The fish are growing "Better than wonderful"

(comment by Egyptian CRSP Participant)

Hillary Egna (CRSP Director), Bartholomew Green (CRSP Egypt Project Chief-of-Party), and Abbassa station researchers Fatma Hafez, Abdel Mostafa, Hussein El Ghobashy, Ali Abdelghany, Zeinab Elnagdy, Hussein Hebicha, Gamal El Naggar (from left to right) gather in front of the newly renovated ponds at the Central Laboratory for Aquaculture.

EXECUTIVE SUMMARY

The Egyptian Central Laboratory for Aquacultural Research (CLAR) and the Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP), during two and one-half years of collaborative research, combined experience and expertise to develop a cohesive, multi-faceted research program. Activities conducted under the program included: (1) the testing of guidelines developed for tropical aquaculture, (2) bioconversion and polyculture research, and (3) biotechnology research. Most of the research was conducted at CLAR, a state-of-the-art research facility located at Abbassa.

For 12 years, CRSP scientists have been conducting research aimed at improving the management of pond systems through the study of pond dynamics in diverse geographic regions. They developed a set of guidelines and models for efficiently programming pond inputs to optimize aquacultural operations. During the Egypt project, researchers compared the effectiveness of CRSP-developed management guidelines with standard Egyptian fish farming practices. This research resulted in the identification of management strategies that save resources through input reduction and improved production. Results from these experiments are entered into the CRSP Central Data Base, the world's largest standardized database on tropical aquaculture, which is accessible to aquaculturists around the world.

Bioconversion studies focused on increasing pond productivity through the enhanced use of underutilized resources. A first set of experiments showed that grass and black carp feed on aquatic vegetation and snails found in Egyptian ponds. A second series of investigations evaluated the suitability of grass and black carp as new components in an Egyptian polyculture system composed of native species such as tilapia, mullet, and catfish. Results indicated that using catfish as a predator for unwanted tilapia reproduction in a polyculture system proved to be less productive than stocking ponds with all-male tilapia.

The Egypt project's biotechnology experiments focused on the practical application of modern technology to biological systems. Researchers identified a binding site for the synthetic androgen mibolerone and studied using short-term immersions of tilapia fry in 17α-methyltestosterone (MT) and 17α-ethynylestradiol to evaluate the efficacy of these treatments for masculinization and feminization. Identification of the mibolerone binding site is a first step toward understanding how steroids cause sex inversion in fish, and may provide a possible tool for screening potential sex-inverting compounds. In a series of hatchery studies the growth-promoting effects of MT were differentiated from its sex-reversing effects. Lastly, scientists tested the progeny of tilapia breeding groups to identify YY male tilapia among broodfish. This effort is a step towards developing a YY tilapia breeding program, and may make a contribution to our ability to produce male tilapia for public consumption that have not been treated with androgenic hormones.

While the primary focus of the Egypt project was collaborative research, institutional and professional development, and the establishment of new linkages were also of importance. It was also envisioned that the Egypt project would act as a catalyst to propel the Abbassa facility to a prominent role in aquaculture research and training, and has been successful in these areas, too. Currently, CLAR is being considered as a new site for the International Center for Living Aquatic Resources Management (ICLARM). The CRSP Egypt project supported through its Scholarly Exchange Program the professional development of Egyptian scientists by sponsoring 21 visits to laboratories and 12 visits to international conferences. Fourteen students, including eight working on advanced degrees, were supported by the Egypt Project. Over 160 individuals participated in CRSP sponsored workshops at CLAR. The CRSP Egypt project also assisted with facility improvement and maintenance, e.g. the renovation of experimental ponds and an overwintering facility.

PROJECT HIGHLIGHTS

— Improved Egyptian aquaculture techniques by providing and applying valuable information about pond dynamics.

— Determined economic returns of different management strategies for Egyptian pond production.

— Transferred CRSP technology for efficient tilapia production to Egypt.

— Described production characteristics of two tilapia species native to Egypt.

— Collected baseline information on Egyptian pond soils.

— Demonstrated the usefulness of grass carp as a biological control agent for vegetative regrowth.

— Collected baseline information on feeding behavior of black carp.

— Advanced efforts towards the creation of an Egyptian polyculture system.

— Advanced state-of-the-art biotechnological aquaculture research.

— Aided in the ongoing effort to obtain U.S. Food and Drug Administration approval of 17 α-methyltestosterone for sex-reversal of fish by conducting clinical field trials.

— Trained and educated over 160 individuals on a wide variety of topics through the presentation of numerous workshops.

— Facilitated the creation of new networks among aquaculture researchers, thereby contributing to a greater flow of information and increased research efficiency.

— Enhanced the infrastructure at the Central Laboratory for Aquaculture Research in Egypt.

— Increased the visibility of Egyptian aquaculture and aquaculture research.

LIVING OFF THE RIVER

Bas-relief from Thebes showing a fishing scene from 4000 years ago. Tilapia, one of the fish pictured, have been valued by Egyptians since these ancient times.

Egypt, located in the northeast corner of Africa, covers over one million square kilometers, yet only three percent of Egypt's total land area is classified as agricultural land. Most of that land is distributed in the Nile Valley, which constitutes only four percent of Egypt's land area and where over ninety eight percent of the population is located. The Nile River, the longest river in Africa, flows through Egypt for 1,600 life-giving kilometers. Fifty one percent of the labor force is employed in agriculture. However, per capita availability of domestically produced food has been decreasing, and imported food products currentlyrepresent one-third of Egypt's total imports, one of the highest food import ratios in the world.

Fish is an important component of the Egyptian diet. It currently accounts for about thirty percent of total animal protein consumption in Egypt. To meet this demand, Egyptians depend on capture fisheries and aquaculture. However, because capture fisheries have declined and aquaculture production has not kept pace with demand, Egyptians increasingly rely on imported fish. Of the 350,000 metric tons of fish consumed in 1989, over 100,000 metric tons were imported, and only 33,000 metric tons were produced through domestic aquaculture.

RAISING FOOD FISH

Aquaculture has been practiced in Egypt for thousands of years. Historically, Egyptian aquaculture consisted of the howash method of fish farming. A howash is a low lying enclosure which fish enter when the land is flooded. After the water level has dropped, farmers harvest the trapped fish. This method of fish-farming has been replaced in this century by more intensive management systems. Currently, Egyptian pond aquaculture involves a polyculture of mixed-sex, young-of-the-year tilapia, mullet, and common and silver carps. Natural food production is stimulated by fertilization, but fish are also fed a commercial food ration.

Over the last decade the supply of fish from aquaculture has increased. However, this rise in supply has resulted primarily from increasing the area of production, rather than from improving yield. Opportunities to further increase the area of production are limited for several reasons. Even though Egypt is land-rich, land in close vicinity to the river or irrigation canals—the prime locations for fish farms—is also in high demand for agriculture and housing. Further, water is a precious resource in arid Egypt and aquaculturists face many competitors for this resource. Therefore, the route to increased fish production will require that pond productivity be improved.

Recognizing the need for improved aquaculture technology, the Egyptian government, with financial support from the U.S., established the Central Laboratory for Aquaculture Research at Abbassa (CLAR). CLAR, with its state-of-the-art facilities and equipment, attracted the attention of international research programs and entered into a partnership with Pond Dynamics/ Aquaculture Collaborative Research Support Program (PD/A CRSP) scientists to tap into the resources and opportunities provided by this U.S.-based program.

The CRSP is an international effort to develop

TAPPING OPPORTUNITIES

aquacultural technology as a means of confronting food and nutritional problems worldwide. The CRSP is funded by the U.S. Agency for International Development (USAID), under the authority of the International Development and Food Assistance Act of 1975 (P.L. 94-161), and by the universities and institutions that participate in the CRSP. 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 research carried out in selected host countries and the U.S. by teams of U.S. and host country scientists. The resources of U.S. and host country institutions are brought together to improve the efficiency of pond culture systems through sustainable aquaculture. The strategy adopted by the CRSP has been to undertake the basic research required to improve the efficiency of pond culture systems.

CRSP research projects have focused on improving the management of pond systems through the study of pond dynamics since 1982. CRSP research successes are well documented, and include guidelines for efficiently programming inputs to optimize aquacultural operations. Using these guidelines, yields of five times the amounts previously attained were experienced at some CRSP research sites. CRSP researchers have also demonstrated that low-cost agricultural products and by-products can be used as successful substitutes for pelleted fish feed, often at considerable savings. In another important research project, CRSP scientists extensively researched water quality issues, resulting in improved pond management and reduced environmental impacts. Additionally, CRSP scientists have developed hatchery techniques that enable countries to provide enough seed fish to “jump-start” their aquaculture industries. Results of these CRSP experiments have yielded valuable information for private aquaculture—information that has translated into significant economic returns.

ADVANCING EGYPTIAN AQUACULTURE

When the CRSP joined the Egyptian effort to increase the availability of animal protein through pond aquaculture in Egypt, an ambitious and exciting endeavor began. Egyptian and CRSP scientists developed a comprehensive plan which fully utilized the facilities provided by CLAR as well as the CRSP’s twelve years of experience in aquaculture research by carrying out innovative research of immediate scientific interest and practical application. The expected outcomes included advancements in current understanding of pond dynamics, improvement of aquaculture techniques and production, and greater visibility for Egyptian aquaculture. The evidence of success is abundant.

The plan to further aquaculture production and technology in Egypt consisted of a coordinated effort on three related fronts. First, the CRSP Egypt project investigated increasing pond production by adapting the CRSP’s extensive research results from tropical countries to Egypt. Second, studies in bioconversion attempted to optimize pond production by utilizing available energy sources, such as snails and pond vegetation, while at the same time reducing pond management problems caused by these organisms. In a related vein, polyculture studies focused on increasing fish yields by combining the species used in the bioconversion studies with traditional aquaculture species. Finally, biotechnology studies investigated various techniques for producing all-male tilapia in order to limit unwanted reproduction in ponds which reduces fish quality.

In addition, the CRSP Egypt project strengthened institutional capacities, promoted education and professional development, established international scientific linkages, and furthered the exchange of technical information. These ancillary benefits increased the impact and scope of the CRSP Egypt project.

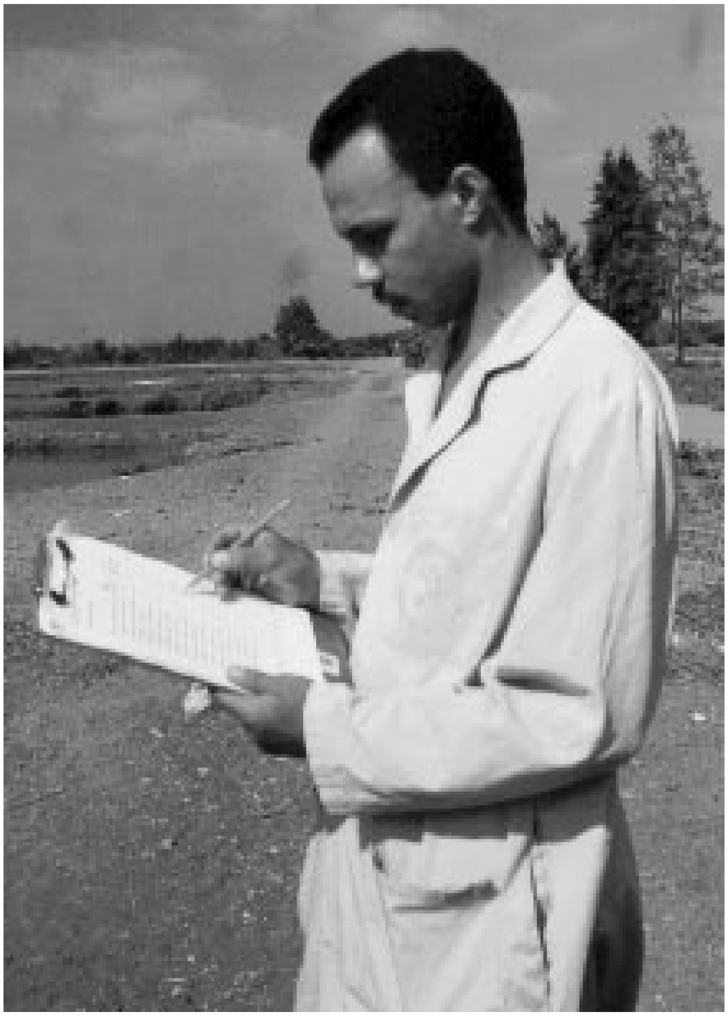
COMBINING EXPERIENCES

The ancient practice of Egyptian fish farming has created a wealth of information. Yet, this information was often anecdotal, incomplete, and limited to extensively managed systems. Since the beginning of this century, more intensive management practices have become commonplace in agriculture enterprises. Egyptian fish farmers, like their international colleagues, increased fish yields by adopting more intensive management practices such as fertilization and feeding. However, Egyptian aquaculturists had not attempted to systematically compare Egyptian management practices to aquaculture techniques used in other countries.

The CRSP Global Experiment uses Nile tilapia (*Oreochromis niloticus*) as the test species. Although the Nile tilapia is one of Egypt's native fish species, the Nile delta region is the most northern border of its natural range. Occasionally, unseasonably cold winters can kill unprotected stocks of Nile tilapia in the delta region, thus jeopardizing local aquaculture operations that rely on this species. Another indigenous species, the blue tilapia (*O. aureus*), is considerably more cold tolerant. However, knowledge of its production characteristics was limited. Therefore, it was not known if blue tilapia could be substituted for Nile tilapia in somewhat harsher environments without experiencing yield reductions. A thorough comparison of Nile tilapia and blue tilapia performance under the same production regime was therefore necessary.

Research Efforts

Two experiments were conducted that specifically fit within the parameters of the CRSP Global Experiment. Each experiment was designed to shed light on different aspects of pond management strategies in Egypt. The first experiment focused on validating CRSP nutrient input strategies and evaluating their economic efficiency. The second Global Experiment focused on comparing production characteristics and economics of two different species of tilapia under different pond conditions. Two other studies, in addition to those in the workplan, constituted further effort on the part of the Egypt project scientists. The first experiment compared the effects of stocking rates on growth and yield of Nile tilapia; and the second collected baseline information on chemical and physical characteristics of pond soils in Egypt.



Dia Kenawy records fertilizer applictions to experimental ponds during the Global Experiment.

Through routine water quality analysis researchers assure that pond conditions do not deteriorate beyond specified limits.

Global Experiment Research Impacts

— The addition of a commercial ration is not necessary during the first two months of fish culture because natural productivity, resulting from fertilization, is sufficient to maintain fast fish growth during the first two months of culture.

— Fertilizer application beyond day 60 in the “Traditional Egyptian” treatment is not necessary.

— Net tilapia yield from ponds fertilized with a high rate of chemical fertilizer is similar in Egypt, Honduras, and Rwanda, and less than in Thailand.

— Young fish probably are unable to consume commercial feed pellets available in Egypt because of the relatively large particle size of the pellets.

— Nile and blue tilapia grown under the same management system showed no significant yield differences. However, Nile tilapia yielded a significantly higher percentage of larger fish than the blue tilapia.

— Pond production strategies based on past CRSP research produce a greater percentage of large tilapia than traditional Egyptian treatments.

— Pond production strategies based on past CRSP research result in significantly less unwanted reproduction during grow-out than other pond production techniques.

— Net returns to land and management are highest with a CRSP pond production strategy.

— A positive relationship exists between the intensity of the pond production system and the average price received for fish.

— Although a less intensive pond management strategy (chemical fertilization using monosex tilapia) has the lowest variable cost, more intensively managed systems following CRSP guidelines have a higher average return per kilogram of fish.

— Semi-intensive pond production strategies can tolerate a greater reduction in average price before net returns become negative.

— The greatest total production, net returns and average rates of return on capital were obtained in semi-intensive production systems. Semi-intensive production strategies produced the highest values of production per labor-hour, per kilogram of feed, or per Egyptian-pound of variable cost. They also had the highest margin between average price and break-even price.

— Pond soils in Egypt had greater concentrations of sulfur, calcium, magnesium, potassium, and sodium, and lower concentrations of iron, manganese, zinc, and copper than pond soils from a humid climate.

— For general purposes, soil sampling should be restricted to the upper 5 cm layer.

OPTIMIZING THE POND ENVIRONMENT

Aquatic plants and snails are abundant in many fish ponds in Egypt and represent a nutrient and energy sink that tilapia cannot use for growth. In addition, several species of snails present a human health hazard because they are hosts to the parasite that causes bilharzia. The aim of CRSP bioconversion research was to select and study fish species that could convert the immobilized nutrients and energy in plants, snails, and unwanted tilapia fry into fish flesh. At the same time, pond management problems associated with plants, snails, and tilapia young were expected to be reduced.

Grass carp (*Ctenopharyngodon idella*) and black carp (*Mylopharyngodon piceus*) were the species identified to bioconvert the plant and snail biomass, respectively. The African catfish, *Clarias*, was selected as a predator of tilapia young. Grass carp were selected because of their unique ability to process large amounts of aquatic plants. Furthermore, by their mechanical processing and digestion, grass carp release and recycle nutrients retained in the plants. The released nutrients stimulate production of preferred plankton communities. Although even grass carp cannot directly utilize the mature high fiber nuisance plants prevalent in Egyptian ponds, CRSP research focused on consumption of new growth after mechanical cutting had taken place. Black carp were selected because they are voracious snail predators. Several snail species are intermediate hosts for the parasite that causes bilharzia. Black carp predation on snails was thought to result in a reduced risk of infection.

The information gathered from the bioconversion studies was to provide the foundation for the development of a polyculture system. The objectives of the polyculture studies were to test an array of species combinations and stocking rates that would optimally utilize the available energy and nutrient supplies under pond conditions in Egypt.

Polyculture is another mechanism for fully using a three-dimensional growing space by exploiting the entire water column. Although other forms of agriculture have used three-dimensional growing spaces aquaculture is alone in the widespread commercial application of this technique. Egyptian aquaculture has traditionally used multispecies stocking; however, simply mixing several species within a single pond does not produce a polyculture system. In order to form a polyculture system, each species must have a function that does not negatively interfere with other constituent species and, more importantly, each species must contribute to mutualistic effects, where positive interactions increase production.

Research Efforts

Initial bioconversion experiments focused separately on (1) grass carp growth from plants, (2) black carp growth from snails, and (3) the effect of stocking density on the biomass of plants and snails. Experiments evolved to study pond production when both species were stocked, with and without supplemental feeding. It was necessary to consider the potential synergism between black and grass carp because plants provide food and cover to snails and thus impact the system. The final bioconversion study focused on the African catfish, *Clarias*, as a bioconverter of unwanted tilapia offspring.

The objectives of the polyculture studies were to test various combinations of grass carp, black carp, tilapia, *Clarias*, and mullet. The studies were designed to determine whether any of these species combinations had greater yields due to synergistic effects. In addition, researchers conducted a study on black carp feeding biology which was not included in the original workplan. Polyculture experiments had to be terminated prior to the proposed evaluation date of the experiments, thus limiting the usefulness of collected data.

Bioconversion and Polyculture Research Impacts

— Grass carp effectively maintain ponds free of emergent vegetative regrowth.

— Grass carp stocking needs to occur immediately after pond filling.

— Black carp are voracious snail predators.

— Black carp growth is reduced in ponds that contained common carp and/or mullet.

— Total length of prey and mouth gape of black carp are directly and linearly correlated.

— Black carp start feeding on mollusks only after they have grown to 160-170 mm in length.

— *Clarias* control tilapia fry populations effectively. However, predation occurs only in semi-intensive culture systems that receive fertilizer but no feed.

— Tilapia production in polyculture with *Clarias* is significantly lower than in either all-male or mixed-sex culture systems.

As a result of his research on the Egypt CRSP Project, graduate student William Gale received the 1995 Hugo Krueger Fish Physiology Award from Oregon State University.

INNOVATIONS IN BIOTECHNOLOGY

The practical application of modern technologies to aquaculture is essential for improving pond production efficiency. A recurrent problem of tilapia culture is related to reproductive behavior. Tilapia attain sexual maturity at an early age and have the ability to spawn repeatedly during a culture cycle. This leads to pond overcrowding, which results in the production of many small fish of little market value. Therefore, methods for controlling reproduction are essential for tilapia systems. Stocking of all-male fish has proved successful in mitigating the negative impact of reproduction on yield of marketable fish. All-male fish can be produced economically using sex-inverting substances. However, this is still a relatively new technology and many questions remain as to the safest and most effective method of producing mono-sex tilapia.

Research Efforts

CRSP biotechnology studies, while diverse, were centered on refining current means of producing and identifying male tilapia. In particular, CRSP studies focused on the use of sex-inverting substances to produce all-male stocks. Research separated the growth-promoting from the sex-reversing effects of 17α-methyltestosterone (MT), determined the androgen-binding characteristics of tilapia gonadal tissue, tested immersion in an androgen-containing solution as an alternative method of producing mono-sex fingerlings, and worked towards the production of YY supermales.

The CRSP also participated in clinical field trials to investigate the safety of using MT for sex reversal of newly hatched tilapia. These experiments supported efforts of Auburn University, the American Tilapia Association, and a commercial feed producer to collect data to obtain approval from the U.S. Food and Drug Administration (FDA) to use this drug. This research was carried out under a "compassionate" Investigational New Animal Drug exemption granted by the FDA. The field trial required the production of large amounts of fry for sex-reversal. An additional study, not part of the original research plan, was conducted to determine the relationship between fry production and water temperature.

Biotechnology Research Impacts

— A receptor assay developed for tilapia may be used as a tool for screening newly developed sex-inverting agents.

— Immersion in an androgen-containing solution resulted in masculinization of tilapia fry.

— MT significantly increases the growth rate of *O. aureus* and *O. mossambicus* under hatchery conditions.

— In freshwater, *O. aureus* grows nearly twice as fast as *O. mossambicus* after having been treated with MT.

— Use of MT-treated feed effectively sex-inverted tilapia fry under field conditions.

— Variability in the sex ratio of repeated spawns produced by YY supermales indicates that sex determination is not solely controlled by the male genome.

— Mass production of Nile tilapia and blue tilapia fry for sex reversal is not possible below 100 or above 190 degree-days.

VALIDATION of CRSP POND MANAGEMENT STRATEGIES

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Zeinab El Nagdy, Ibrahim Shaker, Dia A. R. Kenawy, and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

The objectives of this research were to quantify tilapia yields resulting from established Pond Dynamics/ Aquaculture Collaborative Research Support Program pond nutrient input strategies under the climatic, edaphic and water quality conditions found in Egypt, and to compare these results to those obtained using traditional Egyptian management practices. Five treatments, each replicated four times, were tested in 0.1-ha earthen ponds. Treatments were: Traditional Egyptian, Enhanced Egyptian, Feed Only, Fertilization then Feed, and Chemical Fertilization. Ponds were stocked with 20,000 *Oreochromis niloticus*/ha; mixed-sex fish were stocked in Egyptian treatments and sex-reversed fish in all others. The duration of the experiment was 145 days.

Nile tilapia gross yield differed significantly among treatments and ranged from 1,278 kg/ha (chemical fertilizer treatment) to 2,877 kg/ha (fertilization then feed treatment). Wild tilapia (*O. aureus, Sarotherodon galilae, Tilapia zilli*) invaded all ponds and contributed 81 to 686 kg/ha to total tilapia yield treatment means. Thus, total tilapia yield ranged from 1,407 to 3,537 kg/ha and represented from 78% to 96% of gross fish yield. Gross fish yields ranged from 1,526 to 4,074 kg/ha. Tilapia yields in the Traditional Egyptian and Fertilizer then Feed treatments were significantly greater than in the Chemical Fertilizer treatment. Tilapia are marketed in Egypt by size class as follows: 1st class – 1 to 5 fish/kg; 2nd class – 6 to

12 fish/kg; 3rd class – 13 to 25 fish/kg; and, 4th class – 26 to 40 fish/kg. Farm-gate prices vary from L.E. 7.85/kg for 1st class tilapia to L.E. 1.75/kg for 4th-class tilapia. Yields of 1st- and 2nd-class tilapia were greater when organic fertilization was used in combination with formulated feeds than when chemical fertilization alone or formulated feed alone were used. Results indicate that ponds stocked with young-of-year monosex tilapia and managed according to the tested systems are feasible in Egypt.

ECONOMIc ANAlYSIS of DIFFERENT TILAPIA POND CUlTURE sYSTEMS IN EGYPT

Hussein A. A. Hebicha
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

Five different tilapia pond management strategies, tested in 0.1-ha earthen ponds at the Central Laboratory for Aquaculture Research, Abbassa, were evaluated for economic potential. Pond management strategies were Traditional Egyptian, Enhanced Egyptian, Feed Only, Fertilization then Feed, and Chemical Fertilization. Ponds were stocked with either mixed-sex or all-male populations of Nile tilapia. Yield and input data from 145-day pond trials were used to develop full-cost budgets for each management system. Net returns, values for production for major inputs, break-even prices and yields, and average rates of return to capital were estimated for each system based on a 2.1-ha production pond.

Net returns ranged from L.E. 19,102 for the Fertilizer then Feed treatment to L.E. 985 for the Chemical Fertilization treatment. Rates of return to capital for these two management strategies were 29.97% and 2.42%, respectively. Net returns to land and management for the Fertilizer then Feed treatment were, on average, 16.1 times the net returns for the Chemical Fertilization treatment. The Fertilizer then Feed management strategy also had the highest margin between average price and break-even price to cover total cost, which indicated reduced risk to the farmer in the event of a decline in market price. Sensitivity analyses indicated that the Fertilizer then Feed management strategy maintained positive net returns if fish yield decreased by two standard errors and price decreased by 20%.

YIELD CHARACTERISTICS oF tWO SPECIES of TILApIA UNDER tWO DIFFERENT POND ENVIRONMENtS

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Zeinab El Nagdy, Dia A. R. Kenawy, Ibrahim Shaker,
and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

CRSP research designs have been based on the use of Nile tilapia (*Oreochromis niloticus*) as the test species because this species was common to all research sites. In Egypt, Nile and blue (*O. aureus*) tilapia, both good culture species, are endemic. Severe cold weather occurs periodically in the Egyptian delta during the winter months of December through February, and can decimate unprotected stocks of Nile tilapia, as happened during the 1991/92 winter. *Oreochromis aureus*, much more tolerant of cold temperatures, survives winters in Egypt without having to be over-wintered indoors. The increased cold

tolerance of *O. aureus* would give this species a competitive advantage over *O. niloticus* for pond culture in the Egyptian delta assuming all other production characteristics were similar. The objective of this experiment was to compare production characteristics and production economics of *O. niloticus* and *O. aureus* reared in ponds managed under two different nutrient input regimes.

Eighteen 0.1-ha ponds at the Central Laboratory for Aquaculture Research, Abbassa, Sharkia, Egypt, were used for this completely randomized design in 2 x 2 factorial arrangement, where factors were tilapia species (Nile or blue) and pond environment (chemical fertilization or fertilization then feed); in addition, three ponds per nutrient input regime were co-stocked with equal numbers of Nile and blue tilapia. Weekly applications of nitrogen at 25 kg/ha and phosphorus to maintain 4 N:1 P were made in the Chemical Fertilizer treatment. In the Fertilizer then Feed treatment, chicken litter was applied weekly at 1,000 kg dry matter/ha for the first eight weeks followed by feed (25% protein commercial fish feed) only. Ponds were stocked with sex-reversed tilapia fingerlings on 1 July 94 at a stocking rate of 20,000 fingerlings/ha. Duration of grow-out averaged 158 days.

Nile tilapia gained a mean of 155 g during the grow-out cycle, not significantly different from the 127 g gained by blue tilapia ($P = 0.0642$). Fish in the Chemical Fertilizer treatment gained significantly less weight (95 g) than those in the Fertilization then Feed treatment (181 g). In the Chemical Fertilizer treatment, weight gains were 95 g and 96 g for Nile and blue tilapia, respectively. Nile tilapia appeared to gain weight faster than blue tilapia in the Fertilization then Feed treatment although an analysis of the species by pond environment interaction was not significant ($P = 0.0562$). Weight gains in communally-stocked ponds were similar to those observed in separately-stocked ponds. Nile tilapia gained 106 g and 235 g in Chemical Fertilizer and Fertilization then Feed treatments, respectively. Respective gains for blue tilapia averaged 94 g and 182 g.

Tilapia yield did not differ significantly between species (2,590 kg/ha for Nile tilapia and 2,220 kg/ha for blue tilapia). However, tilapia yield was significantly greater in the Fertilization then Feed pond environment (3,060 kg/ha) compared to the Chemical Fertilizer pond environment (1,646 kg/ha) ($P \leq 0.05$). Mean Chemical Fertilizer treatment yields were 1,455 and 1,773 kg/ha for Nile and blue tilapia, respectively. Yields of Nile and blue tilapia in the Fertilization then Feed treatment were 3,725 and 2,627 kg/ha, respectively. Tilapia survival did not differ significantly between species or in different pond environments, nor was the interaction significant.

In terms of size composition of the harvest, significantly more 1st-class Nile tilapia (1,510 kg/ha) were harvested than blue tilapia (35 kg/ha), and the Fertilization then Feed treatment (1,586 kg/ha) yielded significantly more 1st-class tilapia than the Chemical Fertilizer treatment (5 kg/ha) ($P \leq 0.05$). Significantly greater quantities of 2nd-class blue tilapia (1,115 kg/ha) were harvested than Nile tilapia (46 kg/ha), and the Fertilization then Feed treatment (1,344 kg/ha) yielded significantly more 1st-class tilapia than the Chemical Fertilizer treatment (36 kg/ha) ($P \leq 0.05$). There was no significant difference between species for harvest of 3rd-class tilapia (56 kg/ha for Nile tilapia and 73 kg/ha for blue tilapia). However, significantly more 3rd-class tilapia were harvested from the Chemical Fertilizer treatment

Zeinab Elnagdy, a soil scientist and aquaculturist at Abbassa, was one of the Egyptian researchers involved in the Global Experiment.

(1,184 kg/ha) than from the Fertilizer then Feed treatment (14 kg/ha) ($P \leq 0.05$).

In summary, there was no significant difference in weight gain between Nile tilapia and blue tilapia, nor was the species by pond environment interaction significant, although in both cases the probability level was very near to the alpha level of 0.05. High variability among ponds, which is commonly observed in pond research, was responsible for lack of significant differences. Given the potential significance of these results, further research is necessary to clarify results of this study, particularly in ponds where supplemental feed is offered to tilapia. Tilapia yields in ponds where supplemental feed is offered were about twice as great as yields obtained in chemically fertilized ponds. Similar yields were observed during Year I (1993) of the Egypt CRSP pond trials.

ECONOMIC ANAlYSIS oF tWO TILApIA POND MANAGEMENT SYSTEMS

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Hussein A. A. Hebicha and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

The Chemical Fertilizer and Fertilizer then Feed pond management systems tested as part of the 1993 Egypt CRSP Global Experiment were evaluated again as part of the 1994 Global Experiment in order to estimate year-to-year variability. Twelve 0.1-ha earthen ponds at the Central Laboratory for Aquaculture Research, Abbassa, Abou Hammad, were used for this research. Ponds were stocked with all-male populations of Nile (*Oreochromis niloticus*) or blue tilapia (*O. aureus*). Yield and input data from 158-day pond trials were used to develop full-cost budgets for each management system. Net returns, values for production for major inputs, and break-even prices and yields were estimated for each system based on a 1-ha production pond.

Net returns to land management for the Chemical Fertilizer management system were L.E. 168.55/ha for the 158-day production period, while the corresponding value for the Fertilizer then Feed management system was L.E. 10,111.81/ha. Income above variable costs, which is a measure of short-term profitability, was L.E. 2,073.70/ha and L.E. 12,016.97/ha for the Chemical Fertilizer and Fertilizer then Feed management systems, respectively. Returns per kilogram above total variable costs were L.E. 1.26/kg and L.E. 3.92/kg, respectively. Pond management strategy affected the size composition of harvested fish. In chemically fertilized ponds 3% of harvested fish were 1st class, 22% were 2nd class, 72% were 3rd class, and 3% were 4th class. In ponds managed according to the Fertilizer then Feed management strategy 52% of harvested tilapia were 1st class, 44% were 2nd class, and 4% were 3rd class. Average price received for fish sold was L.E. 4.04/kg for the Chemical Fertilizer system and L.E. 6.84/kg for the Fertilizer then Feed management system. The break-even prices to cover total costs were L.E. 3.94/kg and L.E. 3.54/kg for the Chemical Fertilizer and Fertilizer then Feed systems, respectively. The margins between the average price and the break-even price for these respective management systems were L.E. 0.10 and L.E. 3.30.

Comparison of 1993 and 1994 results showed that tilapia yields for each system were similar. However, the size composition of harvested tilapia varied between 1993 and 1994 in both management systems. Third class tilapia were predominant in the harvest from chemically fertilized ponds during both 1993 (51%) and 1994 (72%). Eighty-eight to 92% of tilapia harvested from chemically fertilized ponds were accounted for by the 2nd and 3rd size classes. First-class tilapia comprised 52% of harvested tilapia from Fertilizer then Feed ponds in 1994, up from 24% in 1993; 1st- and 2nd-size classes represented 96% of harvested tilapia in 1994, compared to 69% in 1993. In addition, no 4th-class tilapia were produced in Fertilizer then Feed ponds in 1994.

Two improvements in pond management techniques in effect during the 1994 season, the stocking of known populations of all male tilapia fingerlings and improved exclusion of wild fish from production ponds, contributed

to the improved size structure of harvested tilapia. Refinement of feed application rates during the 1994 trial also contributed to reduced feed costs. Fish were fed at 3% of body weight during the 1993 trial, but during the 1994 trial feeding rate began at 3% and decreased progressively to 1% as fish grew. As a result, 40% less feed was used during 1994. In conclusion, the economic viability of the Chemical Fertilizer pond management system appears marginal and quite variable from year to year, while that of the Fertilizer then Feed management system appears profitable with less year-to-year variation.

EFFECT OF STOCKING RATE ON GROWTH AND YIELD OF NILE TILAPIA

Bartholomew W. Green,
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Kevin Hopkins,
College of Agriculture
University of Hawaii at Hilo,
Hilo, Hawaii, U.S.A.

Zeinab El Nagdy, Dia A. R. Kenawy, Ibrahim Shaker, and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

Nile tilapia are generally stocked at 10,000-20,000 fish/ha in semi-intensively managed production ponds. Nutrient inputs into these ponds include fertilizers and supplemental feeds; both natural pond productivity and supplemental feed contribute nutrients for fish growth. Often, pond carrying capacity and critical standing crop are not attained during the 5-month grow-out period, which indicates that available pond nutrient resources are underutilized. Knowledge of the pond carrying capacity and density-dependent fish growth for a particular management system would provide the ability to manipulate management to improve production efficiency and economic returns. The objective of this experiment was to quantify growth and yield of Nile tilapia stocked at 30,000 and 40,000 fish/ha in production ponds.

This study was conducted at the Central Laboratory for Aquaculture Research, Abbassa, Abou Hammad, Sharkia, Egypt. Treatments were assigned randomly to three 0.1-ha earthen ponds. Sex-reversed Nile tilapia fry (*Oreochromis niloticus;* mean weight: 0.5 g/fish) were stocked at a rate of 30,000 or 40,000/ha into ponds on 20 and 24 July 1994. Chicken litter was applied weekly at 1,000 kg dry matter/ha for the first eight weeks of the production cycle followed by feed (25% protein commercial fish feed) only. Ponds were harvested 140 days after stocking.

At harvest, it was apparent that high fish mortality had occurred in all ponds. Survival of stocked fish ranged from 9.2% to 58.3%, with mean survival of 37.3% and 15.1% for the 30,000/ha and 40,000/ha stocking rates, respectively. Thus, this experiment provided no data to evaluate the null hypothesis that tilapia growth was not affected by stocking rate. Effective stocking rates were reduced to 11,200/ha and 6,000/ha for the 30,000/ha and 40,000/ha stocking rate treatments, respectively. Tilapia growth at these stocking rates is independent of fish density under the conditions of the present experiment. Individual weight at harvest averaged 176 g and 211 g for the 30,000/ha and 40,000/ha stocking rates, respectively, and did not differ significantly. Possible causes of mortality include stocking mortality, predation on tilapia by the piscivorous African catfish (*Clarias gariepinus*), and poaching. Fry mortality at

Asma Ali El Kerdawy demonstrates the use of state-of-the-art equipment used by researchers in the laboratory at Abbassa.

stocking would be difficult to quantify visually because stocked fry averaged 0.5 g each. No mass mortality was thought to have occurred during the grow-out period as dead fish were not observed. A number of African catfish managed to invade the ponds and a mean of 760 kg/ha and 240 kg/ha of African catfish were harvested from the 30,000/ha and 40,000/ha stocking rate treatment ponds, respectively. The quantity of African catfish harvested from ponds did not differ significantly between treatments. However, the individual size of catfish may have affected survival as tilapia survival appeared to decrease as individual catfish size increased from 0.2 to 1.3 kg (P = 0.07). It was impossible to verify whether poaching had occurred.

Joel Watkins (left) of the Salmon River Hatchery in Oregon discusses a fish disease problem with Ahmed Said (center) and Abdel El Gamal. The two Egyptian scientists visited aquaculture facilities in Oregon after they attended the CRSP Annual Meeting in Portland in 1993.

CHEMICAL AND PHYSICAL CHARACTERISTICS OF BOTTOM SOIL PROFILES IN AN ARID CLIMATE AT ABBASSA, EGYPT

Claude E. Boyd, Bartholomew W. Green, Prasert Munsiri
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Zeinab El Nagdy and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

Soil cores were taken from ponds at the Central Laboratory for Aquaculture Research, Abbassa, Egypt. Three ponds had received little management since construction in the early 1980s. Three other ponds were fertilized heavily in 1993 and 1994 to stimulate tilapia (*Oreochromis niloticus*) production. A new classification system for aquaculture pond horizons was applied. Thicknesses of S, M, and T horizons in soil profiles averaged 5, 7.5, and 10 cm, respectively. The S horizon contained more silt than clay, but the T horizon and the original pond soil (P horizon) were 60% clay. Concentrations of total carbon, total nitrogen, total sulfur, phosphorus, calcium, and potassium were greatest in the S horizon and lowest in the T horizon. Intensively-managed P-Ponds had higher concentrations of phosphorus and lower concentrations of organic matter and sulfur in S and M horizons than B-Ponds. Compared with pond soils from a humid climate (Alabama, U.S.A.), pond soils at Abbassa had greater concentrations of sulfur, calcium, magnesium, potassium, and sodium, and low concentrations of iron, manganese, zinc, and copper. Over the entire two-year study period at Abbassa, the only changes noted between P-Ponds and B-Ponds was an increase in phosphorus and a decrease in organic matter and sulfur in the heavily fertilized P-Ponds. Because of high moisture content, low dry bulk density, and greater concentrations of organic matter and nutrients in the S horizon, reactions in this layer probably have a greater

influence on pond water quality than those in deeper horizons. For general purposes, soil sampling should be restricted to the S horizon or the upper 5 cm layer where depth of the S horizon is not known.

USE OF GRASS CARP AND BLACK CARP IN EGYPTIAN FISH CULTURE

William L. Shelton
Zoology Department
University of Oklahoma
Norman, Oklahoma, U.S.A.

Kevin D. Hopkins
University of Hawaii at Hilo
Hilo, Hawaii, U.S.A.

Abdel R. El Gamal, Abdel R. Mostafa, Fatma Hafez,
Ashraf Soliman, and Gamal Nasser
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

Grass carp (*Ctenopharyngodon idella*) and black carp (*Mylopharyngodon piceus*) were evaluated as biological control agents and building blocks for a polyculture system suited to Egyptian conditions. Grass carp were expected to reduce the dependence on mechanical control of plants, concomitantly transforming a management problem and unused resource into an asset. Black carp were evaluated for their potential as control agents of snails, another management problem and unused resource in current Egyptian aquaculture. Several snail species are intermediate hosts for bilharzia, a parasitic disease effecting humans. Interaction between grass carp and black carp was expected to be beneficial as grass carp remove refuges for snails by cropping vegetation. Reduced cover may improve the predacious effectiveness of black carp. These bioconversion experiments were followed by polyculture experiments in which the two species were raised together with additional species (tilapia, mullet, and *Clarias*).

Bioconversion experiments were conducted in two growing seasons, while polyculture experiments were only conducted during the second growing season. Results of the first cycle of bioconversion experiments were inconclusive, due to late stocking resulting from difficulties in obtaining fish and to contamination with "wild species" (mainly common carp). However, stocking proceeded on schedule in the second cycle of experiments and bioconversion ponds were not found to be contaminated with common carp, a suspected competitor for black carp. Polyculture experiments had to be aborted, hence no final data could be collected.

Ponds were prepared by hand-cutting plants (mainly *Typha* and *Phragmites*) to near the soil surface. The ponds were refilled and stocked with grass carp (average size 1 kg) at approximately 275/ha. Black carp (average size 250 g) were stocked at 110/ha. Supplemental feed was given daily at 1% estimated biomass. Three ponds received no feed. The area covered by plants was estimated visually each month. Several snail sampling methods were tried, but none were found to be entirely satisfactory. Final evaluation of snail biomass was achieved by collecting the animals from sample areas of recently dewatered pond bottoms.

Grass carp were effective in maintaining ponds free of emergent vegetative regrowth. A standing crop of about 250 kg/ha grass carp appears to be adequate to maintain ponds clear of nuisance plants, even when supplemental feed is provided. Plant regrowth in the control ponds ranged from 50-95% coverage by the end of the season. Grass carp growth averaged 2.8 g/d in the ponds receiving supplemental feed, but only 0.5 g/d in the non-fed ponds. Black carp survival was low. Growth averaged 2.4 g/d when the fish were fed, but only 1.7 g/d when no supplemental food was provided. Black carp appear to effectively control smaller sized snails. Mollusks were present at substantial levels in several ponds (up to 39/m^2 or 73 g/m^2), however, but only at sizes larger than the black carp could eat. Vector species for bilharzia were found in all ponds and the potential of black carp as a biological control for this disease needs further study.

FEEDING BIOLOGY OF BLACK CARP

William L. Shelton
Zoology Department
University of Oklahoma
Norman, Oklahoma, U.S.A.

Ashraf Soliman and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

The black carp (*Mylopharyngodon piceus*), used in the traditional Chinese polyculture system, is a known mollusk predator. It crushes the shells of mollusks with strong, molariform pharyngeal teeth which develop during the first year of life. The pattern of tooth development reflects the dietary change that black carp exhibit during this period. Black carp diet changes from zooplankton to benthic invertebrates and finally to mollusks.

A study was conducted to determine the physical limitation of black carp to engulf mollusks by examining prey size in relationship to the mouth capacity of fish of different sizes. Total prey length (L) was directly and linearly correlated to mouth gape (G) with G=1.60+.0471 L (both measured in mm). The size of a snail that could be eaten was closely related to mouth gape. Black carp ate snails equal to their mouth width and were usually able to crush them. Some would engulf snails larger than their gape, but usually were unable to crush them. Black carp were hesitant to take prey from the water surface, but would eat snail after snail from the bottom to satiation.

Within the fish sizes tested, the approximate range of single-bout satiation was 2-8% of the body weight for fish about 100g body weight (210 mm TL), and upwards of 8-13% in multiple feeding trials which were separated by 3-4 hours. Larger fish appeared to be satiated at slightly lower levels; fish of about 200 g (320 mm) consumed a number of snails which were equivalent to between 1 and 5% body weight. Stomach analysis from pond populations of black carp suggest that fish less than 160-170 mm fed primarily on soft-bodied invertebrates. The gut of larger fish almost always contained mainly the remains of snails.

Martin Fitzpatrick (Oregon State University, foreground) demonstrates how to identify the sex of tilapia fry by gonadal examination during a laboratory class conducted at Abbassa in Fall of 1995.

CLARIAS AND TILAPIA INTERACTION

C. Kwei Lin
Division of Agriculture and Food Engineering
Asian Institute of Technology
Bangkok, Thailand

Abstract

The precocious breeding behavior of tilapia leading to pond overcrowding is often solved by stocking ponds with tilapia of only one sex. However, production of mono-sex populations requires additional efforts. Another approach to this problem entails co-stocking a predator species together with mixed-sex tilapia. By feeding on tilapia offspring, the predator controls the size of the tilapia population. Using an economically valuable species as biological control also increases financial returns at harvest time. A candidate for this scenario is the African catfish (*Clarias gariepinus*), a species native to Egypt. An experiment was conducted to determine (a) the suitability of *Clarias* for polyculture and (b) the effect of polyculture on tilapia growth. Originally, the experiment was to be conducted at the Central Laboratory for

Aquaculture Research at Abbassa, Egypt. However, inclement weather resulted in serious die-offs of Nile tilapia (*Oreochromis niloticus*) and a consequent shortage of tilapia fry. The experiment was therefore conducted at the Asian Institute of Technology in Thailand.

The experiment consisted of three treatments: ponds stocked with male tilapia only, ponds stocked with mixed-sex tilapia, and ponds stocked with mixed-sex tilapia and catfish. Catfish were stocked two weeks after stocking of tilapia to ensure abundant tilapia offspring. Ponds were fertilized with urea and Triple Super Phosphate at 21 and 7 kg/ha/week, respectively. During the first six weeks of the study, the fish were fed with a commercial diet at 1.5% body weight of tilapia/day. Feeding was discontinued after six weeks, as the catfish prefered the feed over the tilapia fry. Standard water quality analyses were conducted biweekly. Comparable water quality values were observed for the different treatments. Growth analysis revealed that fish from ponds stocked only with male tilapia grew better than tilapia from the other two treatments. However, there was no significant difference between mixed-sex tilapia raised with or without catfish. Fry production was significantly greater in ponds stocked with mixed-sex tilapia only compared to the polyculture ponds. Gut analysis of catfish demonstrated that the predators fed on tilapia fry. Mean weight of Nile tilapia and net fish yield were lowest in the polyculture system and highest in the mono-sex culture system.

As part of the Global Experiment researchers regularly monitor fish growth.

USE OF 17α–METHYLTESTOSTERONE FOR TILAPIA SEX REVERSAL

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Esam H. Rizkalla, Ahmed Nassr Alla, Ahmed Khater, and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

Tilapia aquaculture generally is based on stocking populations of only male fish into production ponds, as males grow significantly faster than females. In addition, stocking only male fish effectively controls the precocious spawning behavior characteristic of tilapia. Populations of all male tilapia may be obtained by one of several methods: manual separation of sexes based on visual examination of external morphology, interspecific hybridization, and sex reversal. At hatch, tilapia are sexually undifferentiated. Sex reversal directs differentiation of gonadal tissue to testes through oral administration of an androgen to newly-hatched tilapia fry. The androgen (17α-methyltestosterone (MT)) is administered orally to newly-hatched fry for a 28-day treatment period and then withdrawn permanently from the diet. A clinical field trial at research institutions and commercial tilapia growers throughout the U.S. and overseas is currently underway to collect efficacy data of MT on tilapia sex reversal under field conditions. Data collected under this clinical field trial will support a New Animal Drug Application to the U.S. Food and Drug Administration for the use of MT for sex reversal of newly-hatched tilapia. U.S. and Egyptian researchers involved with the CRSP participated in the field trial.

Eduardo Lopez (Central Luzon State University in the Philippines) and Ali Abdelghany (Central Laboratory for Aquaculture Research, Egypt) discussed tilapia culture during the meeting of the PD/A CRSP Technical Committee in Hilo, Hawaii.

Two trials were conducted to determine the efficacy of MT (60 mg MT/kg feed) in producing populations of Nile tilapia (*Oreochromis niloticus*) or blue tilapia (*O. aureus*) comprised of greater than 95% male fish. Additional objectives were to determine the effect of MT treatment on fry growth, as expressed by final weight and length, and fry survival. The operating null hypothesis was that no differences would be observed between the control and MT treatment groups.

Upon completion of Trial I treatment period, Nile tilapia averaged 0.67 and 0.60 g/fry and 32.0 and 31.3 mm/fry total length for the control and MT treatments, respectively. Differences in mean final weight and length were not significant ($P \geq 0.05$). Mean final individual weight and length for blue tilapia in Trial I were 0.36 and 0.34 g/fry, and 25.9 and 27.5 mm/fry for the control and MT treatments, respectively; no significant differences were detected. Fry survival was not affected adversely by MT treatment for sex reversal; control and MT treatment survival averaged 73.5 and 89.4%, and 96.0 and 91.4% for Nile and blue tilapia, respectively.

In Trial II, mean final weights of Nile tilapia did not differ significantly for control (0.46 g/fry) and MT (0.34 g/fry) treatments. Observed final lengths were 27.9 and 25.1 mm/fry for control and MT treatments, respectively. Fry survival in the control treatment averaged 48.9% and did not differ significantly from the MT treatment average of 63.5% survival. Blue tilapia mean final weights were not significantly different and averaged 0.34 and 0.36 g/fry for control and MT treatments, respectively. Observed final lengths were 27.2 and 28.1 mm/fry, respectively. Treatment differences in survival of blue tilapia fry were not observed; control and MT treatment mean survival were 44.2 and 41.9%, respectively.

Fish in the control treatments ranged from 42% male:58% female to 38% male:62% female; these results are within the expected range for the mean of 50% male:50% female ratio observed for untreated tilapia populations. Efficacy of MT treatment appeared slightly greater for Nile tilapia: male fish comprised 96.0% and 98.9% of treated populations in Trials I and II, respectively. Male fish comprised 84.6% and 65.1% of treated blue tilapia populations in Trials I and II, respectively. Deteriorated water quality in blue tilapia treatment tanks may have affected treatment efficacy, particularly during Trial II.

In conclusion, oral administration of MT to newly hatched tilapia fry for a 28-day period results in fish populations comprised predominantly of male fish. The results of these studies indicate that oral administration of MT does not affect growth or survival of tilapia fry during the treatment period.

MASS PRODUCTION OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) AND BLUE TILAPIA (*O. AUREUS*) FRY IN RELATION TO WATER TEMPERATURE

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Esam H. Rizkalla, Ahmed Nassr Alla, Ahmed Khater, and Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Abou Hammad, Sharkia, EGYPT

Abstract

A consistent, reliable supply of fingerlings of the desired species, sex, and size is critical to the success of any

aquacultural enterprise. Of the four tilapia species endemic to Egypt, Nile Tilapia (*Oreochromis niloticus*) and blue tilapia (*O. aureus*) are considered better species for pond culture than *Sarotherodon galilae* and *Tilapia zilli*. Hormonal sex reversal is the most efficient means of mass production of monosex tilapia fingerlings at present. Newly hatched fry 9- to 11-mm total length are fed androgen during a 28-day treatment period. Fry for sex reversal can be mass produced in earthen ponds, but water temperature can affect productivity. The objective of this research is to quantify production of Nile and blue tilapia fry in relation to water temperature in Egypt.

Sixty-three trials were conducted between 28 April 1994 and 24 November 1994 at the Central Laboratory for Aquaculture Research, Abbassa. Nile or blue tilapia broodfish were stocked into small (0.01 ha) earthen ponds at a rate of 1.5 female:1 male. Water temperatures in three ponds were monitored continuously by a computerized data logger. Mean hourly water column temperature was calculated. Degree days were calculated by subtracting the base temperature (15°C) from the mean daily water temperature. Accumulated degree-days for each trial were obtained by summation.

Fry production for all trials totaled 322,814 for Nile tilapia and 282,360 for blue tilapia. A mean of 10,087 Nile tilapia/0.01 ha and 9,108 blue tilapia/0.01 ha were obtained at each harvest. Target fry production, i.e., fry of suitable size for sex reversal, totaled 216,900 Nile tilapia and 209,112 blue tilapia. Mean harvest of target fry was 7,746 Nile tilapia/0.01 ha and 7,468 blue tilapia/0.01 ha. Production of both total and target blue tilapia was more variable than that of Nile tilapia.

No Nile tilapia fry production was observed at fewer than 115 degree-days. At greater than 100 degree-days total Nile fry production (expressed as fry/g female) increased significantly with increased degree-days ($Y = 0.013x - 1.445$, $r^2 = 0.563$, $p \leq 0.01$). Above 100 degree-days, production of target Nile tilapia fry per gram of female also increased with increased degree-days ($Y = 0.007x - 0.43$, $r^2 = 0.428$, $p \leq 0.01$). The percentage of total Nile tilapia fry production retained by the grader, i.e., too large for sex reversal, increased significantly with accumulated degree days above 190 degree days ($Y = 0.52x - 100.57$, $r^2 = 0.564$, $p \leq 0.01$).

Blue tilapia fry production did not occur at less than 115 degree days. Total blue tilapia fry production per gram of female broodfish increased significantly with degree days above 100 degree days ($Y = 0.016x - 1.832$, $r^2 = 0.469$, $p \leq 0.01$). Production of target blue tilapia at greater than 100 degree days increased significantly with accumulated degree days ($Y = 0.01x - 0.871$, $r^2 = 0.325$, $p \leq 0.01$). Above 190 degree days, the percentage of the blue tilapia fry population retained by the grader increased significantly with increased cumulative degree days ($Y = 0.463x - 89.698$, $r^2 = 0.481$, $p \leq 0.01$).

PROGENY TESTING TO IDENTIFY YY MALE TILAPIA

Ronald P. Phelps
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, U.S.A.

Abstract

Sex determination in *Oreochromis niloticus* has been described as an XX female:XY male system in which the presence of a Y chromosome establishes the male sex. If a genotypic male is sex reversed to a phenotypic female, and if that phenotypic (XY) female is crossed with a normal male, a portion of the offspring will be of the YY genotype. Fish of this genotype (YY supermales) would produce only Y sperm and produce only male offspring if this inheritance pattern holds true. However, a supermale can only be identified by examining the sex ratio of his offspring.

Past research initiated a breeding program which resulted in the production of several families with different sex ratios. Three of these families had 3:1 male to female sex ratios which could be expected from a cross of a XY female to a XY male producing viable YY offspring. Another three families exhibited a 2:1

male:female sex ratio, a result which suggests a lethal YY genotype. Males from these families were mated with normal females and the sex ratio of their offspring determined. If the theoretical model holds true, the observed sex ratio should be close to the theoretical sex ratio. A second set of experiments consisted of spawning males from families that produced more than 99% male offspring. In addition, two individual males, identified in the 1993 spawning season as producing more than 95% male offspring and therefore being potential supermales, were spawned again in the 1994 season to check the constancy of reproductive results.

Males from the three families with a 3:1 male:female sex ratio produced progeny with a mean percentage of 57.4% males. Only 11% of the tested males produced more than 95% male progeny. The expected values for a XX:XY inheritance pattern would have been 66.7% for the mean percentage and 33.3% for males that produce more than 95% male offspring. Males from the 2:1 male:female families produced 54.2% male progeny and 8.3% of the tested males produced more than 95% male offspring. Males from the families that produced more than 99% male offspring produced 43.4% male progeny. None of these males produced more than 95% male progeny.

These distributions are similar to that of the parent population which was used as a control and for which the values were 54.1% and 5.3%, respectively. In this parent population, individual males were identified that sired more than 95% male progeny. Repeat spawning of these individuals resulted in varying sex ratios, contrary to what would be expected from a XX:XY inheritance. Male “A” produced five sets of progeny; three were 100% male, one was 83% male, and one was 60% male. Male “B” produced four sets of progeny with the following sex composition: 63, 63, 74, and 95% males.

The results of these studies indicate that sex inheritance in the Ivory Coast strain of *O. niloticus* cannot be explained by a XX:XY system. The variance from the expected ratios suggests control mechanisms from both the male and the female genome. Such contributions complicate a YY supermale breeding program and will require additional selection to obtain true breeding lines.

BINDING SITES FOR THE MASCULINIZING STEROID MIBOLERONE IN THE GONADAL TISSUE OF ADULT NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

William L. Gale, Martin S. Fitzpatrick,
and Carl B. Schreck
Oregon Cooperative Fisheries Research Unit
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, U.S.A.

Abstract

A commonly used masculinizing agent in international aquaculture is 17α-methyltestosterone (MT). Although procedures are well established for using steroids as sex inverting agents, the physiological mechanism of action of these steroids is still unknown. Past studies have demonstrated that MT accumulates in the liver, digestive tract, kidney, and gonadal tissues of tilapia. The presence of MT in gonadal tissue and the profound changes that must occur in order to direct differentiation towards the development of testes suggests that they may be target organs for masculinizing steroids. The classical model of steroid action is through an intracellular receptor that once bound to a steroid acts as a transcription factor.

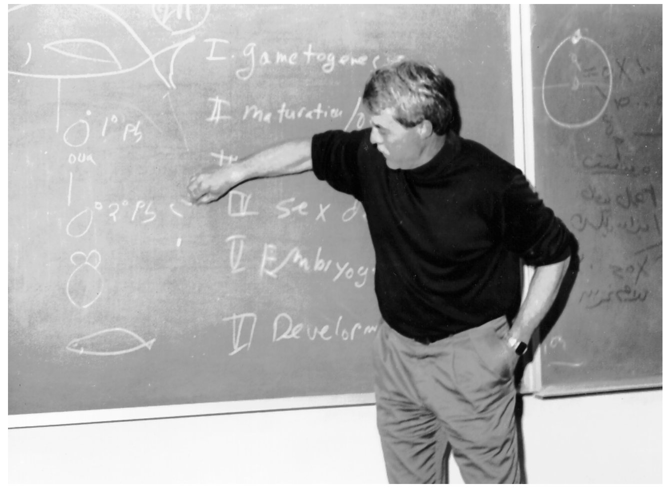
A binding site in the gonadal tissue of adult Nile tilapia (*Oreochromis niloticus*) was characterized using the synthetic androgen mibolerone (17-hydroxy-7,17-dimethylestr-4-en-3-one). The binding site demonstrated high affinity ($K_d = 1.03 \pm 0.11$ nM ; n=2) and low capacity ($B_{max} = 5.65 \pm 0.42$ fmol/mg protein; n=2) for mibolerone binding. Furthermore, it was located in gonadal cytosol only. The binding site also demonstrated ligand specificity. Only steroids with sex inverting capabilities displaced tritiated mibolerone binding. In addition a receptor assay based on the binding characteristics of different sex inverting agents was developed to determine in a fast and effective way the sex inverting potential of new synthetic steroids.

IMMERSION OF NILE TILAPIA IN 17α-METHYLTESTOSTERONE AND 17α-METHYLDIHYDROTESTOSTERONE FOR THE PRODUCTION OF ALL-MALE POPULATIONS

William L. Gale, Martin S. Fitzpatrick,
and Carl B. Schreck
Oregon Cooperative Fisheries Research Unit
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, U.S.A.

Abstract

Although hormone therapy for sex control has become nearly routine in aquaculture, there is room for improvement in selecting the safest and most effective hormones, as well as in developing procedures to minimize human and environmental exposure. The effectiveness of steroid immersion for masculinization of tilapia (*Oreochromis niloticus*) fry was examined. A 12-day exposure (between 10 and 22 days post-fertilization) to 17α-methyltestosterone (MT; 1000, 100, or 10 μg/l) was used initially, but resulted in high mortality and was ineffective in masculinizing the survivors. Factors such as paradoxical feminization and stress associated with steroid exposure and crowding may explain these observations. Further studies were conducted using 3-hr immersions in MT or 17α-methyldihydrotestosterone (MDHT) at 500 or 100 μg/l administered at 10 and 13 days post-fertilization. Mortality was considerably reduced with this treatment scheme as compared to the 12-day exposure. In one trial in which controls were 48% males, MDHT at 500μg/l produced 100% males; MDHT at 100 μg/l produced 78% males; MT at 500 μg/l produced 73% males; and MT at 100 μg/l produced 80% males. These results suggest that immersion offers potential as an alternative method for masculinization of tilapia and that further studies are warranted.



William Shelton (University of Oklahoma) lectures on black carp reproduction during a seminar at CLAR.

EFFECT OF 17α-METHYLTESTOSTERONE ON THE GROWTH OF TWO TILAPIA SPECIES, *OREOCHROMIS AUREUS* AND *OREOCHROMIS MOSSAMBICUS*, IN FRESH WATER

N. Harold Richman III and E. Gordon Grau
Hawaii Institute of Marine Biology
University of Hawaii at Manoa
Kaneohe, Hawaii, U.S.A.

Abstract

We examined the effect of 17α-methyltestosterone (MT) on the growth of two tilapia species, *Oreochromis aureus* and *Oreochromis mossambicus*, reared in freshwater. The growth rate of *O. aureus* was nearly twice that of *O. mossambicus* at each dose level (0, 1, 10, and 25 mg of MT/kg of feed). With the exception of *O. aureus* treated with 1 mg of MT/kg of feed, MT treatment significantly increased ($p \le 0.01$) growth in both species over control animals. In *O. mossambicus*, growth performance increased with increased levels of MT. By contrast, the 10 and 25 mg of MT/kg of feed treatments stimulated growth equally in *O. aureus*. The gonadosomatic index (GSI) was not significantly different between treatments within each species. It was, however, significantly lower ($p \le 0.0001$) in *O. aureus* than in *O. mossambicus*. Gonadal weights were not significantly different between species, which

suggests that the smaller GSI in *O. aureus* results, at least in part, from the larger somatic mass of the animals. In both species, the hepatosomatic index (HSI) and absolute liver weight tended to increase with increased levels of MT and were significantly greater ($p \leq 0.05$; $p \leq 0.01$) in the 25 mg of MT/kg of feed treatment groups than in controls. The male-to-female sex ratio was not significantly different from 1:1 in any treatment group in either species.

ADDITIONAL ACHIEVEMENTS: PUBLIC SERVICE AND COMMUNITY DEVELOPMENT

As a research program, the focus of the CRSP in Egypt was the generation of technical information; however, the achievements of the Egypt project encompass more than the successful completion of experiments. This is largely due to ancillary activities associated with the Egypt project. The collaboration between Egypt and the CRSP resulted in the strengthening of institutional capacities, the development of new linkages, and increased educational opportunities for Egyptian scientists and farmers in the Nile delta region.

Main entry into the Central Laboratory for Aquaculture Research at Abbassa, Egypt.

BOLSTERING INSTITUTIONS

In Egypt, the CRSP assisted with facility maintenance. Ponds at the Central Laboratory for Aquaculture Research in Abbassa were renovated to prepare them for the start of the CRSP experiments. The CRSP also supported the refurbishing of an over-wintering facility for tilapia. Egyptian aquaculture and fish research benefited from the collaboration of U.S. and Egyptian scientists, who developed a comprehensive list of 26 journals on aquaculture, fisheries, and aquatic environments to be included as serial acquisitions for the new library of the National Agricultural Research Project. The CRSP further contributed to the library at the Central Laboratory for Aquaculture Research by sponsoring two-year subscriptions to several journals. The visits of CRSP researchers in Egypt also enlarged the institutional and professional network available to students and faculty, strengthening both U.S. and Egyptian universities through these increased international linkages.

AMPLIFYING RESULTS

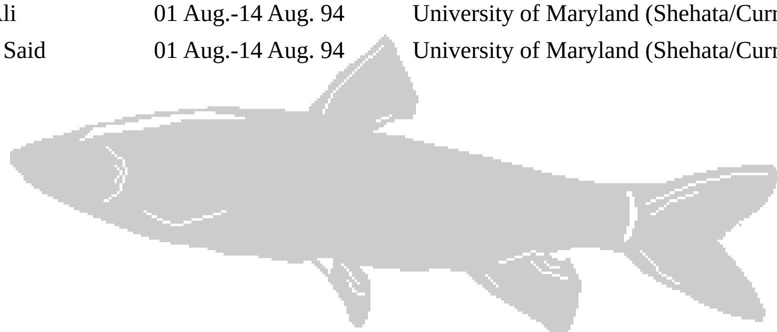
Formal training programs have not been funded by the CRSP Egypt project; nevertheless, the involvement of students constitutes an important part of the CRSP's international outreach. Ten students were supported by the Egypt project; six were working on advanced degrees, while four others conducted research at the University of Hawaii, at Auburn University, and at Oregon State University.

Scholarly Exchange Program

The centerpiece of the CRSP's professional development activities in Egypt was the scholarly exchange program. Twenty Egyptian researchers participated in this program. Egyptian scientists visited CRSP counterparts at their home institutions in the U.S. and abroad. Collaborative research was conducted at Oregon State University, Auburn University, the University of Oklahoma, the University of Hawaii, and the Asian Institute of Technology in Thailand. In addition, the Scholarly Exchange Program supported the attendance of CRSP Egyptian scientists at prominent scientific meetings,

Scholarly Exchange Program Overview

Name	*Dates*	*Destination (host)*	*Purpose*
Abdel R. El Gamal	16 Mar.-31 Mar. 93	University Oklahoma (Shelton),	collaborative visit
		CRSP Annual Meeting	CRSP Ann. Meeting
		Oregon State University (Goetze, Fitzpatrick)	collaborative visit
		Auburn University (Duncan)	collaborative visit
Ahmed Said Deyab	16 Mar.-31 Mar. 93	University Oklahoma (Shelton),	collaborative visit
		CRSP Annual Meeting	CRSP Ann. Meeting
		Oregon State University (Goetze, Fitzpatrick)	collaborative visit
		Auburn University (Duncan)	collaborative visit
Fatma Hafez	23 May-31 May 93	Torremolinos, Spain	WAS meeting
Gamal El Nagar	23 May-31 May 93	Torremolinos, Spain	WAS meeting
Ali Abdelghany	02 Oct.-09 Oct. 93	Hobart, Tasmania	Int'l Symp. on Fish Nutr.
Abdel Rahman Mostafa	05 Dec.-18 Dec. 93	Asian Institute of Technology, Thailand (Lin)	collaborative visit
Fatma Hafez	11 Jan.-19 Jan. 94	New Orleans	WAS meeting
Yassir Amad	11 Jan.-19 Jan. 94	New Orleans	WAS meeting
Ibrahim Shaker	11 Jan.-19 Jan. 94	New Orleans	WAS meeting
Hussein El Ghobashy	11 Jan.-19 Jan. 94	New Orleans	WAS meeting
Ali Abdelghany	11 Jan.-19 Jan. 94	New Orleans	WAS meeting
	19 Jan.-28 Jan. 94	NW Fisheries Science Center, Seattle (Hardy)	collaborative visit
Hussein Hebicha	30 Jan.-11 Feb. 94	Auburn University (Hatch)	collaborative visit
Ashraf Soliman	06 Mar.-19 Mar. 94	University of Oklahoma (Shelton)	collaborative visit
Hani Ebrahim	06 Mar.-18 Mar. 94	University of Hawaii (Grau)	collaborative visit
Ali Abdelghany	26 Mar-04 Apr. 94	Hilo, Hawaii	CRSP Ann. Meeting
	04 Apr.-08 Apr. 94	University of Hawaii (Grau)	collaborative visit
Zeinab Elnagdy	26 Mar-01 Apr. 94	Hilo, Hawaii	CRSP Ann. Meeting
	01 Apr.-16 Apr. 94	Auburn University (Boyd)	collaborative visit
Hussein El Ghobashy	08 May-21 May 94	Auburn Universiy (Dunham)	collaborative visit
Gamal A. Naser Mohamed	24 Jul.-05 Aug. 94	Oregon State University (Fitzpatrick)	collaborative visit
Khaled H. Hassan	24 Jul.-05 Aug. 94	Oregon State University (Fitzpatrick)	collaborative visit
Samir Ali Zein Elabedeen	01 Aug.-13 Aug. 94	Auburn University (Phelps)	collaborative visit
Ahmed Mostafa Khater	01 Aug.-13 Aug. 94	Auburn University (Phelps)	collaborative visit
Waheed Elwan Gadallan	01 Aug.-13 Aug. 94	Auburn University (Phelps)	collaborative visit
Nema A. Fatah Ali	01 Aug.-14 Aug. 94	University of Maryland (Shehata/Curry Woods)	collaborative visit
Samir Mohamed Said	01 Aug.-14 Aug. 94	University of Maryland (Shehata/Curry Woods)	collaborative visit



including the World Aquaculture Society conferences in both Spain and New Orleans, which promoted and facilitated Egypt project research.

Workshops and Seminars at the Central Laboratory for Aquaculture Research

As the collaborative process matured, workshops and seminars evolved to become an important component of the CRSP Egypt project. They provided a unique opportunity for information exchange that was specifically responsive to the needs of the attendees. Over 160 individuals (CRSP participants, outside researchers, farmers, and other interested people) participated in CRSP-sponsored workshops at the Central Laboratory for Aquaculture Research at Abbassa.

Workshops and seminars were conducted at Abbassa on a wide variety of topics, for example:

— Reproductive biology of fishes, a series of seminars and laboratory presentations covering reproductive physiology of fishes, induced breeding in fishes, sex differentiation in tilapia, sex identification of tilapia fry, and physiological sampling methods.

— Tilapia fingerling production, including field demonstrations of spawning pond harvest, broodfish handling, fry collection, handling and transport, and sex reversal treatment.

— Water quality management in aquaculture ponds, a two-day workshop which emphasized the influence of pond soils on water quality parameters.

— An Egypt CRSP field day was held at CLAR to highlight project progress and results to USAID and Government of Egypt personnel. Participants were informed about the status of the experiments and given a tour of the facility.

— An international workshop providing in-service training for Egyptian government aquaculture/ fisheries personnel covered a variety of topics. In an unprecedented move made possible through the contacts of a CRSP scientist, a leading scientist from Israel was invited by the Government of Egypt to participate in the workshop.

Linkage Development

The collaboration between the Central Laboratory for Aquaculture Research and the CRSP enabled both institutions to widen and strengthen their professional networks. The most visible success in this area is ICLARM's current interest in moving its research activities to the Central Laboratory for Aquaculture Research. Visiting CRSP scientists attended workshops at CLAR presented by University of Washington scientists discussing fish health management and nutrition, as well as a University of Arizona scientist's workshop on cage culture and integration of fish culture with irrigation water. A visit to CLAR by a U.S. Fish and Wildlife Service employee resulted in establishing communications with a group of fish farmers that had never previously communicated with CLAR or the CRSP. CRSP researchers also visited the Mariut Fish Farm and met with members of the Oceanic Institute. CRSP scientists discussed black carp studies with faculty of Zagazig University. The Director of the Aquatic Animal Health Research Institute in Thailand presented a seminar about diseases of cultured fish. Other connections included the Northwest Fisheries Science Center in Seattle and the University of Maryland.

These professional interactions contributed to a global information exchange, helped to increase the visibility of both the CRSP and CLAR, and promoted cooperation in research efforts.

ENDURING CONTRIBUTIONS:

CRSP Central Database

The standardized data collected during the Egypt project's Global Experiment research will be added to the CRSP Central Data Base. The CRSP Central Data Base contains standardized records from all CRSP research sites; thus, it provides opportunities for many kinds of global analyses. The data base was designed to facilitate communication with other large data bases, thereby creating opportunities for collaboration. CRSP scientists, as well as scientists in the aquaculture community at large, may contribute to and access the data base. To further broaden the use of and access to the database, the CRSP is currently collaborating with ICLARM to integrate the CRSP database with ICLARM's *FISHBASE*.

The Egypt data are particularly valuable because they represent a climate thus far not represented in the CRSP database. This will provide a new basis for comparisons between ponds. Further, information in the data base will be of use to the CRSP Data Analysis and Synthesis Team and will be incorporated into pond models. In this way the Egypt data will be of ongoing value to the CRSP and the aquaculture community. The result will be a deeper and more complete understanding of pond dynamics.

Economic Returns

The CRSP Egypt project generated substantial benefits to the U.S. as well as to Egypt. Not only did participating U.S. researchers benefit from collaborating with their Egyptian counterparts, but U.S. products and services were extensively involved in the project. Due to bilateral agreements, Egyptian scientists were able to purchase scientific equipment without having to pay duty and/or other fees. Over $123,635 was spent on equipment and airfare provided by U.S. companies. Although not a direct goal of the project, these "ripple" effects contribute to the wide-reaching positive influence of the CRSP project.

INSTITUTIONAL cOLLABORATION

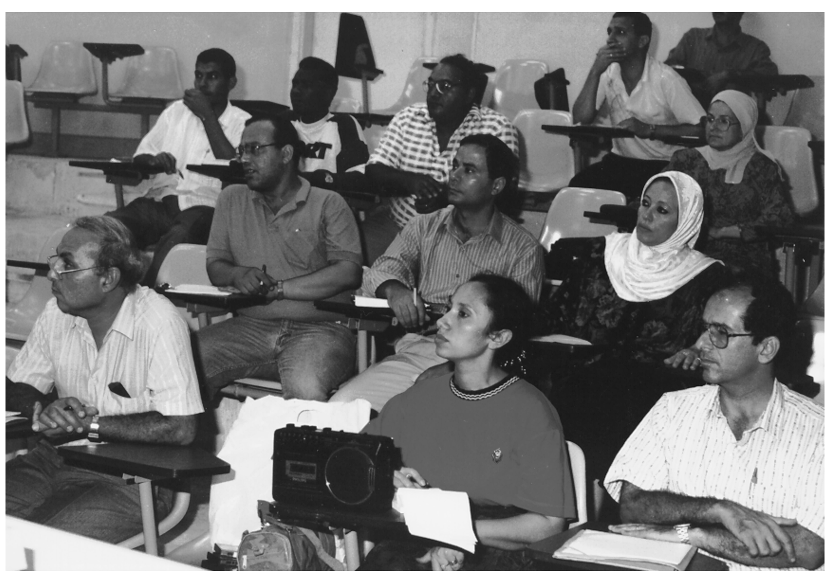
Research projects were conducted by members of the following institutions:

Auburn University, Auburn, Alabama, U.S.A.
Central Laboratory for Aquaculture Research, Abbassa, Abou Hammad, Sharkia, Egypt
Oregon State University, Corvallis, Oregon, U.S.A.
University of Hawaii, Hilo, Hawaii, U.S.A.
University of Michigan, Ann Arbor, Michigan, U.S.A./Asian Institute of Technology, Bangkok, Thailand
University of Oklahoma, Norman, Oklahoma, U.S.A.

Other institutional connections (through participation in the CRSP Technical Committee) involved the following U.S. universities:

Michigan State University, East Lansing, Michigan, U.S.A.
University of Arkansas at Pine Bluff, Pine Bluff, Arkansas, U.S.A.
University of California, Davis, California, U.S.A.

The Central Laboratory for Aquaculture Research falls under the authority of the Agricultural Research Center, Ministry of Agriculture and Land Reclamation.



Workshop participants at the Central Laboratory for Aquaculture Research in Abbassa, listening to presentations from visiting CRSP scientists.

PROJECT pARTICIPANTS

The Egypt project of the Pond Dynamics/Aquaculture CRSP represents the joint effort of 61 researchers, technicians, students, and support personnel from Egypt, the U.S.A., and Thailand. Twelve Egyptian scientists collaborated with twelve U.S. and one Thai researcher. The expertise of host country and U.S. personnel is broad-based and includes, but is not limited to, the following fields of specialization: general aquaculture, fisheries, limnology, water quality, biotechnology, physiology, nutrition, fish health, data management, soil science, chemistry, biology, social science, economics, and administration.

		FIELDS OF SPECIALIZATION					
Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
		MANAGEMENT ENTITY					
Hillary Egna	Director	X	X	X			Corvallis, Oregon
Brigitte Goetze	Deputy Director and Egypt Coordinator	X	X				Corvallis, Oregon
Marion McNamara	Assistant Director	X					Corvallis, Oregon
Naomi Weidner	Admin. Assistant	X					Corvallis, Oregon
		AUBURN UNIVERSITY					
Claude Boyd	U.S. Co-Principal Investigator		X	X			Auburn, Alabama
Bryan Duncan	U.S. Co-Principal Investigator	X		X			Auburn, Alabama
Bartholomew Green	U.S. Co-Principal Investigator	X	X	X	X		Abbassa, Egypt
Ronald Phelps	Researcher		X	X			Auburn, Alabama
Valentin Abe	Graduate Research Assistant		X	X			Auburn, Alabama
Shivaun Leonard	Graduate Research Assistant			X			Auburn, Alabama
Prasert Munsuri	Graduate Research Assistant		X	X			Auburn, Alabama
P. Parks	Fiscal Officer	X					Auburn, Alabama

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.

Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
		FIELDS OF SPECIALIZATION					
CENTRAL LABORATORY FOR AQUACULTURE RESEARCH							
Abdel Rahman El Gamal	H.C. Principal Investigator	X	X	X			Abbassa, Egypt
Ali E. Abdelghany	Researcher	X		X			Abbassa, Egypt
Hussein El Ghobashy	Researcher	X		X			Abbassa, Egypt
Gamal El Nagar	Researcher			X			Abbassa, Egypt
Fatma El Nemaky	Researcher				X		Abbassa, Egypt
Abdel Moez Faried	Researcher		X				Abbassa, Egypt
Fatma Hafez	Researcher			X			Abbassa, Egypt
Hussein Hebicha	Researcher				X		Abbassa, Egypt
Esam Hosny Rizkalla	Researcher			X			Abbassa, Egypt
Abdel Rahman Mostafa	Researcher			X			Abbassa, Egypt
Zeinab Attia Nagdy	Researcher		X				Abbassa, Egypt
Ahmed Said	Researcher			X			Abbassa, Egypt
Ahmed Khater	Research Associate			X			Abbassa, Egypt
Gamal Abdel Nasser	Research Associate			X			Abbassa, Egypt
Ibrahim Shaker	Research Associate		X				Abbassa, Egypt
Ahmed Abdel Fatah	Research Assistant			X			Abbassa, Egypt
Safwat Abdel Ghany	Research Assistant		X				Abbassa, Egypt
Khalid Hussein	Research Assistant			X			Abbassa, Egypt
Nabil Ibrahim	Research Assistant		X				Abbassa, Egypt
Dia A. R. Kenawy	Research Assistant		X				Abbassa, Egypt
Mohamed Abdel Salam	Research Assistant			X			Abbassa, Egypt
Naem Shamees	Research Assistant			X			Abbassa, Egypt
Namat Abdel Fatah	Chemist		X				Abbassa, Egypt

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.

FIELDS OF SPECIALIZATION

CENTRAL LABORATORY FOR AQUACULTURE RESEARCH (continued)

Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
Samir Said	Chemist		X				Abbassa, Egypt
Mona Hamed	Biologist		X				Abbassa, Egypt
Mostafa Abdel Mohsen	Biologist		X				Abbassa, Egypt
Samir Zain Elabeden	Technical Engineer			X			Abbassa, Egypt
Wahied Elwan	Technical Engineer			X			Abbassa, Egypt
Tharwat Ismail	Technical Engineer			X			Abbassa, Egypt
Ahmed Nassralla	Technical Engineer			X			Abbassa, Egypt
Ashraf Soluman	Technical Engineer			X			Abbassa, Egypt
Mohamed Wafik	Technical Engineer		X				Abbassa, Egypt
Seham Ahmed	Laboratory Assistant		X				Abbassa, Egypt
Mahmoud Abou El Nour	Accountant	X					Abbassa, Egypt

OREGON STATE UNIVERSITY

Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
Martin Fitzpatrick	U.S. Co-Principal Investigator	X		X			Corvallis, Oregon
Carl Schreck	U.S. Co-Principal Investigator	X		X			Corvallis, Oregon
William Gale	Graduate Research Assistant			X			Corvallis, Oregon
Robert Halvorsen	Fiscal Officer	X					Corvallis, Oregon

UNIVERSITY OF HAWAII

Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
Gordon Grau	U.S. Principal Investigator	X		X	X		Kaneohe, Hawaii
Kevin Hopkins	U.S. Principal Investigator	X		X	X		Hilo, Hawaii
Hal Richmond	Research Assistant			X	X		Kaneohe, Hawaii
Steve Shimoda	Research Assistant	X		X			Kaneohe, Hawaii
Bo Alexander	ResearchAssistant			X			Kaneohe, Hawaii
A. Chang	Fiscal Officer	X					Kaneohe, Hawaii

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.

Individual	CRSP Function	Research Administration	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Social Sciences	Location of Work (1)
			FIELDS OF SPECIALIZATION				
			UNIVERSITY OF MICHIGAN				
James Diana	**U.S. Principal Investigator**	**X**		**X**			**Ann Arbor, Michigan**
P. Stemple	**Fiscal Officer**	**X**					**Ann Arbor, Michigan**
			UNIVERSITY OF MICHIGAN/ASIAN INSTITUTE OF TECHNOLOGY				
C. Kwei Lin	**Principal Investigator**		**X**	**X**			**Bangkok, Thailand**
			UNIVERSITY OF OKLAHOMA				
William Shelton	**U.S. Principal Investigator**			**X**			**Norman, Oklahoma**
B. Quinn	**Fiscal Officer**	**X**					**Norman, Oklahoma**

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.

Staff at the Central Laboratory for Aquaculture Research at Abbassa take a seine sample for a mid-term evaluation of fish growth and survival in the polyculture experimental ponds.

FINANCIAL SUMMARY

The expenditure of funds for research and project management activities is summarized in the following table. Funding was provided under a grant from USAID/Cairo and the National Agricultural Research Project of Egypt (USAID Grant No. 263-0152-G-00-2231-00) and by the participating institutions, although cost-sharing was not required.

Research activities were conducted during the period from 1 October 1992 through 31 December 1994. Data analysis and report writing occurred during the period from 1 January 1995 through 31 March 1995. The project-end-date was 31 March 1995. This unaudited summary is still preliminary; a final financial report will be submitted to USAID by the Management Entity 90 days after the project end date.

EGYPT PROJECT ESTIMATED EXPENDITURES FROM 1 OCT. 92 THROUGH 31 MAR. 95

	USAID allocations[1,2]	USAID funds expended[1]	Voluntary contribution[3]	Total expenses
U.S.A.-based activities				
Research conducted in Egypt:				
Auburn University	$513,274	$508,798	$25,009	$533,807
University of Oklahoma	$111,596	$107,980	$20,883	$128,863
Subtotal	$624,870	$616,778	$45,892	$662,670
Research conducted in Thailand:				
University of Michigan/AIT	$24,684	$24,176	$7,836	$32,012
Subtotal	$24,684	$24,176	$7,836	$32,012
Research conducted in U.S.A.:				
Auburn University	$11,004	$11,004	$550	$11,554
University of Hawaii	$65,323	$65,300	$13,515	$78,815
Oregon State University	$110,906	$112,177	$25,497	$137,674
Subtotal	$187,233	$188,481	$39,562	$228,043
Management Entity				
Program Management[4]	$379,119	$375,093	$24,570	$399,663
Total U.S.A.	*$1,215,906*	*$1,204,528*	*$117,860*	*$1,322,388*
Transferred funds[5]	$125,600	$120,954	n.a.	$120,954
Total U.S.A. plus transferred funds	*$1,341,506*	*$1,325,482*	*$117,860*	*$1,443,342*
Egypt-based activities				
Total Egypt (incl. transfers)[6]	*$369,569*	*$369,569*	*n.a.*	*$369,569*
Total project[7]	**$1,585,475**	**$1,574,096**	**$117,860**	**$1,691,956**

Notes:

1 Values include subcontract charges
2 Based on obligations under grant no. 263-0152-G-00-2231-00
3 Estimates of U.S. university voluntary contributions
4 Also includes technical publications for the entire project and library support for CLAR
5 Transfers from the Egyptian portion of the budget to the U.S. portion of the budget were initiated to expedite travel authorizations and equipment purchases
6 Estimate based on original grant document budget
7 The sum of “Total U.S.A.” and “Total Egypt”