Pond Dynamics/Aquaculture Collaborative Research Support Program

SECOND ADDENDUM TO THE NINTH WORK PLAN

Pond Dynamics/Aquaculture CRSP
Oregon State University
418 Snell Hall
Corvallis, OR 97331-1643 USA

POND DYNAMICS/AQUACULTURE COLLABORATIVE RESEARCH SUPPORT PROGRAM

SECOND ADDENDUM TO THE NINTH WORK PLAN

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The *Ninth Work Plan*, published in Spring 1999, described a standardized set of experiments to be undertaken by the Pond Dynamics/Aquaculture Collaborative Research Support Program beginning between 1 August 1998 and 1 May 1999. An addendum containing official changes relating to schedules and/or methods to the work plans as described in the *Ninth Work Plan* was published in Fall 2000. This Second Addendum contains official changes to Ninth Work Plan activities, schedules, and/or methods implemented since the publishing of the *First Addendum*. Program activities are funded in part by Grant No. LAG-G-00-96-90015-00 from the United States Agency for International Development (USAID), Bureau for Economic Growth, Agriculture, and Trade, Office of Agriculture and Food Security. The authors' opinions expressed herein do not necessarily reflect the views of USAID.

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CONTENTS

INTRODUCTION

The goal of the CRSPs current USAID grant is to provide a basis for improving the sustainability of aquaculture production systems. This approach uses two building blocks to identify research priorities: research in production systems; and capacity building via research support. Research in production systems is organized into three research areas (Production Optimization, Environmental Effects, and Social and Economic Aspects), which are further subdivided into specific research themes.

The Ninth Work Plan of the Pond Dynamics/Aquaculture CRSP describes activities to be conducted by the CRSP beginning between 1 August 1998 and 1 May 1999, to be finished by 30 April 2001. Previous activities under this grant are described in the Eighth Work Plan, which covered the period from 1 August 1996 to 31 July 1998. Work under the Ninth Work Plan was implemented at research sites in Mexico, Honduras, Peru, Kenya, the Philippines, Thailand, and the US.

As needed, addenda to the work plans are prepared to document changes to schedules or methods that have been necessitated as work has proceeded. The (first) Addendum to the Ninth Work Plan was printed in Fall 2000.

SECTION A: NEW WORK PLANS

MEXICO RESEARCH

Collaborating Institutions
Universidad Juárez Autónoma de Tabasco
Wilfrido M. Contreras Sánchez
Gabriel Márquez Couturier

Oregon State University—Lead US Institution
Martin S. Fitzpatrick
Carl B. Schreck

Masculinization of Nile Tilapia Fry by Immersion in Trenbolone Acetate: Reuse of Hormone Solution and Effects of Temperature

Reproduction Control Research 9 (9RCR9)/Study

Objectives

1) To determine if masculinization of Nile tilapia fry by immersion in synthetic steroids is efficient in large-scale systems.
2) To evaluate if the interaction of immersions with elevated temperatures improves masculinization rates.
3) To evaluate the potential for re-usage of steroid solutions used in immersions.

Significance

Recent studies have shown that short-term immersions can result in significant masculinization of Nile tilapia fry (Contreras-Sánchez, 2001). This technique has the advantage of using the steroid solution under controlled systems allowing for re-use and/or safe disposal. However, little is known regarding the efficacy of this technique in large-scale systems.

We are also interested in investigating the potential enhancing effects that elevated temperatures may have when used in combination with short-term immersions in steroids. Recent studies in our laboratory (Contreras-Sánchez, 2001), as well as in other laboratories (D'Cotta et al., 1999; Wang and Tsai, 2000) indicate that elevated temperatures can induce masculinization to a certain degree; however, the interactive effects between temperatures and steroid treatment have not been studied.

Optimization of steroid usage can be achieved by reusing the solutions utilized in an immersion trial. If significant masculinization is achieved this way, masculinization costs might be reduced.

Anticipated Benefits

The implementation of masculinizing trials using immersion will set up the base for the application of large-scale use of immersions under farm conditions. This will provide great opportunities for extending research and impacts of PD/A CRSP to tilapia producers.

Three undergraduate degree students will immediately benefit from the research results because their thesis projects focus on the topics mentioned above.

Research Design

Site: Universidad Juárez Autónoma de Tabasco, Mexico.

Tank Facilities: 3 concrete tanks (8 m^2), 1 grow-out tank (200 m^3), 20 l chambers for fry immersion.

Cage Facility: 40 net cages (1 m^3).

Culture Period: 3 months or until tilapia reach sampling size.

Culture Species: Nile tilapia, 120 females and 40 males for fry production.

Water Management: Water exchange will be provided to fry production tanks (50%, two times per week).

Treatment: Immersion in steroids at large scale.

Sampling Plan:
The reuse of TA solution experiment will consist of six groups:

- fry immersed in TA at 500 $\mu g\ l^{-1}$ for 3 h;
- fry immersed in reused TA solution (1^{st} reuse) for 3 h;
- fry immersed in reused TA solution (2^{nd} reuse) for 3 h;
- fry immersed in EtOH control solution for 3 h;
- fry immersed in reused EtOH control solution (1^{st} reuse); and
- fry immersed in reused TA solution (2^{nd} reuse) for 3 h.

The effects of temperature experiment will consist of six groups:

- fry immersed in TA at 500 $\mu g\ l^{-1}$ for 3 h at 28°C;
- fry immersed in TA at 500 $\mu g\ l^{-1}$ for 3 h at 32°C;
- fry immersed in TA at 500 $\mu g\ l^{-1}$ for 3 h at 36°C;
- fry immersed in EtOH at 500 $\mu g\ l^{-1}$ for 3 h at 28°C;
- fry immersed in EtOH at 500 $\mu g\ l^{-1}$ for 3 h at 32°C; and
- fry immersed in EtOH at 500 $\mu g\ l^{-1}$ for 3 h at 36°C.

Both experiments will be triplicated for each group. At the end of a three month grow-out period, the tilapia will be killed with an overdose of anesthetic (MS-222) to determine if the treatments resulted in masculinization. The following water quality parameters will be measured weekly: pH, DO, and temperature.

Schedule

1) Experiments will be conducted at the Laboratory of Aquaculture at UJAT from February to June 2001.
2) Information will be analyzed between June and July 2001.

Report Submission

Final report due by 30 June 2001.

References

Contreras-Sánchez, Wilfrido, 2001. Sex Determination in Nile Tilapia, *Oreochromis niloticus*: Gene Expression, Masculinization Methods, and Environmental Effects. Ph.D. thesis, Oregon State University.

D'Cotta, H., Y. Guiguen, M. Govoroun, O. McMeel, and J.F. Baroiller, 1999. Aromatase gene expression in temperature-induced gonadal sex differentiation of tilapia Oreochromis niloticus. In: B. Norberg, O.S. Kjesbu, G.L. Taranger, E. Andersson, and S.O. Stefansson, (Editors), Proceedings of the Sixth International Symposium on Reproductive Physiology of Fish. Bergen, Norway, pp. 244-246.

Wang, L.H. and C.L. Tsai, 2000. Effects of temperature on the deformity and sex differentiation of tilapia, *Oreochromis mossambicus*. J. Exp. Zool. 286:534-537.

Fate of Methyltestosterone in the Pond Environment:
Use of MT in Earthen Ponds with no Record of Hormone Usage

Effluents and Pollution Research 2D (9ER2D)/Study

Objectives

1) To determine if 17α-methyltestosterone persists in pond sediment after dietary treatment of tilapia with 17α-methyltestosterone.
2) To produce a manual on Nile tilapia fry masculinization and safe handling of steroids.

Significance

Treatment of tilapia fry with 17α-methyltestosterone (MT)-impregnated food for producing all-male populations is a common practice throughout the world. All male populations offer the advantage of enhanced growth potential under culture conditions (Green et al. 1997). However, significant "leakage" of MT into the pond environment may occur from uneaten or unmetabolized food. This leakage poses a risk of unintended exposure of hatchery workers as well as fish or other non-target aquatic organisms. In recent studies (Contreras-Sánchez, 2001) we found that masculinization of fry through dietary treatment with MT results in the accumulation of MT in sediments and causes the production of intersex organisms and females with altered ovarian development. In Tabasco, we have sampled water and sediment from an earthen pond that has received MT for one masculinization cycle; however, we consider it important to continue masculinization treatments of fry in such system (to be more representative of tilapia culture in Mexico and around the world) and subsequently determine if accumulation of MT in sediments occurs.

In Mexico, the use of MT for masculinizing tilapia fry is a new activity and little information has been generated regarding its use and the potential risks of this practice. We have detected the need of a manual written in Spanish that describes the methods for masculinizing tilapia fry using steroids while emphasizing safe handling procedures. This would complement efforts already underway at Oregon State University with the development of a safe-handling manual for MT treatment of tilapia.

Anticipated Benefits

The documentation of MT leakage and accumulation in sediments will provide relevant information needed for determining if the use of this steroid in tilapia farms represents health and/or environmental hazards. The manual will be a reliable source for tilapia producers interested in masculinization and safe handling of steroids.

Research Design

Site: Universidad Juárez Autónoma de Tabasco, Mexico.

Pond Facility: 1 earthen pond, (200 m^2).

Tank Facilities: 3 concrete tanks (8 m^2), 1 grow-out tank (200 m^3), 20 l chambers for fry randomization and storage.

Cage Facility: 20 net cages (1 m^3).

Culture Period: 3 months or until tilapia reach sampling size (2 cycles).

Culture Species: Nile tilapia, 120 females and 40 males for fry production.

Water Management: Water exchange will be provided to fry production tanks (50%, two times per week).

Personnel involved: 2 professors, 1 technician, 3 students.

Treatments: Oral administration of MT (dose = 60 mg kg^{-1}).

Sampling Plan: The experiment consists of three groups:

- fry fed MT at 60 mg kg^{-1} food for 28 days in earthen pond;
- fry fed control food for 28 days in earthen pond; and
- fry fed control food for 28 days in grow-out tank.

The net cages where MT and control feed will be administered will be placed in opposite sides of the earthen pond. Each group will be triplicated. Water (12 ml) and sediment (20 g) samples will be collected from the earthen pond on days 0, 7, 14, 21, 28, and 35. Three sampling stations will be sampled each time (under MT hapas, middle of pond, and under control hapas). All samples will be extracted using ether and the concentration of MT determined by RIA (at OSU). At the end of the three month grow-out period, the tilapia will be killed with an overdose of anesthetic (MS-222) to determine if the treatment with MT resulted in masculinization. The following water quality parameters will be measured weekly: pH, DO, and temperature.

Statistical Methods and Hypothesis:
Null Hypothesis:

- MT is not detectable in water at any time during and one week after treatment of tilapia fry with MT-impregnated food;
- MT is not detectable in substrate at any time during and one week after treatment of tilapia fry with MT-impregnated food.

This is a descriptive study and therefore, statistical analysis is unnecessary for testing the null hypothesis (i.e. detection of any amount of MT in water or substrate will be sufficient for rejecting the null hypothesis). Sex ratios will be compared between MT fed and control groups by Chi-squared test.

Schedule

1) Experiments will be conducted at the Laboratory of Aquaculture at UJAT from February to June 2001.
2) Water and Soil samples will be processed at OSU from April until June 2001.
3) Information will be analyzed between May and June 2001.
4) Masculinization manual will be produced between February and June 2001.

Report Submission

Final report due by 30 June 2001.

PERU RESEARCH

Collaborating Institutions

Institute for the Investigation of the Peruvian Amazon
Salvador Tello
Fernando Alcántara

Southern Illinois University Carbondale—Lead US Institution
Christopher C. Kohler
Susan T. Kohler

Sustainable Aquaculture in the Peruvian Amazon

New Aquaculture Systems/New Species Research 6 (9NS6)/Activity

Objectives

1) Conduct outreach activities to regionalize CRSP outcomes.
2) Complete Spanish-language production manual for small-scale pond aquaculture in the Peruvian Amazon.
3) Expand list of locally available ingredients for practical diets suitable for *Colossoma* and *Piaractus* broodstocks to include grow-out diets.

Significance

Aquaculture has been practiced for the last ten years in areas along the only road stretching from Iquitos to the city of Nauta (95 km away). Total pond surface area has increased from 22 ha in 1991 to slightly above 100 ha in 2000 (Alcántara 2001). Fish farmers received support from public and private entities. Still, the industry's rate of development was minimal and results were scarce. Until recently, poor technology transfer and misinformation to the farmers led to poor production. Furthermore, some of these extension programs dissolved, leaving farmers stranded and feeling uncertain of the benefits of aquaculture. Still, a sociological study determined that over 80% of the population along the Iquitos-Nauta road and in the Tamishiyacu and Mazan River areas had great interest in aquaculture practices, and over 80% of practicing farmers saw aquaculture as more feasible than other forms of land farming (Molnar et al. 1999).

It has only in the past two years that fish farmers have been properly supported with aquaculture extension activities. The food security program (PROSEAL) directed by Terra Nuova (NGO) and IIAP has accounted for most of this enhancement. Their goal has been to promote the organization of fish farmers into self-sustainable associations in order to develop the aquaculture industry in a coordinated form, allowing for vital farmer interactions and common education among them. In the past two years, PROSEAL has received support from IIAP, Terra Nuova, PD/A CRSP, Maynas municipal government, Ministry of Fisheries, as well as additional contributions from two other NGOs. PROSEAL goals have been met by developing continuous workshops aimed at teaching local fish farmers about the production process, ranging from pond construction and pond management to commercialization of their product. All activities are directed at native fish species.

By the end of January 2001, PROSEAL had greatly impacted the aquaculture industry in the Iquitos region. They now provide services to 88% of fish farmers, who account for almost 55% of the total fish ponds in the region. PROSEAL has been a direct beneficiary from the CRSP program in Peru. Results from research conducted at our host country facilities provided much of the information that PROSEAL extended to farmers. Thanks to leadership provided by our host country PI, Dr. Fernando Alcántara, as well as other IIAP and UNAP members, valuable information developed from our project has been transferred to the local area fish farmers via PROSEAL. We will continue to assist in this effort during the project extension period.

Anticipated Benefits

The development of sustainable aquaculture will benefit many sectors throughout the Peruvian Amazon. Rural farmers will benefit from the addition of an alternative form of agriculture. Aquaculture production requires considerably less land than that needed for cattle ranching. Moreover, ponds can be used year after year whereas rainforest lands converted to traditional agricultural practices are rarely productive for more than a couple of seasons. Such lands, once abandoned, usually can no longer support normal jungle growth. Both rural and urban poor will benefit by the addition of a steady supply of high quality protein in the marketplace. Aquaculture of *Colossoma* and/or *Piaractus* should relieve some of the fishing pressure on these overharvested, native species. These species have been suggested to play a crucial ecological role in disseminating seeds from the flooded forest (Goulding 1980, Araujo-Lima and Goulding 1997). Accordingly, the aquaculture of *Colossoma* and/or *Piaractus* may be ecologically as well as economically and nutritionally beneficial to the inhabitants of the Peruvian Amazon. Host country consumers and fish farmers, researchers, extensionists and planners, local and foreign Latin-American governmental organizations and/or NGOs, and users of global CRSP-sponsored models and data will benefit from this activity.

Activity Plan

Objective 1) We will continue to reinforce extension activities with the 240 local farmers currently being served along the road system between the cities of Iquitos and Nauta. Our activities will reinforce and complement similar activities being conducted by the Italian NGO, Terra Nuova. Farmers will be provided with knowledge gleaned from the CRSP-sponsored studies with *Colossoma* and *Piaractus* conducted in Workplans 8 and 9.

Objective 2) The production manual is nearly complete and will be finalized during the extension period. If feasible, we will publish the manual through a local vendor in Peru. The Spanish-language manual will be used for teaching prospective farmers the basics for pond culture of *Colossoma/Piaractus*.

Objective 3) We will expand the list of practical ingredients developed by R. Lochmann for broodstock diets to include grow-out diets. In addition, data on the seasonal availability of the plants/plant products will be collected.

Schedule

All activities will take place from 1 April through 31 July 2001.

Report Submission

Final report will be submitted by 31 July 2001.

References

Alcántara, F., 2001. Caracterizacion piscicola del area de influencia de la carretera Iquitos-Nauta. Proyecto "Zonificacion ecologica-economica para el desarrollo sostenible de la zona Iquitos, Nauta, Requena, e Intuto." Instituto de Investigaciones de la Amazonia Peruana y Proyecto "Araucaria, Amazonas-Nauta." 45 pp.

Araujo-Lima, C. and M. Goulding, 1997. So Fruitful a Fish: Ecology, Conservation, and Aquaculture of the Amazon's Tambaqui. Columbia University Press, New York, 191 pp.

Goulding, M. 1980. The Fishes and the Forest. University of California Press, London, 78 pp.

Molnar, J., F. Alcántara, and S. Tello, 2001. Identifying Goals and Priorities of Fish Farmers in the Peruvian Amazon. In: A. Gupta, K. McElwee, D. Burke, X. Cummings, and H. Egna (Editors), Eighteenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Oregon State University, Corvallis, Oregon, pp. 127–130.

KENYA RESEARCH

Collaborating Institutions
Moi University
Charles C. Ngugi

Auburn University
Karen Veverica
Len Lovshin
Tom Popma

Oregon State University–Lead US Institution
James Bowman

Development of Training Modules for Aquaculture Extension Workers and University Students in Kenya

Feeds and Fertilizers Research 6 (9FFR6)/Activity

Objectives

1) To increase the capability of the Department of Fisheries at Moi University (MU) to contribute to sustainable utilization of aquatic natural resources through development of aquaculture.
2) To develop educational materials such as extension bulletins to be used for training Fisheries Extension Workers and university students.
3) To develop teaching modules for dissemination of research information to producers
4) To learn how to use software and hardware needed for making teaching aids, e.g., digitizing slides and photos, presentation programs.
5) To search and retrieve information from the library, download extension bulletins and transfer for use in preparation of course modules.

Significance

The development and management of culture fisheries resources demands multidisciplinary training in order to provide knowledge, skills, and technological know-how. Since its inception, the Department of Fisheries at Moi University has and continues to develop and implement training activities aimed at aquaculture development. However, from Ngugi's experience, the Department's major constraint has been to disseminate research findings and aquaculture information in a concise format to extension workers who will in turn should transfer it to the farmers.

In recognition of the training needs, the MU Department of Fisheries feels that training should be conducted at both the institution and the community levels. For over one year, Veverica and Ngugi have been involved in training Fisheries Department Officers in pond construction, pond management, and commercial fish farming. They have developed training materials relevant to the needs and level of education of the trainees. However, they have been constrained by a lack of modules relevant to Kenya's situation. Although some training modules have been borrowed from Auburn University's professors, modules are still needed on pond construction, composting, pond production of mixed-sex tilapia, fish nutrition, and production by species.

Ngugi therefore proposes to spend six weeks at Auburn University (AU) developing modules for training extension officers and undergraduates in the MU Department of Fisheries. In addition, this would provide an opportunity to work with AU faculty who are experienced in areas of module development, use of equipment and facilities, literature searches, and downloading extension files from the Internet. Modules developed will be used to train aquaculture extension officers and university students within the region.

Anticipated Benefits
This activity will provide Moi University faculty with improved training and course preparation skills and lead to better dissemination of aquaculture information to extension workers and university students. In line with PD/A CRSP objectives, linkages between research and extension workers in Kenya will be strengthened. Also, this will provide faculty with international exposure.

Training modules will provide extension workers and fish farmers with better information on pond construction and management. This will lead to improved fish production and poverty alleviation to the rural communities. It will also spin off small-scale commercial fish production that will improve farmers' incomes, and serve to standardize the information given to farmers.

Activity Plan
1) Attend the World Aquaculture Society's "Aquaculture 2001" conference in Orlando, which will provide an opportunity to meet well-known professionals and researchers to discuss aquaculture information.
2) Spend six weeks at Auburn University concentrating on learning to use software, digitizers, and other equipment required to develop the modules and developing training modules. The principal collaborator at Auburn will be Len Lovshin.
3) In the course of the six weeks stay, conduct aquaculture literature searches and learn how to download and transfer materials for use in developing course modules.
4) Spend time discussing and sharing information with aquaculture staff at Auburn University.
5) Work with Karen Veverica to develop extension bulletins for fish farmers in Kenya.

Impact Indicators
Number of students or Fisheries Extension Workers trained using the new educational materials and training modules.

Regional Integration
Development of aquaculture educational materials and training modules for Kenya will complement and build upon the training effort already carried out under the CRSP's Ninth Work Plan for the Africa Region. Modules developed for use in Kenya will also be useful in other countries in the Region.

Schedule
Week One: In Auburn, settling down and meeting collaborating personnel.
Week Two: In Orlando, attending Aquaculture 2001 and the CRSP Annual Meeting.
Weeks Three to Six: In Auburn, conducting library searches in journals and periodicals, downloading relevant information for use in Kenya, and developing course materials and modules

Report Submission
Activities undertaken will be described in a report submitted by June 30, 2001, after Ngugi's return to Kenya.

THAILAND RESEARCH

Collaborating Institutions
Asian Institute of Technology
Yang Yi

University of Michigan—Lead US Institution
C. Kwei Lin
James Diana

Supplemental Feeding for Semi-Intensive Culture of Red Tilapia in Brackishwater Ponds

New Aquaculture Systems/New Species Research 5 (9NS5)/Experiment

Objectives
1) To optimize supplemental feeding levels for tilapia cultured in brackishwater ponds.
2) To exploit underutilized or abandoned shrimp ponds for tilapia production.

Significance
Many tilapia species are euryhaline and can grow in saline water after proper acclimation (Suresh and Lin, 1993). A variety of red tilapia have been successfully cultured in saline waters (Watanabe, 1991). However, most of those tilapia culture trials were conducted in intensive systems with pelleted feeds, requiring frequent water exchanges or cages. Compared to the voluminous literature available for semi-intensive culture of tilapia in freshwater ponds, information on semi-intensive culture in saline ponds is almost nonexistent. On the other hand, the desire to culture tilapia in brackishwater ponds has been widely expressed in Southeast Asia as well as Central/South America during the last few years (Green, 1997). The major reason for this need is that there are a large number of shrimp ponds available, either resulting from failure in shrimp farming or desires to diversify shrimp culture. Tilapia appears to be a reasonable choice for such culture systems because there are few domesticated finfish species that feed on low-cost natural foods such as detritus and plankton. This interest in brackishwater culture is particularly strong in Thailand and Vietnam where shrimp culture is now commonly reduced to one crop per year, leaving the ponds empty for half of the year. Tilapia culture is also attractive to shrimp farmers as a by-product to utilize abundant phytoplankton in either shrimp ponds or pond effluents. The results from a recent PD/A CRSP experiment conducted in Thailand showed that red tilapia grew better in ponds with 10 ppt salinity and fertilized according to common CRSP fertilization guidelines (4 kg N and 7 kg P ha^{-1} d^{-1}) compared to several other salinity levels and fertilization regimes. However, to rear tilapia to weigh over 500 g, which fetch a higher market price, supplemental feeds are required. In freshwater ponds, the most efficient system is to grow tilapia to 100 to 150 g with fertilizer alone, then add feed (Diana et al., 1996). This study is being conducted to determine the appropriate feeding levels of supplemental feed in fertilized ponds with 10 ppt salinity.

Anticipated Benefits
This experiment will provide some guidelines on appropriate levels of supplemental feeding in fertilized tilapia brackishwater ponds. Successful trials of tilapia culture in brackishwater ponds will provide farmers with a low-risk, readily available species to stock in thousands of empty ponds in the coastal zones in the Southeast Asia region. Such aquaculture can be profitable and over time may help reclaim these pond areas to agriculture.

Research Design
Site: AIT, Thailand

Methods: Pond research.

Pond Facility: 1 earthen pond, 200 m^2 size.

Cage Facility: 15 net cages (1 m^3).

Culture Period: 3 months or until tilapia reach 500 g.

Stocking Density: 50 fish m^{-3}.

Test Species: Thai strain red tilapia.

Fertilizer Input: 4 kg N and 7 kg P ha^{-1} d^{-1}.

Water Management: Water depth 1.2 m in the pond and 1.0 m in cages; salinity 10 ppt. Salinity will be initially regulated by trucking hypersaline water to AIT and diluting it to the appropriate concentration. Flooded pond will be inoculated with phytoplankton.

Sampling Schedule: Regular CRSP protocols for water quality and biological parameters.

Statistical Design and Analysis: A randomized complete block design with five feeding levels (0, 25%, 50%, 75%, and 100% satiation ration; each treatment in triplicate). Results will be analyzed with ANOVA for significant difference.

Null Hypothesis: Supplemental feeding treatments do not affect fish production.

Regional Integration

Tilapia culture in brackishwater ponds is relevant to all countries in the Southeast Asia region where extensive coastal zones exist. The pond culture technologies developed for freshwater ponds by the CRSP project will be transferred to brackishwater systems where appropriate.

Schedule

February to May 2001

Report Submission

Final report due July 2001

References

Diana, J.S., C.K. Lin, and Y. Yi, 1996. Timing of supplemental feeding for tilapia production. Journal of the World Aquaculture Society, 27(4):410–419.

Green, B.W., 1997. Inclusion of tilapia as a diversification strategy for Penaeid shrimp culture. IV Symposium of Central American Aquaculture. Tegucigalpa, Honduras, pp. 85–93.

Suresh, R.V. and C.K. Lin, 1992. Tilapia culture in saline waters: a review. Aquaculture, 106:201–226.

Watanabe, W.O., 1991. Saltwater culture of tilapia in the Caribbean. World Aquaculture, 22:49–54.

A Manual of Fertilization Strategies and Supplemental Feeding for Small-Scale Nile Tilapia Culture in Ponds

Adoption/Diffusion Research 11 (9ADR11)/Activity

Objectives

1) To produce guidelines for fertilization, supplemental feeding, and pond management for small-scale Nile tilapia culture in ponds.
2) To provide training materials for extension workers, trainers, and well-educated farmers.

Significance

Pond fish culture can be practiced at many levels of production intensity based on the quantity and quality of nutrients added to enhance, supplement, or replace natural pond productivity. Since the early 1980s, PD/A CRSP researchers have conducted sequentially staged experiments to increase Nile tilapia (*Oreochromis niloticus*) production through intensification by increasing nutrient inputs and stocking densities. Researchers have also conducted experiments to reuse wastes derived from intensive systems as fertilizers for semi-intensive fish ponds. The PD/A CRSP has developed Nile tilapia culture strategies for small-scale farmers with various resources and financial affordability. The proposed manual will summarize the PD/A CRSP work on Nile tilapia culture in Thailand and provide some guidelines and recommendations for fertilization, supplemental feeding, and pond management of Nile tilapia culture. The main audiences of the manual are extension workers, trainers, and well-educated farmers.

Anticipated Benefits

Small-scale fish farmers will benefit from this manual. The farmers will be able to produce Nile tilapia by effectively using fertilizers and feeds to increase fish production, achieve higher economic returns, and reduce environmental impacts.

Activity Plan

1) Researchers with PD/A CRSP projects in Thailand will write the manual.
2) Staff from the Information Management and Networking Component at Oregon State University will edit and finalize the manual.

Regional Integration

The manual is relevant to many countries in Southeast and South Asia where Nile tilapia culture is popular.

Schedule

January to July 2001

Report Submission

Final report due 15 July 2001.

Establishment of New Collaboration in Bangladesh

Regionalization Activities (9RA1)/Activity

Objectives

1) To establish a new link to a Bangladesh institution.
2) To identify a potential PD/A CRSP site in Bangladesh.

Significance

PD/A CRSP has conducted research/outreach activities in Southeast Asia for nearly two decades. However, outreach activities have not been expanded to South Asia, where a large part of the population is poor, especially in Bangladesh.

Bangladesh is one of the most populous countries of the world. Three-quarters of Bangladesh is covered by flat flood plains rich in water resources that support enormous amounts of freshwater fish. Although fish is the traditional source of animal protein, recently per capita availability has declined drastically due to destruction of natural habitat; this has led to an increased role of aquaculture. Indian major carps are the dominant cultured species; however, tilapia is playing an increasing role in solving problems of malnutrition and health and alleviating poverty.

Anticipated Benefits

The establishment of collaboration with Bangladesh institutions will provide great opportunities for extending research and impacts of PD/A CRSP to Bangladesh and South Asia. Bangladesh researchers and fish farmers will benefit from the experiences, research results, and approaches of PD/A CRSP through the proposed collaboration.

Activity Plan

1) An Asian Institute of Technology (AIT) researcher will travel to Bangladesh to identify a collaborator and potential experimental sites.
2) A selected senior research staff from the identified Bangladesh institution will be trained for a week at AIT to become familiarized with previous work, approaches, and standard analytical methods of PD/A CRSP.

Schedule

February to May 2001

Report Submission

Final report due July 2001.

SECTION B: REVISED SCHEDULES

MARKETING AND ECONOMIC ANALYSIS

Development of Central American Markets for Tilapia Produced in the Region

Marketing and Economic Analysis Research 3 (9MEAR3)/Activity

Old Schedule		New Schedule	
Study End Date:	31 January 2001	Study End Date:	31 July 2001
Final Report Due:	31 January 2001	Final Report Due:	31 July 2001

Economic and Social Returns to Technology and Investment in Thailand

Marketing and Economic Analysis Research 4 (9MEAR4)/Study

Old Schedule		New Schedule	
Study End Date:	30 April 2001	Study End Date:	31 July 2001
Final Report Due:	30 April 2001	Final Report Due:	31 July 2001

KENYA RESEARCH

On-Farm Trials: Evaluation of Alternative Aquaculture Technologies by Local Farmers in Kenya

Appropriate Technology Research 1 (9ATR1)/Study

Central Province Trials

Old Schedule	
Start of Investigation:	November 1999
End of Investigation:	November 2000
Final Report Due:	April 2001

New Schedule	
Start of Investigation:	November 1999
End of Investigation:	March 2001
Final Report Due:	April 2002

Western Region Trials

Old Schedule	
Start of Investigation:	November 2000
End of Investigation:	April 2001
Final Report Due:	April 2001

New Schedule	
Start of Investigation:	March 2001
End of Investigation:	March 2002
Final Report Due:	April 2002

Aquaculture Training for Kenyan Fisheries Officers and University Students

Adoption and Diffusion Research 3 (9ADR3)/Activity

Old Schedule	
Start of Investigation:	December 1998
End of Investigation:	November 2000
Final Report Due:	March 2001

New Schedule	
Start of Investigation:	January 1999
End of Investigation:	April 2002
Final Report Due:	April 2002

THAILAND RESEARCH

The Application of Ultrasound to Produce All-Male Tilapia Using Immersion Protocol

Reproduction Control Research 8 (9RCR8)/Study

Old Schedule
Final Report Due: October 2000

New Schedule
Final Report Due: 30 June 2001

Lotus-Fish Culture in Ponds: Recycling of Pond Mud Nutrients

New Aquaculture Systems/New Species Research (9NS1)/Experiment

Old Schedule
Final Report Due: November 2000

New Schedule
Final Report Due: 30 June 2001

Culture of Mixed-Sex Nile Tilapia with Predatory Snakehead

New Aquaculture Systems/New Species Research (9NS2)/Experiment

Old Schedule
Final Report Due: September 2000

New Schedule
Final Report Due: 30 June 2001

Semi-Intensive Culture of Tilapia in Brackishwater Ponds

New Aquaculture Systems/New Species Research (9NS4)/Experiment

Old Schedule Final Report Due: November 2000

New Schedule Final Report Due: 30 June 2001