of nursery ponds is becoming more widely recognized, techniques for their management are not clearly established. In Panama, there are three commercial diets; two contain 25% protein and the other contains 40% protein. In the following study, these diets were compared in the production of Penaeus vannamei larvae at two densities with and without supplemental substrate.

Materials and Methods. Hatchery produced post-larvae (PL stages V-VII) of Penaeus vannamei were stocked the beginning of the 1986 rainy season at either 100 or 200 PL/m² and cultured 30 days. Each stocking density received one of three commercial rations of 25%, 25% or 40% protein. One of the 25% diets used at both densities was tested in the presence or absence of a plastic mesh substrate. Each treatment without substrate had four replicates and those with substrate had two replicates.

Results. In all treatments, growth rates decreased significantly after 21 days. The average weight of larvae were similar at harvest for all diets (0.43-0.53 g). However, the high protein diets generally produced larger larvae. The lowest final shrimp biomass, 303.7 kg/ha and 305.6 kg/ha, occurred at the lower stocking density (100 PL/m²) for the rations containing 25% and 40% protein, respectively. Survival was lower (53%) at the higher stocking density. The survival rates (64-74%) at the lower density were similar for all three diets. Feed conversion rates at the lower density were better for the 25% protein diets (1.14:1 and 1.19:1) than for the 40% protein diet (1.5:1). Feed conversion at the higher density was greater (1.59:1) than at the lower density with one of the 25% protein diets (1.14:1).

The presence of substrate increased the final average weight and biomass for both the high and low densities. Survival was not affected by the presence of substrate. Feed conversion at low density improved in the presence of substrate (0.87:1 versus 1.14:1) but there was no difference at the high density.

The least expensive feed was one of the 25% protein diets, at \$0.18 per 1000 juvenile shrimp produced. The most expensive feed, at \$0.62 per 1000 juveniles produced, was the 40% protein diet.

PHILIPPINES

Effects of water exchange rates on nutrient levels and productivity of brackish water fishponds

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Introduction. Brackish water pond management practices strongly advocate the regular removal and addition of pond water as a recommended water management procedure every spring tide. However, research has never shown the effectiveness of these practices in a brackish water environment. The effect and influence of these practices on nutrient levels and primary productivity in ponds have never been evaluated. Although it has been demonstrated in freshwater catfish ponds that water exchange rates do not have a significant effect on fish production (McGee and Boyd 1983), the opposite is suspected to happen in tidal-fed brackish water fishponds because water exchange occurs abruptly and involves massive volume turnovers.

Objectives. This study aims to evaluate existing water exchange practices by monitoring levels of important pond nutrients and related biological

parameters and how they influence water quality and fish production in brackish water fishponds. Alternative water management strategies will be developed based on the results of this investigation.

Materials and Methods. Nine 500-m² ponds were stocked with 3,000 milkfish (Chanos chanos) fingerlings per hectare. Three water exchange rates of 1/3 volume, 2/3 volume and no exchange are maintained in three replicates. Orthophosphates, nitrates and total ammonia of pond water are measured before draining and after refilling the ponds with tidal water every 14 days. Diurnal oxygen production and pond respiration rates are monitored between exchanges as measures of biological productivity, in addition to the fish samples taken every month. Other physicochemical parameters such as salinity, pH, temperature, turbidity and dissolved oxygen are measured at regular intervals over a 90-day culture period.

Results. The experiment currently is in progress and the results have not yet been analyzed. Problems have been encountered with dike leaks and scientific equipment. Another month of culture is required to collect the necessary data.

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Factors affecting the feeding rhythm of Milkfish (Chanos chanos)

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Introduction. Milkfish raised in brackish water ponds have been observed to be daytime feeders. Their feeding is characterized by a single, intense peak shortly after noon, which appears to coincide with the diel pattern for dissolved oxygen (DO), temperature and sunlight intensity in ponds (Lin 1969; Chiu and Benitez 1981). In order to develop a feeding program for milkfish, it is important to understand their feeding habits and the factors affecting feeding.

Objectives. Three experiments were conducted to investigate the effect of dissolved oxygen, artificial feed and light on the feeding rhythm of milkfish.

Materials and Methods. The fish were reared in circular canvas tanks supplied with water flowing through at different rates from an adjacent pond. The fish were either fed or not fed with artificial feed. Some of the tanks were covered. The flow rates affected DO patterns. Fish were sampled at regular intervals for 24 hours and their feeding index (FI = weight of intestine with contents/weight of fish x 100) was determined. Water parameters were monitored immediately before each sampling period.

Results. The three experiments consistently demonstrated a number of points regarding the feeding habit of milkfish: (1) regardless of the experimental parameters, the whole digestive tract of milkfish is completely devoid of

food between 2200 and 0200 h; (2) in the presence of both natural and artificial food, natural food is preferred between 0600 and 1800 h; (3) below a limiting DO level, which is about 1.5 ppm, milkfish stop feeding; and (4) the apparent biological rhythm for the feeding activity of milkfish is not completely correlated with temperature and DO levels. Moreover, feeding activity can start before dawn and continue after dusk if DO is adequate and artificial feed is provided.

Anticipated Benefits. If the same phenomenon observed during this study occurs in milkfish culture, the removal of highly supersaturated oxygen, which occurs at the peak of the day, may effect a significant increase in production. Removal may be done by using equipment like paddlewheel aerators, which can at the same time be used to maintain DO above limiting levels before dawn. It would be of tremendous interest to fish farmers to determine the economic inputs involved in feeding and in certain water management practices.

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Incidence of disease in certain strains of tilapia cultured in brackish water

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Introduction. Tilapia have been cultured at the Brackishwater Aquaculture Center (BAC) for several years with varying success. Recent culture of a strain of Oreochromis niloticus (Tilapia nilotica) in brackish water has resulted in very high mortality caused by an unknown pathogen. The disease is characterized by large lesions on the body of the fish. These lesions have been observed regularly in only one strain of Oreochromis niloticus. It is not known whether the disease is specific to the saltwater culture of the particular strain of tilapia or whether the disease is restricted to the particular ponds in which the affected strain is reared. This experiment was set up to test the pond location versus strain specificity of the disease. In addition, we studied the effects of antibiotics (added to the feeds) on inhibiting the disease.

Methodology. Feeding management and strain were combined for the following treatments;

1. Feeding with antibiotic and Oreochromis niloticus
2. Feeding with antibiotic and Oreochromis mossambicus (T. mossambica)
3. Feeding with antibiotic and red tilapia (T. nilotica X T. mossambica)
4. Feeding without antibiotic and Oreochromis niloticus

The experiemntal design used a 2 x 3 factorial in a randomized block. Three 500-m² ponds served as blocks. Six hapas were installed in each pond with one representative for every treatment. The hapas are small cages of dimensions 1 m x 1 m x 1.5 m. Hapas containing fish that received feed without antibiotic were grouped together and placed upwind from those without antibiotic to reduce the effect of the antibiotic in case leaching occurs.

Oreochromis niloticus and Oreochromis mossambicus were stocked at 30 fish per hapa while red tilapia were stocked at 10 fish per hapa because they were in short supply. Fish were fed 8% of their body weight daily. The antibiotic, Terramycin (trademark of oxytetracycline) was administered at 5 gm per 100 kg of fish.

Water parameters such as salinity, dissolved oxygen, and temperature were monitored twice a week. The fish were sampled weekly to determine feeding rates and to note the occurrence of lesions.

Results. The study is still in progress. However, preliminary observations show the occurrence of one lesion in each of the treated (with antibiotic) and untreated (without antibiotic) Oreochromis niloticus on day 12.

Studies on the use of teaseed cake for the selective elimination of finfish in shrimp ponds

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Introduction. Predators and competitors adversely affect the growth and survival of shrimp in ponds. Therefore, it is necessary to apply a toxicant, preferably one that is biodegradable, which will kill finfish but not shrimp. An example of such a toxicant is teaseed cake, the residue of Camellia sp. seeds after oil extraction. It contains saponin, a water soluble glucoside, that destroys red blood cells. Finfish are more sensitive than shrimp to saponin; hence, it is potentially an effective method of eliminating finfish in shrimp ponds.

Objectives. The studies were conducted to: determine the minimum concentration of teaseed cake that would cause the selective elimination of finfish within three to six hours; evaluate differences in the response of Tilapia mossambica and Glossogobius giurus to teaseed cake; to assess the effect of temperature and dissolved oxygen on the potency of teaseed cake; and to determine whether substantial degradation of teaseed cake can occur within twenty-four hours.

Materials and Methods. A series of experiments were conducted in 20-liter, round plastic tanks using three replicate tanks for each treatment. Two of each of the following species were placed in each tank: Tilapia mossambica, Glossogobius giurus, metapenaeus ensis, and Penaeus monodon. In Experiment 1, the test species were exposed to five different concentrations (2.5, 5, 10, 15 and 20 ppm) of teaseed cake for 48 hours. Mortalities were monitored every hour for the first 8 hours and again at 24 h and 48 h. In Experiment 2, the potency of teaseed cake was evaluated using a 2x2x2 factorial design involving two concentrations (2.5 and 15 ppm) with and without exposure to sunlight or aeration. The test species were exposed to the various

conditions for 6 hours. In Experiment 3, tanks containing 15 ppm of the toxicant were exposed for various periods of time (0,4,12 and 24 hours) prior to stocking. Aeration was provided in all tanks. Water temperature and DO levels were monitored every two hours and mortality every hour for Experiments 2 and 3.

Results. Experiment 1. Significant differences in the response of the two species of finfish to teaseed cake were observed, with Tilapia mossambica showing a higher sensitivity (LT100 = 3 hours) than Glossogobius giurus (LT100 = 7 hours) at 10 ppm. A concentration of 15 ppm was needed for the elimination of both species within 6 hours. Both species of shrimp survived concentrations of up to 20 ppm.

Experiment 2. The decrease in DO levels due to the lack of aeration and the increase in water temperature, which resulted from exposure to sunlight, significantly increased the sensitivity of finfish to teaseed cake. At higher temperatures, lower survival resulted at 1 and 2 h after exposure to 15 ppm for T. mossambica and G. giurus, respectively. Significantly higher survival was attained at 1 h at an exposure of 15 ppm for both species when aeration was provided.

Experiment 3. After two hours of exposure, T. mossambica previously treated with teaseed cake for 12 and 24 h had significantly higher survival than those treated with teaseed cake for 4 h or less. This trend was also observed in G. giurus.

Anticipated Benefits. A management scheme for the application of teaseed cake in shrimp ponds could be developed once minimum allowable concentrations are known. This will minimize the cost of using teaseed cake to control unwanted finfish.

THAILAND

Pond management, production and marketing of Macrobrachium rosenbergii (de Man) in Thailand

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Introduction. Commercial farming of giant freshwater prawns in Thailand has been expanding rapidly (New and Singholka 1982) since its domestication in the late 1960's (Ling 1969). An estimated 3000 hectares of commercial prawn farms produce 3000 tons of prawns annually. Prawn farming requires intensive labor for pond preparation, seed production, feed preparation, pond management, harvest, and marketing. Most of these processes were developed based on artisanal knowledge derived from trial and error. Scientific documentation of the artisanal knowledge is necessary to further advance prawn-farming technology in Thailand.

Objectives. Our objectives were two-fold: (1) to document and evaluate the management, production and marketing of prawn farming by artisanal methods in

Thailand; and (2) to investigate water quality dynamics in prawn culture ponds.

Materials and Methods. Three 0.5-ha earthen ponds were used to study a 7-month grow-out cycle of a typical commercial prawn farm. Ponds were dried, filled with water to 1 m, and lime was added. The water level of each pond was maintained at 1 meter. Every 10 to 14 days, depending on water quality, 60-70% of the pond water was exchanged. Ponds were stocked with juvenile prawns (average weight of 4.2 g each) at a density of 6 prawns/m². In this intensive monocultural system, prawns were fed twice daily with homemade pellets. Water quality parameters (e.g. dissolved oxygen, pH, turbidity and ammonia) were monitored regularly to determine when to exchange the water. Prawn growth rate was determined and the feed ration was adjusted monthly. Partial harvest of marketable-sized prawns began at 4 months and continued every month thereafter until the end of the grow-out cycle. Prawns harvested in each crop were sorted according to sex and morphotype. Biomass, population composition, and market value were analyzed.

Results. In general, farmers maintained suitable water quality by observing water color and the feeding behavior and early morning behavior of the prawns. Water quality measurements were as follows: water temperature, 26-34°C; pH, 7.2-8.8; transparency, 20-40 cm; ammonia, less than 50 µg/l; and dissolved oxygen, 2-15 mg/l. Oxygen concentration, dependent on phytoplankton density, increased with aging pond water and the diel fluctuations of oxygen gradually increased when water was exchanged every 10-14 days. Detritus on the pond bottom caused anoxic conditions in the sediments; the subsequent release of hydrogen sulfide caused a serious problem that was not easy to remedy.

Average growth rate was 0.4 g/prawn/day during the pre-harvest period. Marketable-sized prawns (average weight of 42 g) were selectively harvested thrice over a 4-month period, resulting in a total accumulated yield of 1.3 tons/ha. The survival rate was 60%. For marketing, prawns were sorted into several categories: large, short claw; large, long claw; medium and small males; egg-bearing and infertile females; soft shells and scraggs. Female prawns predominated the population in the first and second partial harvests and males predominated in the third. The prawn population had a female-to-male ratio of 1.6:1 by weight and 4:1 by number; the ratio of short-to-long-clawed males was 3:1 by weight and 4:1 by number. The head-to-tail ratio (an indicator of available meat) was approximately 1.0 for females, and 2.3 and 1.5 for long-clawed and short-clawed males, respectively. Market price varied according to category and season, ranging from US\$ 1.2/kg to US\$ 6.7/kg. The economic yield of prawn farming was influenced by biomass, population composition and seasonal market price. In addition, pond yields may be affected by the composition of morphotypes, which can be manipulated by stocking and harvest schemes (Ra'anan and Cohen 1983, Karplus et al. 1986).

Anticipated benefits. Our preliminary investigation provides a scientific basis for documenting and elucidating artisanal knowledge and for formulating a sound management strategy in prawn farming.

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RWANDA

The influence of chicken manure on the growth of Tilapia nilotica in Rwandan fish ponds

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Introduction and Objectives. The use of chicken manure as a fertilizer to increase productivity of Rwandan fish ponds holds promise. Although there are very few large-scale poultry operations, chickens are common throughout the countryside and chicken manure is available, if only in small amounts, in most rural areas. However, fish culture must compete with other types of agriculture as a potential consumer of chicken manure, as well as of other animal and agricultural wastes. This experiment examined the cost effectiveness of using chicken manure to increase fish production in ponds, and the effect of chicken manure on pond water characteristics.

Materials and Methods. Water chemistry and fish growth data collected during the Cycle 3 (wet season) experiment were analyzed to determine those chemical factors which contributed to the differences in growth and production noted between the three treatments. The cost effectiveness of the manure inputs for the three treatments was also determined.

Results. Average net productivities for ponds receiving 250 and 500 kg/ha/week of chicken manure did not differ significantly from each other, but did differ from that of ponds receiving 125 kg/ha/week. The average growth rate for fish in high level treatment ponds differed significantly from that of fish in ponds receiving medium and low level inputs, which did not differ. Chlorophyll a, total phosphorus and total nitrogen differed significantly between ponds receiving different levels of manure inputs. Chicken manure was found to be a cost effective input, if it is available locally so that transportation costs do not make it prohibitively expensive.

Anticipated Benefits. The use of chicken manure as an input to increase fish production should be recommended to rural fish farmers if it is available to them locally.

The influence of chicken manure on soil and water fertility in several fish ponds at Twasave

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Introduction and Objectives. The soil of the pond basin has an important influence on the water in the pond, hence on the productivity of the pond, as measured in terms of fish production. Likewise, the pond water influences the soil underlying it. The input of nutrients into the pond, in the form of fertilizers, manures or feeds also has a role in the interaction between pond soil and water. The objective of this study was to clarify that role.

Materials and Methods. Soil samples were taken monthly during the course of the Cycle 3 experiment and were analyzed for pH, phosphorus, calcium, magnesium, potassium, sodium, cation exchange capacity, total organic matter, total nitrogen, and total carbon. The chicken manure used as input for the Cycle 3 experiment was also analyzed for determination of the above parameters.

Results. The majority of the soil parameters examined did not show significant changes during the course of the experiment. Only calcium and magnesium showed significant differences between ponds receiving different manure levels. The time frame of the experiment may have been too short to properly evaluate soil dynamics since several parameters displayed definite trends. Not surprisingly, the levels of certain soil parameters were found to be significantly correlated to the levels of parameters in pond water. Soil organic matter and total soil nitrogen were significantly correlated with nitrates in the water; soil phosphorus levels were significantly correlated with phosphorus in the water.

Anticipated Benefits. In Rwanda, where inputs needed to increase pond fertility are extremely limited and expensive, it is important to use these inputs efficiently. A knowledge of the extent to which these inputs are incorporated into pond muds and the evolution of the nutrients in the muds is necessary so that the role of the mud in an integrated agriculture-aquaculture scheme can be established.

A study of conditions affecting the reproduction of Tilapia nilotica in Rwandan fish ponds.

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Introduction. Although excessive reproduction of tilapia in fish ponds, and the resultant stunting, is a problem often encountered in tilapia culture, the lack of reproduction also may be a problem when the supply of fingerlings is insufficient. Such is the case in Rwanda, where climatic conditions limit reproductive rates in tilapia. The objective of this study was to examine reproductive rates of Tilapia nilotica in Rwandan ponds and to determine those factors which may be limiting them.

Materials and Methods. Fingerling production was studied for a total of nine brood ponds at two stations. In addition to recording total weight and numbers of fingerlings produced each month; minimum and maximum temperatures, pH, dissolved oxygen, secchi disk visibility and alkalinity were determined on a weekly basis. Other factors examined were the size and age of the brooders and the sex ratio. Water depth and soil texture were also measured in the nesting areas.

Results. Fingerling production was frequently greater than 100 fingerlings/female/month, and the highest value observed for a one-month period was 749 fingerlings/female. Fingerlings were found only in very limited numbers in ponds with brooders less than 10 months old. After moving mature brooders to a new pond, a delay of 4 months could be expected before the first fingerlings were fished. Reproduction was reduced when water temperatures fell below 20°C, or when dissolved oxygen was below 2-3 mg/l. Most nests were found in areas where the water depth ranged from 20-60 cm.

Anticipated Benefits. An estimation of fingerling production under different conditions will help hatchery managers to more efficiently manage station resources and to more accurately project numbers of available fingerlings.

INDONESIA

Inorganic carbon limitation on fish production in ponds in West Java

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Introduction. The Bogor region of West Java is hot and hyperhumid with annual rainfall in the range of 3-6 m per year, increasing with elevation on the surrounding mountain peaks. High rainfall combined with low evaporation rates causes severe leaching of ions from porous volcanic soils in the region. Since these soils have been in place for a long time, they yield few mineral nutrients to surface waters that drain them. Inorganic carbon is in short supply in surface waters: carbonate-bicarbonate alkalinity is on the order of 20 mg/l. This has important implications for freshwater pond culture in the Bogor region and other wet, tropical regions like it; nutrients necessary for pond production tend to be in short supply in water used to fill ponds. In practice, this condition is overcome by adding fertilizers and/or feeds to ponds. For economic and biological efficiency, fertilizer applications should be made with due consideration to the balance of mineral nutrients required by fish-food organisms namely, algae, bacteria and associated microfauna.

Phosphorus, nitrogen and carbon are elements that most frequently limit production of pond organisms used as food by fish. For normal growth, algae require phosphorus, nitrogen and carbon in the atom ratio of 1:16:100. In fish ponds where this ratio is not approximated in the process of fertilizer application, the element(s) in shortest supply should be exhausted by uptake and growth of algae, leaving surplus quantities of the other essential elements unused in the water. These unused nutrients from fertilizers represent an economic loss in the aquaculture process. The object of the work presented here was to assess the efficiency of fertilizer applications made in Cycle II of the CRSP at Babakan Fisheries Station of Institut Pertanian Bogor.

Materials and Methods. In this experiment, three treatments were applied to a total of nine ponds: three ponds were consigned to each treatment. After liming, ponds in treatment I were filled with water from the irrigation canal running along the periphery of the station. Chicken manure was added to these ponds at the rate of 500 kg/ha/wk. Ponds in treatment II were also filled with water from the irrigation canal. Triple-super-phosphate (TSP) and urea were added weekly to these ponds at a rate that supplied the same amounts of total phosphorus and total nitrogen as in chicken manure used in treatment I. After liming, ponds in treatment III were filled with effluent from a water conditioning system (WCS) that had been installed on the site to increase alkalinity, and thereby, the availability of inorganic carbon in ponds. After ponds were filled with water, male-selected Oreochromis niloticus (Tilapia nilotica) fingerlings were planted at a density of one fish per square meter of each pond. During the experiment, ponds were maintained at a depth of 0.9 m with

additions of irrigation canal water or WCS effluent as required. Measurements of phosphorus, nitrogen, inorganic carbon, and other parameters required by the CRSP protocol were made according to procedures prescribed by the CRSP over a 151-day interval of the experiment.

Results. Data from the experiment showed that low levels of inorganic carbon ($\text{CO}_2\text{-C}$) in the alkalinity system limited productivity of algae and fish in ponds filled with irrigation canal water when they were fertilized with either chicken manure or urea + TSP. Mean algal productivities for treatments I and II, where irrigation canal water was used, were 288 and 204 mg C/m²/day respectively; mean fish yields were 2590 and 2150 kg/ha/yr. Higher primary productivity in treatment I was due to CO_2 released during mineralization of organic material in chicken manure spread on ponds each week. A much smaller amount of inorganic carbon was available from the decomposition of urea used in treatment II. In treatment III, inorganic carbon was added to water from the irrigation canal by the water conditioning system prior to filling ponds. Mean alkalinity was increased during WCS passage from 20.3 to 54.7 mg/l. This alleviated the carbon limitation observed in treatment I, where, like in treatment III, chicken manure was used as a fertilizer. Mean algal productivity in treatment III was 408 mg C/m²/day; fish yield was 3540 kg/ha/yr.

In the absence of sufficient inorganic carbon during these experiments, phosphorus and nitrogen added to ponds in fertilizers remained in the water and were under-utilized in processes of pond productivity. The data showed that phosphorus tended to be consistently plentiful in pond water in all treatments, while inorganic nitrogen concentrations and primary productivity, as well as inorganic nitrogen concentrations and fish yields, were inversely related. That is to say, as inorganic carbon became more available in treatments, inorganic nitrogen from fertilizers was more heavily utilized by increased algal production, and increased algal production was correlated with the increased yield of grazing fishes. Because of the controlling influence of inorganic carbon on pond productivity in all treatments, efficient utilization of nitrogen in fertilizer was approached only in treatment III. Phosphorus in fertilizer was grossly under utilized in all treatments. The imbalance in phosphorus:nitrogen utilization was caused, at least in part, by the imbalance of these nutrients in fertilizers used in the experiment. Phosphorus and nitrogen were added in fertilizers in an atom ratio of 1:2 rather than in a ratio that approached that required for algal growth: namely, 1:16.

Anticipated Benefits. There appear to be many areas in the tropics where freshwater pond culture is conducted in a setting similar to that at the Babakan Station in Indonesia: namely, in wet climates, and in watersheds with heavily leached soils and surface waters with low alkalinity and low concentrations of essential mineral nutrients. It is clear from the results of this work that inorganic carbon is a key to efficient conversion of fertilizers to fish in these settings. Aquaculture literature from the wet, tropical areas does not appear to have adequately treated this topic. One benefit from this work is to provide notice to the aquaculture community that inorganic carbon is a likely determinant of fish yield obtained with fertilizers in portions of wet, tropical areas dominated by old volcanic soils.

Additionally, fertilizers are commonly used to promote fish yield in the variety of settings that occur around the tropics. This work provides solid experimental observations on which future CRSP research with fertilizers can be based. For example, we have proposed a model for research on fertilizers for CRSP Cycle IV, and will use pond measurements related to that model to optimize biological and economic use of fertilizers added to ponds. This model is a benefit from work conducted in Cycles I and II of the CRSP. It is a data-based approach to fertilizer research: an approach that has been largely lacking and is broadly applicable in tropical settings.

APPENDIX B

U.S. Special Topics Research Reports

U.S. Special Topics Research Reports

Metabolism and excretion of methyltestosterone in mature and sexually undifferentiated Tilapia nilotica

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Introduction and Objectives. When fed to sexually undifferentiated Tilapia nilotica at an appropriate concentration, the synthetic steroid methyltestosterone (MT) produces all male cohorts of fish in about 30 days (Geurrero 1975; Shelton et al. 1981). This manipulation permits culture of fish that will expend minimal energy for reproduction and thereby enhances growth at a given ration. Since the ultimate goal of this strategy is increased production for human consumption, it is prudent to carefully assess the safety of MT for use in aquaculture. Previous work showed rapid decline of tissue concentrations of MT-derived radioactivity in Tilapia aurea fed [³H]MT (Goudie 1984), but no data on metabolism of MT in fish are available. Therefore, the chemical form of MT residues in sex-reversed Tilapia is unknown. We undertook the studies described below to evaluate the capacity of Tilapia nilotica to metabolize doses of MT used in aquaculture.

Materials and Methods. Juvenile and sexually undifferentiated Tilapia nilotica were donated by Auburn University. [³H]MT was purchased from Amersham. Fish were maintained for 30 days on an ad libitum ration of Oregon Test Diet (Sinnhuber et al. 1977) containing 0 to 30 mg MT/kg. Ration provided on day 30 contained a tracer concentration of [³H]MT which yielded approximately 1 μ Ci of radioactivity per 20 g fish.

Fish were killed and weighed 1,3,7 and 10 days after feeding [³H]MT. Parent compound and polar metabolites were separated by liquid-liquid extraction of homogenized fish with chloroform-methanol/water (2:1). Organic phases (parent MT) were concentrated by evaporation under a nitrogen stream while methanol/water phases (polar metabolites) were concentrated by lyophilization. Further analysis of extracts will entail reaction with β -glucuronidase and thin layer chromatography.

Results and Discussion. Radioassay of tissue extracts from both juvenile and sexually undifferentiated Tilapia nilotica indicate rapid clearance of [³H]MT in both cases. This is consistent with earlier reports on MT elimination by fish (Fagerlund and Dye 1979; Goudie 1984). Our data demonstrate extensive bio-transformation of [³H]MT to polar metabolites. At all time points sampled, the majority of radioactivity present was associated with the methanol/water phase of our extraction system. Tissues of fish pre-fed MT contained higher concentrations of tracer [³H]MT polar metabolites than those pre-fed control diet. This indicated that MT preexposure of even sexually undifferentiated Tilapia nilotica stimulated the bio-transformation of that compound. Induction of hepatic bio-transformation enzymes by MT likely explains this result.

Anticipated Benefits. While our examination of MT elimination by Tilapia nilotica is not yet complete, our preliminary results indicate rapid bio-transformation to polar metabolites followed by excretion of most of this material in a course of days. Considering the pharmacokinetics of [³H]MT and the contribution of growth dilution of MT residues as fish approach marketable size we expect that extremely low or undetectable concentrations of MT would occur in sex-reversed Tilapia nilotica harvested for human consumption. When complete, our data should contribute to prudent judgement on the safety of MT use in culture of Tilapia nilotica.

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Metabolism, conversion efficiency, and growth of different genetic types of Tilapia nilotica

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Introduction. Monosex culture of Tilapia nilotica is practiced to circumvent the problem of overpopulation and resultant stunting of fish (Guerrero 1982a, Diana et al. 1985). Monosex culture is achieved by: 1) manually sorting fish of sizes at which external characteristics allow differentiation between males and females; 2) inducing sex reversal of fry using methyltestosterone (Clemens and Inslee 1968, Yamamoto and Kajishima 1968); 3) causing triploidy by temperature shock (Valenti 1975, Thorgaard et al. 1981); or 4) producing interspecific hybrids which are infertile (Rothbard and Pruginin 1975). Male fish are generally preferred for culture because they are thought to grow larger than females (Stone 1980, Guerrero 1982b). However, quantification of growth differences between sexes and the basis for such differences in terms of physiology and energetics have not been demonstrated.

Sex-related differences in energy accumulation and use could occur in any portion of the energy budget, and may be due to differences in the costs of reproduction (Diana and Mackay 1979), or to physiological differences between the sexes (Shul'man 1974). Potential physiological differences between sexes are most likely to be found in metabolic rates (Diana 1982), food consumption (Diana 1983), or assimilation efficiencies (Kelso 1972), all of which may vary tremendously with biomass and temperature (Webb 1978, Brett and Groves 1979). Sex-related differences in all these factors may be reflected in measurements of gross conversion efficiency (GCE), the key variable for fish production.

Objectives. The first-year objective of this project is to determine if energetic differences exist between male and female T. nilotica and if so to identify and quantify these differences and document the conditions (fish size, ration, temperature) under which they occur.

Materials and Methods. Existence of energetic differences between male and female tilapia are being evaluated through feeding and respiration experiments. Feeding experiments entail measurement of the following: 1) GCE for 5- and 150-g fish at 25°C fed at rations of 1% body weight (BW) per day and at satiation; 2) GCE for 50-g fish at 20,25,30, and 35°C fed at rations of 1% BW/d and at satiation. Feeding experiments are conducted simultaneously on eight fish held singly in aquaria which are maintained in a water bath for temperature control. Aeration is provided; exposure to light and dark is alternated over a 12-hour period each day. The fish are weighed prior to the experiment, then put into an aquarium and fed a prescribed daily ration (Purina Trout Chow). Excess food is removed from each tank 15-30 min after feeding. Feces are collected by siphon each morning prior to feeding. Growth rate is measured over a two-week period by estimating the initial and final caloric content of each fish. Caloric values for food, feces, fish flesh, and gonads are determined with a Phillipson micro-bomb calorimeter (see Paine 1971 for methods). Fish are sacrificed after each experiment and the final caloric value of fish flesh and gonads are determined directly. Initial caloric contents are calculated by multiplying initial wet weight of the experimental fish by the mean proportion of dry matter and calories per gram for a control group of fish sacrificed at the start of each experiment. GCE is calculated as calories produced divided by calories consumed.

Experimental design and methodology for respiration experiments will be detailed in a future progress report.

Results. To date, experiments have been completed for many of the weight, temperature, and ration level permutations outlined in Materials and Methods. Caloric evaluations for samples from experiments recently completed have yet to be determined, so broad-scale conclusions can not be made at this time. However, the following trends have been noted for existing data:

1) GCE varies greatly among different fish within a given experiment. The extreme example is for 50-g fish fed 1% BW/d at 25°C where GCE ranged from -4.8 to 77.8 for individual fish.

2) For 5-g fish, mean GCE was -6.4 for fish fed 1% BW/d but was 13.6 for fish fed at satiation levels. Assimilation efficiencies for the same fish ranged between 84% and 94% and in general were slightly higher for fish fed ad libitum than for those fed at the lower ration.

3) GCE for 50-g fish was higher for males (mean=39.4) than females (mean=7.4) at both levels of ration at 25°C, but was about the same for both sexes at 30°C (male mean=29.8; female mean=27.1).

4) At ad libitum ration, GCE was similar for males at both 25°C (mean=33.4) and 30°C (mean=29.8), but was different for females (mean 25°C=2.1; mean 30°C=27.1).

5) For different experiments with 50-g fish, the mean number of calories invested in gonads ranged from 163 to 322 cal for males; 1808 to 4072 cal for females. Taken as a percentage of final total calories, these means represented from 0.18 to 0.38% for males, and from 2.46 to 5.40% for females. On average, males invested relatively more energy in gonads at 30°C than at 25°C, while females exhibited the opposite trend.

Anticipated Benefits. Monosex culture of Tilapia is currently state-of-the-art in most countries, yet sex control generally is achieved by manual sorting and discarding of female fish. Male fish present certain problems in pond culture, since they generally continue to dig nests, causing turbidity in the water which decreases photosynthesis by phytoplankton (Bardach et al. 1972). Female fish do not build nests, and as such, monosex culture of females should not cause the same problems. Even if females are slightly less capable of producing edible flesh than males (Stone 1980), monosex culture of each sex would result in less wastage of fish seed.

The general area of sex-related differences in energetic efficiency in fish is not well understood. In fact, the literature reports few studies on the energetics of T. nilotica. One of the few is the work of Farmer and Beamish (1969) on metabolism. The present study could contribute to our knowledge of fish energetics since it would allow one to separate the differences in growth caused by gonadal growth and those caused by energetic efficiency in adult fish. Also, the project allows the use of domestic research to answer biological problems encountered in pond systems in the host countries, and therefore extends the collaborative aspect of our CRSP.

The further focusing of this work into genetic-related differences in the future will allow a large base of data to be produced on genetic types and Tilapia culture, and will give the potential for different CRSP sites to use these types in their experiments. For example, as already suggested, females may have a different optimum temperature for growth than males. Sites with different temperature conditions could be selected for the use of certain genetic types which are suitable to the local conditions. This has not been practiced in the past, indeed, we have attempted to overcome any potential for local adaptation by the fish stocks used in each experiment. The level of adaptation to climate has been rapid and large in other fish species (for example see Venables et al. 1977), and there is no reason to expect that genetic selection could not have occurred in Nile tilapia as well.

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Water quality dynamics in brackish water shrimp ponds with artificial aeration and circulation

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Introduction. The effect of different combinations of continuous and intermittent artificial circulation/aeration on water quality and shrimp growth are not well documented. Many types of artificial aeration and circulation are used in intensive shrimp farming but, their impact on dissolved oxygen and ammonia concentrations is not well understood.

Continuous aeration tends to remove supersaturated dissolved gases from water. This may be self-defeating in the case of dissolved oxygen. However, it may be beneficial to remove ammonia gas, especially at elevated water pH and temperatures such as those occurring midday when oxygen values are greatest. The benefits of ammonia removal could outweigh the negative effect of oxygen removal.

Fast et al. (1983) found that artificial circulation, without aeration, caused a redistribution of oxygen throughout the water column but, did not affect the exchange of oxygen between the pond water and the atmosphere.

Because of the unknown and possibly negative influences of artificial aeration on water quality, this experiment was designed to evaluate the effects of aeration and circulation on dissolved oxygen, temperature and ammonia concentration.

Materials and Methods. Four 500-m² ponds were treated as follows:

- Treatment I - Continuous aeration, 24 h/day
- Treatment II - Nighttime aeration, from 2100 h to 0600h
- Treatment III- Nighttime aeration from 2100 h to 0600 h and daytime circulation from 0600 h to 2100 h
- Treatment IV - Control; no circulation or aeration

Each pond was drained and dried prior to the start of the experiment. No lime or chicken manure was added since the shrimp were given a complete artificial diet. Ponds were filled with water to a depth of one meter and stocked with Penaeus monodon (average wt.= 0.03 mg) at 33 shrimp/m². Every two weeks 80% of the water was changed, and water was occasionally added to maintain the depth at one meter.

Oxygen and temperature were measured five times a week at 0400, 1000, 1400, and 1700 h; pH was also measured five times a week. Chlorophyll and ammonia were measured twice a week.

Shrimp were sampled and weighed every two weeks and the experiment was terminated on day 63.

Results. Several conclusions can be drawn from the data:

- a) artificial aeration causes a slight reduction in oxygen concentration during midday when oxygen was supersaturated;
- b) artificial aeration and circulation results in a uniform distribution of oxygen and temperature throughout the pond;
- c) there are no clear effects of aeration/circulation on pH, chlorophyll and shrimp size; and
- d) the trends observed for ammonia concentration indicate that aeration may reduce ammonia, but there were no significant differences between ammonia in the continuously aerated pond (Treatment I) and ammonia in ponds receiving other treatments.

These conclusions indicate that the overall effect of continuous aeration may not be beneficial. Rather, a combination of nighttime aeration, when needed, and daytime circulation would result in the greatest water quality benefits with the least energy consumption.

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Genetic homogeneity of Tilapia nilotica in Africa, Central America and Southeast Asia

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Introduction. The ability of a fish to grow is dependent upon environment, genotype of the fish and the interaction between the genotype and the environment. An effective evaluation of environmental variables should include standard or well-defined genetic stocks to minimize genetic and genotypic-environmental variations.

The global experiments presently being conducted by the Pond Dynamics/Aquaculture CRSP should be concerned with the genetic homogeneity of Tilapia nilotica among the test locations. In fact, it has been demonstrated that genotypic-environmental interactions exist when different strains of T. nilotica are grown in different environments.

Genotypic-environmental interactions are most likely to occur when large differences exist in environment or genotype. Genotypes at biochemical loci detectable through electrophoresis are predictors of genetic variability and are good markers for possible genetic contamination from related species. The objective of this study is to determine genetic homogeneity among the six populations of T. nilotica in the CRSP pond dynamics experiment. If the six populations are genetically homogeneous, greater confidence can be placed in the results and conclusions of the pond dynamics study. If significant genetic differences exist, they may affect the interpretation of the data, and determination of possible genotypic-environmental interactions may be warranted in future experiments.

Materials and Methods. Tilapia nilotica from six locations in Africa, Central America and Southeast Asia will be analyzed utilizing horizontal, starch-gel electrophoresis. Approximately 50 biochemical loci will be studied. Allelic and genotypic frequencies will be analyzed using several statistical methods to determine the genetic relatedness and genetic homogeneity of the six tilapia populations. These methods will include Wright's fixation statistics, contingency χ^2 for heterogeneity and modifications of Student's t-Test for ratios and frequencies.

Results. Samples have been received from Honduras, Panama, Philippines, Rwanda, and Thailand. These fish are being grown in tanks at Auburn University to a size suitable for biopsy of tissue samples. Allelic frequencies have been determined for control populations at Auburn University. Samples from the six experimental locations will be analyzed in January and February of 1987.

Data synthesis and analysis

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Introduction. The task of data synthesis and analysis for the CRSP has been delayed by the lack of availability of adequate data sets. Efforts to date have been concentrated on the development of computer techniques for data manipulation and analysis, and on the adaptation of an existing computer model of aquaculture ponds for future calibration and validation. Additional efforts are being directed to the formulation of computer models that are suitable for different applications by diverse user groups. The conceptual development of management, planning, and teaching models is progressing, with the intention of making optimum use of the data being collected.

Objectives. The objectives of our current activities are:

1. to develop data management techniques for the information being generated in the CRSP project sites;
2. to analyze the global data and establish site-specific as well as global relationships that are statistically significant; and
3. to develop computer models that make optimum use of the data base, and that are usable for diverse applications (i.e. management, teaching, planning, and research).

Results. Due to the unavailability of data, work to date has focused on the development of data management and analysis techniques with the computer system available, and computer modeling. Software for data manipulation and analysis has been identified and acquired. Procedures for data analysis have been established and tested with preliminary data sets obtained from the data management office. A computer model of an aquaculture pond ecosystem that had been previously developed has been translated to Pascal (from Fortran), and implemented in the computer system currently being used. The program has also been implemented in its original language. The data from the CRSP project will be used to validate and calibrate this general research model. The conceptual framework for other models is being developed, and will be based on simulation results with the current model, as well as on data availability and intended model uses.

In an effort to identify deviations from the work plan in the procedures used for sample collection and analysis, a survey was prepared and sent to the research associates. The reason for developing the survey was to gather information that would allow the data analysis and synthesis team to establish bases for comparison between data sets. Results of the survey will be made available to other members of the data analysis and synthesis team, and to the main program office. Only one reply to the survey has been received to date.

Anticipated Benefits. With the CRSP project now in its third experimental cycle, the amount of data and information that is becoming available is immense. The task of the data analysis and synthesis team is to develop techniques to make optimum use of this information to identify significant relationships between the parameters measured. Results from the data analysis and the computer models will be useful in planning future experiments for the CRSP project, and eventually will provide tools for pond management, planning, and teaching.

Data Synthesis and Analysis

W. Chang, Ph.D., University of Michigan

Introduction. The experimental plan of the Pond Dynamics/Aquaculture CRSP includes data collection on physical, chemical, and biological pond variables over five-month intervals. Measurements are carried out on twelve or more ponds at each of several locations including sites in Rwanda, Panama, Honduras, Thailand, Indonesia, and the Philippines. The data collection began in 1983 and the experiment in most sites has progressed into the third cycle of the experimental design.

For synthesizing the data collected from these sites, a data synthesis team was selected by the CRSP Board of Directors and formed in 1985. The principal responsibility is to analyze and synthesize the collected CRSP data base. Major tasks include the evaluation of the results of the first, second and third cycles of standardized CRSP experiments, development of descriptive models for farm pond management and development of numerical models for pond dynamics.

Materials and Methods. The CRSP data sets from each research site were submitted to the Program Management Office situated at Oregon State University. The data then were transferred on computer disks from the Management Office to this investigator. The data available at present consist of Cycle I from two different sites in Thailand and Cycle I and II from Indonesia. These data were transferred by IBM Microcomputer to the MTS (Michigan Terminal System). The CRSP data files have been compiled according to the variables shown in a series of templates which were organized by Dr. Kevin Hopkins in 1985. These data are stored both on computer tape and in on-line files. The statistical analyses were made using the MIDAS program (Michigan Interactive Data Analysis System).

Results. The results from these data sets showed three types of numerical difficulties which may be characteristic of the other sets of data that are not yet available. First, some values are obviously erroneous (for example, values for pond depth greater than 10 meters and pH greater than 14). Second, data collection frequency and types of variables monitored are sometimes inconsistent, both within a site and between sites. Third, data sometimes have large variability and the variability does not converge statistically when sample size is increased in a randomized sampling test. The changes in monitoring techniques and the inexperience of technicians collecting the data are the reasons given for this type of problem in other studies.

To reduce these difficulties, a few error checking procedures should be implemented. First, a computer-based error detection program should be used to select the out-of-bounds values and eliminate them from the data base. In addition, the out-of-bounds values can be greatly reduced once the data sets are cross-checked by the host country researchers. A reliability test should also be done to select the outlying points and reduce the variability in the data. The parameters monitored and the sampling frequencies should be standardized so that the values can be compared among sites and potential relationships can be constructed from the data.

Several significant statistical relationships have been constructed from the data available. Because these relationships are constructed with very limited data, they cannot be said to represent the general relationships in all the study sites. They only show the existence of possible statistical relationships in the data.

Statistically significant relationships ($p < 0.05$) were found between chlorophyll a, and total nitrogen, pH, alkalinity, and SD. The relationship between chlorophyll a and phosphorus was not statistically significant. These results might indicate that phosphorus is not a limiting nutrient for phytoplankton growth in the ponds from which data are available. In contrast, nitrate and total nitrogen may be a limiting element for algal growth.

The strong relationship between chlorophyll a, pH and alkalinity could be an indication of a strong linkage between the demand for free CO_2 and primary productivity. A high rate of primary productivity can deplete the free CO_2 in the water and result in an increase in pH. The reduction in the pool of CO_2 from bicarbonate can affect the alkalinity values.

Anticipated Benefits. Data synthesis work began in October 1985. Progress has been impeded by the unavailability of data; however, once the data become available, it is expected that the analysis will progress rapidly.

Several prototypes of conceptual frameworks will be constructed to represent different pond culture systems existing in tropical pond environments. The data will be used to identify critical elements in pond dynamics and to develop numerical models for use in pond management in Lesser Developed Countries.

A Research Plan for the Faculty of Fisheries, Institut Pertanian Bogor, Indonesia

Developed by IPB/USA Joint Committee for Research Planning: C.D. McNabb ^{1/}, H. M. Eidman ^{2/}, P. Suwignjo ^{2/}, D.L. Garling ^{1/}, K. Sumawidjaja ^{2/}, H.C. Lampe ^{3/}, S.M.H. Simandjuntak ^{2/}, R.F. Kinnunen ^{1/}, R.R. Nitibaskara ^{2/}, J. McAlister ^{3/}, T.R. Batterson ^{1/}, and C.F. Knud-Hansen ^{1/}.

1/ Michigan State University; 2/ Institut Pertanian Bogor; and 3/ University of Rhode Island

Introduction. The Faculty of Fisheries at Institut Pertanian Bogor (IPB) in Bogor, West Java is the leading unit for fisheries education in the university system of the Republic of Indonesia. Collectively, the Faculty represents a concentration of highly qualified fisheries scientists. In August 1985, USAID/Jakarta requested that CRSP personnel lead a planning group with the Faculty of Fisheries at Institut Pertanian Bogor. In November and December of 1985, pre-project planning and liaison between IPB and USAID/Jakarta were carried out in Indonesia by Dr. Ted R. Batterson, MSU Co-Principal Investigator in the CRSP. During this period, Dr. H.M. Eidman, Dean of the Faculty of Fisheries, selected four of the five departments in the Faculty for participation in this project: Aquatic Resources Management, Aquaculture, Fisheries Economics, and Fisheries Product Technology. He also appointed an IPB/Fisheries Research Planning Committee for the work of this project. Members of the committee were heads of participating departments.

A group of USA scientists was organized in November and December of 1985 to collaborate with the IPB Research Planning Committee. It consisted of the specialists from Michigan State University and the University of Rhode Island. Department heads of IPB and USA counterparts formed an IPB/USA Joint Planning Committee that was the operational unit for this project. It was co-chaired by Dr. Eidman and Dr. McNabb, principal investigators for the Pond Dynamics CRSP at IPB. Dr. Ken Randolph, Fisheries Project Officer, USAID/Jakarta, served as advisor to the committee. Dr. Chris Knud-Hansen, MSU resident scientist for the CRSP, was a member of the joint committee responsible for long-term liaison between IPB and USAID/Jakarta regarding efforts to implement the research plan. The planning committee did its work while USA counterparts were in-residence at IPB from 17 January to 26 February 1986.

Objectives. Richard A. Cobb, Director, Office of Agriculture and Rural Development, USAID/Jakarta, described elements of the planning task at a meeting with committee members in Jakarta on 16 January 1986:

1. to obtain a collective judgment of fisheries scientists as to major problems facing fisheries and aquaculture production and product management over the next 5-10 years;
2. to define the role of the Faculty of Fisheries at IPB in addressing these problems, considering the location of the university, its human resources, its institutional facilities, and its mandate for work in fisheries;
3. to develop a 5-10 year research strategy in the Faculty of Fisheries at IPB for solving major national fisheries production problems; and
4. to determine training, equipment, and facility needs of the Faculty to implement their research strategy.

These were taken as the purposes of the work of the planning committee.

Procedures. Prof. Dr. Andi Hakim Nasoetion, Rector of Institut Pertanian Bogor, met with the committee during the first week of its work to outline his goals for development of the Faculty of Fisheries, and to describe constraints on that development. During its work, the committee also met with representatives of USAID/Jakarta, the Indonesian Directorate General of Fisheries (DGF/Ministry of Agriculture), and the Indonesian Agency for Agricultural Research and Development (AARD/Ministry of Agriculture). The purpose was to inform them of the committee's work and its progress, and to obtain data and insights on fisheries problems and research. In addition, individual members of the committee and their counterparts traveled to various sites in the Bogor/Jakarta region to observe facilities and enterprises related to the work of particular departments at IPB.

The IPB/USA Research Planning Committee analyzed: (1) composition of staffs in the departments of the Faculty of Fisheries at IPB; (2) their instructional responsibilities; (3) the equipment and facilities they used in on-going research; and (4) their past records of research performance. From this and from consultations with fisheries experts in National agencies, a program was developed whereby IPB staff research would contribute to solving national fisheries problems, and the Faculty would assume the prominent role in the fisheries that was expected of it over the next decade.

Results. The research and staff development strategy for departments at IPB had essentially four principal components: (1) short-term (two-year) research projects in areas consistent with REPELITA IV that established priority fisheries problems in Indonesia; (2) a plan for development of staff research capability through graduate training; (3) seed-money equipment purchases to promote research by qualified staff members; and (4) consulting personnel to collaborate in the program. The strategy was laid out in a calendar that covered the interval 1987-1997, and a budget was provided for each program element.

Anticipated Benefits. The IPB/USA research Planning Committee-1986 finished its work with submission of the final draft of the report to USAID/Jakarta and to the dean of the Faculty of Fisheries at IPB. Purposes of work of the Committee, given in the Introduction, were accomplished. It was the hope of the committee that reviewers of its work in donor agencies would appreciate the long-term benefits the program could have for

developing Indonesian fisheries and would find a way to implement elements of the plan.

APPENDIX C

List of CRSP Publications

LIST OF PUBLICATIONS

Pond Dynamics/Aquaculture Collaborative Research Support Program As of 12/86

AUBURN/HONDURAS

Theses

- Echeverria, Maria Angelica. In preparation. Primary production in Tilapia nilotica production ponds fertilized with triple superphosphate. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Cerna, Carolina. In preparation. Zooplankton dynamics in Tilapia nilotica production ponds fertilized with triple superphosphate. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Garcez, Carla. In preparation. Rainy season zooplankton dynamics in ponds stocked with Tilapia nilotica. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Mejia, Carlos. In preparation. Rainy season phytoplankton dynamics in ponds stocked with Tilapia nilotica. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Gomez, Ricardo. In preparation. Production of Tilapia nilotica in ponds fertilized with dairy cow manure. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Lopez, Luis. In preparation. Production of Tilapia nilotica in ponds fertilized with layer chicken litter. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Paz, Santos Audato. In preparation. The relationship between primary productivity and chlorophyll and their relation to tilapia production. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)
- Sherman, Catalina. In preparation. All female culture of Tilapia nilotica in ponds fertilized with chicken litter. B.S. thesis, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Berrios, Jaime. In preparation. Growth and survival of hybrid tilapia (Tilapia nilotica x Tilapia hornorum) fingerlings during the nursery phase. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Reports

Alvarenga, H.R. and B.W. Green. 1984. Growth and production of all male Tilapia nilotica and all male hybrid tilapia (Tilapia nilotica x Tilapia hornorum) in ponds. C.R.S.P. Technical Report, unpublished. 11 p. (In Spanish.)

Alvarenga, H.R., B.W. Green and M.I. Rodriguez. 1984. A system for producing hybrid tilapia (Tilapia nilotica x Tilapia hornorum) fingerlings at the El Carao Aquaculture Experiment Station, Comayagua, Honduras. C.R.S.P. Technical Report, unpublished. 9 p. (In Spanish.)

Green, B.W. and H.R. Alvarenga. 1985. Tilapia and carp polyculture in ponds receiving organic fertilization and supplemental feed. C.R.S.P. Technical Report, unpublished. 10 p. (In Spanish.)

Green, B.W. 1985. Report on the induced spawning of the silver and grass carps. C.R.S.P. Technical Report, unpublished. 8 p. (In Spanish.)

Alvarenga, H.R. and B.W. Green. 1985. Production of hybrid tilapia (Tilapia nilotica x Tilapia hornorum) fingerlings. C.R.S.P. Technical Report, unpublished. 12 p. (In Spanish.)

Green, B.W., H.R. Alvarenga, R.P. Phelps and J. Espinoza. 1985. Technical Report: Honduras Aquaculture C.R.S.P. Cycle 1 Dry Season Phase. C.R.S.P. Technical Report, unpublished. Auburn University, AL. 51 p.

Alvarenga, H.R., B.W. Green and M.I. Rodriguez. In preparation. Production of hybrid tilapia (Tilapia nilotica x Tilapia hornorum) in ponds using corn gluten as a supplemental feed. C.R.S.P. Technical Report, unpublished. (In Spanish.)

Alvarenga, H.R., B.W. Green and M.I. Rodriguez. In preparation. Pelleted fish feed vs. corn gluten as feed for tilapia and chinese carp polyculture in ponds. C.R.S.P. Technical Report, unpublished. (In Spanish.)

Alvarenga, H.R., B.W. Green. Intensive fingerling production of hybrid tilapia (Tilapia nilotica x Tilapia hornorum). To be presented at the 1987 World Aquaculture Society Meeting, Guayaquil, Ecuador.

- Alvarenga, H.R., B.W. Green and M.I. Rodriguez. In preparation. Production of hybrid tilapia (Tilapia nilotica x Tilapia hornorum) fingerlings using two different brood stock densities. C.R.S.P. Technical Report, unpublished. Auburn University, AL. 77 p.
- Green, B.W., H.R. Alvarenga, R.P. Phelps and J. Espinoza. 1986. Technical Report: Honduras Aquaculture C.R.S.P. Cycle 1 Rainy Season Phase. C.R.S.P. Technical Report, unpublished. Auburn University, AL. 77 p.
- Green, B.W., Ronald P. Phelps, and H.R. Alvarenga. The effect of nitrogen and phosphorus sources in fertilizers used for the production of Tilapia nilotica. To be presented at the 1987 World Aquaculture Society Meeting, Guayaquil, Ecuador
- Green, B.W., H.R. Alvarenga, R.P. Phelps and J. Espinoza. 1986. Technical Report: Honduras Aquaculture C.R.S.P. Cycle 2 Dry Season Phase. C.R.S.P. Technical Report, unpublished. Auburn University, AL.
- Green, B.W., H.R. Alvarenga, R.P. Phelps and J. Espinoza. In preparation. Technical Report Honduras Aquaculture C.R.S.P. Cycle 2 Rainy Season Phase. C.R.S.P. Technical Report, unpublished. Auburn University, AL.

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- Green, B.W., R.P. Phelps, H.R. Alvarenga and J. Espinoza. In preparation. The effect of nitrogen and phosphorus sources in fertilizers used for the production of Oreochromis niloticus.

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- Gartini, Titin. 1986. Flow rate dependent changes in turbidity and phosphorus in the water conditioning system at Darmaga. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 66 pp.
- Haryani, Gadis Sri. 1985. The growth rate, mortality and feeding habits of Tilapia nilotica. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 76 pp.
- Litasari, Liliek. 1985. The composition and abundance of macrobenthos in relation to pond productivity. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 71 pp.

- Radiastuti, Fifi. 1986. The balance of nitrogen from an irrigation canal that flows through a water conditioning system in Darmaga. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 63 pp.
- Strahle, Scott L. 1986. The use of resin cartridges for the storage and preservation of aqueous samples for pesticide residue analysis. M.S. Thesis, Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan. 45 pp.
- Subyakto, Slamet. 1985. The relationship between chlorophyll a and Secchi disk visibility in Tilapia fish ponds at Darmaga, Bogor. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 51 pp.
- Suratman, Ida Farida. 1985. Composition and abundance of zooplankton in Tilapia nilotica L. fish ponds fertilized with TSP at Darmaga. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 87 pp.
- Tumbelaka, Ronald. 1986. Primary productivity of aquaculture ponds at Darmaga. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 87 pp.
- Yulanti, Sumara. 1986. Removal of detergents in irrigation canal water by water conditioning system at Darmaga, Bogor. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 71 pp.
- Yulisto. 1985. Effect of fish predation on macrobenthos density in aquaculture ponds. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 82 pp.
- Widjaja. 1985. Flushing rate of experimental Tilapia nilotica (J.) ponds at Darmaga, Bogor and its relationship to some physical and chemical factors of the ponds. B.S. Thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia. 64 pp.

Scientific Paper Presentations

- McNabb, C.D., T.R. Batterson, B.J. Premo, and J.R. Craig. 1984. Photosynthetically active radiation in tropical and temperate zone habitats. 88th Annual Meeting of the Michigan Academy of Science, Arts, and Letters, Big Rapids, Michigan. (March)
- McNabb, C.D. 1984. Application of limnological technology to fish pond management. National Institute of Biological Science, Bogor, Indonesia. (December)
- Batterson, T.R. 1985. The problems of water quality for Indonesian fisheries. Seminar series of the Bogor Chapter of the Indonesian Fisheries Society, Bogor, Indonesia. (December)

Sumatadinata, Komar. 1985. Genetic characteristics of strains of Indonesian carps. Special Symposium of the Japanese Fisheries Society, Tokyo, Japan. (February)

McNabb, C.D. 1986. Limnology of fish ponds in Java. Visiting Scientists Seminar Series, College of Fisheries and Marine Science, Agricultural University of Malaysia, Serdang, Malaysia. (February)

McNabb, C.D. 1986. Carbon limitation in fish culture ponds in Indonesia. Visiting Scientists Seminar Series, Lake Biwa Research Center, Shiga University, Otsu, Japan. (March)

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McNabb, C.D., K. Sumawidjaja, B.J. Premo, and K. Sumatadinata. 1984. Aquaculture-CRSP project report first 5-month experiment Indonesia. Michigan State University, East Lansing, Michigan. 107 pp. (March)

McNabb, C.D., T.R. Batterson, M. Eidman, B.J. Premo, and K. Sumatadinata. 1985. Aquaculture-CRSP project report second 5-month experiment Indonesia. Michigan State University, East Lansing, Michigan. 71 pp. (January)

McNabb, C.D., T.R. Batterson, M. Eidman, C.S. Annett, and K. Sumatadinata. 1985. Aquaculture-CRSP Indonesia project report first 5-month experiment, second experimental cycle (January-June 1985). Michigan State University, East Lansing, Michigan. 105 pp. (September)

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Premo, B.J. and K. Sumatadinata. 1984. Laboratory manual of water quality techniques. Julia Press, Bogor, Indonesia. 43 pp.

Kinnunen, R.E. and C.D. McNabb. 1986. Water treatment for small pond fisheries. Broadcast: National News Network, Television of the Republic of Indonesia (TVRI), Jakarta, Indonesia. 3 minutes. (March)

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- Abrego Ramos, R. 1985. Uso de androgenos en alevines de Tilapia nilotica para la produccion de tilapias monosexuales. Licenciatura Thesis in Biology, Univ. of Panama.
- Avila, Moises. (In preparation). El efecto del policultivo del pez, Mugil curema, a varias densidades de siembra con la produccion de Penaeus vannamei y en la calidad de agua en estanques de tierra. Licenciatura Thesis in Biology, Catholic University of Chile, Santiago, Chile.
- Chavez, H. 1984. Estudio trofodinamico de Penaeus vannamei cultivado en estanques experimentales de aguas salobres. Licenciatura Thesis in Biology, Univ. of Panama.
- Hernandez de Santamaria, Dora. (In preparation). El efecto de dietas experimentales en el crecimiento y sobrevivencia de Penaeus vannamei cultivado en estanques. Licenciatura Thesis in Biology, Univ. Panama.
- Lasso de la Vega, E. 1985. Variacion del zooplancton en estanques de cria de camarones blanco durante la estacion seca. Licenciatura Thesis in Biology, Univ. Panama.
- Lore, D., H. Tunon y R. Visuetti. 1984. Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (Dormitator latifrons) en la produccion de Penaeus stylirostris y Penaeus vannamei. Licenciatura Thesis in Biology, Univ. Panama.
- Quesada, Italo. (In preparation). Ocurrencia de organismos bentonicos en estanques no alimentados sembrados con Penaeus vannamei durante la estacion seca. Licenciatura Thesis in Biology, Univ. Panama.
- Quiroz, Virginia. (In preparation). Efectos de varios niveles de recambio de agua a la calidad de agua y en la produccion de Penaeus vannamei en estanques de tierra. Licenciatura Thesis in Biology, Univ. Panama.
- Quiroz, Virginia. (In preparation). Efectos de varios niveles de recambio de agua a la calidad de agua y en la produccion de Penaeus vannamei en estanques de tierra. Licenciatura Thesis in Biology, Univ. Panama.

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- Pretto, R., G. Garson, V. Batista y M. de Leon. 1983. Estudio preliminar del policultivo de Peneidos con peces nativos de aguas salobres. Presented by R. Pretto to the Fifth Symposium of Latin American Aquaculture, Univ. Austral de Chile, Valdivia, Chile, 5-9 September.

- Chavez, H. 1984. Estudio trofodinamico de Penaeus vannamei cultivado en estanques experimentales de aguas salobres. Presented to the First National Scientific Congress, Univ. Panama, Panama, 3-5 December.
- Hughes, D.G. 1984. The marine shrimp culture industry in Panama. Presented to First Annual Shrimp World Marketing Conference, Acapulco, Mexico, 29 Nov.-1 December.
- Hughes, D.G. y O.M. Garcia A. 1984. La produccion de semilla de Tilapia nilotica en hapas: una comparacion de productividades de clima templada con clima tropical. Presented by David Hughes to First National Aquaculture Seminar in Univ. Nacional, Heredia, Costa Rica, 26-28 June.
- Kivers, A. 1984. Comparacion de dos rangos y dietas alimentacias con alevines de Tilapia nilotica en piletas de concreto. Presented to the First National Scientific Congress, Univ. of Panama, Panama, 3-5 December.
- Kivers, A. 1984. Comparacion de tres densidades de seimbra de alevines de Tilapia nilotica en piletas de concreto. Presented to the First National Scientific Congress, Univ. Panama, Panama, 3-5 December.
- Lore, D., H. Tunon and R. Visuetti. 1984. Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (Dormitator latifrons) en la produccion de Penaeus stylirostris y Penaeus vannamei. Presented by H. Tunon to the First National Scientific Congress, Univ. Panama, Panama, 3-5 December.
- Moreno, J.M. 1984. Alimentacion de la Tilapia nilotica en la etapa de alevinaje. Presented to the First National Scientific Congress, Univ. Panama, Panama, 3-5 December.
- Moreno, J.M. 1984. El uso del androgeno 17-metil-testosterona en alevinaje de Tilapia nilotica para la produccion de Tilapia monosexuales en Panama. Presented to the First National Scientific Congress, Univ. Panama, Panama, 3-5 December.
- Torres, A. 1984. Produccion de Penaeus stylirostris bajo la influencia del Penaeus vanamei, en estanques experimentales de agua salobre con y sin alimentacion durante la epoca seca. Presented to the First National Scientific Congress, Univ. Panama, Panama 3-5 December.
- De Leon, Ameth. 1985. El efecto de aplicar fertilizantes inorganicos en la produccion de Penaeus vannamei en estanques. Presented to the Second National Scientific Congress, Univ. Panama, Panama, November.

Hughes, D.G., A. Torres and R.P. Phelps. 1985. Production and growth characteristics of Penaeus stylirostris and P. vannamei in mono- and polyculture in fed and unfed earthen ponds. Presented by D. Hughes at the Annual Meeting of the World Mariculture Society, Orlando, Florida, 13-17 January.

Hughes, D.G. 1985. Prediction of pond productivities: a challenge for aquaculture. Presented to the Pontifical Catholic Univ. of Ecuador, Quito, Ecuador, November.

Lasso de la Vega, E. and M. Villareal. 1985. Variacion del zooplankton en estanques de cria de camarones blanco durante la estacion seca. Presented to the Second National Scientific Congress, Univ. Panama, November.

Reports

Van Wyk, Peter. 1986. The relationship of pump discharge and fuel efficiency to tidal height for a brackish-water aquaculture pumping station. Masters of Aquaculture Special Project, Auburn University, Alabama.

Manuscripts

Hughes, David G., Lasso de la Vega, Ernesto, Hernandez de Santamaria Dora, Phelps, Ronald P., Pretto Malca, Richard. Rainy and dry season comparisons in Peneaus vannamei production ponds in Panama receiving various water exchange rates: 1. Algal fluctuation. Submitted to World Aquaculture Society, August, 1986, for presentation at 1987 meeting.

Hughes, David G., de Gomez, Garciela, Lasso de la Vega, Ernesto, Phelps, Ronald P. Pretto Malca, Richard. Rainy and dry season comparisons in Panaeus vannamei production ponds in Panama receiving various water exchange rates: 2. Water quality fluctuation. Submitted to World Aquaculture Society, August 1986, for presentation at 1987 meeting.

AUBURN/PANAMA - GUALACA

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Barrios, C.M. 1985. Analysis of water quality in new fresh water ponds at the Freshwater Aquaculture Station in Gualaca.

Freile, M.E. F. 1985. Stomach analysis of Macrobrachium rosenbergii, Tilapia nilotica, Colossoma macropomum and the hybrid Hypophthalmichthys molitrix x Aristhichthys nobilis in polyculture at the Gualaca Freshwater Aquaculture Experiment Station, Panama.

Perez, M.J. 1985. Economic and marketing study of fish and shrimp in polyculture systems in freshwater ponds at Gualaca, Chiriqui Province.

Pimentel, C.A.B. 1984. Effect of liming on new unfertilized ponds at the Gualaca Aquaculture Experiment Station.

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Teichert-Coddington, D., R. Pretto, and M. Peralta. 1986. Prawn and tilapia culture in Panama: commercialization of freshwater aquaculture. Submitted to Infofish, FAO Publ.

Teichert-Coddington, David R. and Ronald P. Phelps. Effects of water loss by seepage on concentrations of inorganic nutrients, primary production and fish production in tropical ponds receiving inorganic phosphorus as the nutrient input. Submitted for consideration for presentation at the 1987 World Aquaculture Society Meeting.

UNIVERSITY OF HAWAII/ THE PHILIPPINES

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Pahila, I.G. 1986. Sorbed and soil solution phosphorus in relation to the optimum phosphorus level of lab-lab in some brackish water ponds. M.S. Thesis. University of the Philippines in the Visayas, Department of Fisheries.

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