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New Fish Species Studied for Aquaculture Potential by Aquaculture CRSP Researchers

By Dharendra Prasad Thakur, Asian Institute of Technology

(Editor's note: This is the last article in a series discussing detailed aspects of biology of three fish species being studied for aquaculture potential.)

Climbing Perch (*Anabas testudineus*)

The climbing perch (*Anabas testudineus*) is a fish of tropical fresh waters of Asia and the Far East. The fish derives its name from the widely held belief that it can climb on trees, but this is actually a result of faulty observation.

A. testudineus is a very hardy fish. It is mostly caught from swampy and marshy tracts, as well as derelict pits, pools, and puddles that continue drying up during summer months. In its natural habitat, the fish can "walk" over dry land for some distance using its operculum and pectoral fins.

A. testudineus is in the family Anabantidae. It has an elongated body, with broad anterior and head, while the posterior is compressed. The dorsal side, and dorsal and caudal fins, are greenish to dark grey, while the belly, pectoral, and anal fins are pale yellow-colored. At the base of the caudal fin, a dark spot is present. *A. testudineus* is an obligatory air-breathing fish. In addition to four pairs of gills, it bears accessory respiratory organs—one pair of labyrinthine and respiratory membranes within the suprabranchial chamber. The fish is highly esteemed for its fine flavor and prolonged freshness out of water. The maximum recorded length is 26 cm.

Seed of *A. testudineus* can be collected from nature or obtained under controlled conditions. *A. testudineus* is notorious for migrating and breeding into prepared carp nurseries. This habit is advantageously used for seed production. Gonad maturity in *A. testudineus* manifests with early rains, and the retrogression is noticed abruptly from September. Breeding takes place only after rain fully sets in and fills ditches. According to Besra (1997), breeding season lasts between the middle of April to the middle of



Climbing Perch (*Anabas testudineus*)

June. In the laboratory, end of breeding was delayed as late as September. Induced breeding by hypophysation was successfully performed. Water temperature of $28 \pm 1^\circ\text{C}$ and darkness were important environmental factors for successful spawning. A female weighing about 50 g produces about 20,000 eggs. Eggs float in an upside-down position at the surface. Feeding commences from the second day. Ciliates, flagellates, and other such minute zooplankton form the chief

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Small-Scale Fish Farming is Picking Up as an Enterprise in Kenya

By Charles Ngugi, Moi University;
and James Bowman, Oregon State University

Small-scale fish farming has had many false starts in sub-Saharan Africa, dating back to the beginning of the twentieth century. Pessimists still consider aquaculture to be a risky enterprise and argue that it will take a long time for farmers to adopt the technology of pond fish production. They advance reasons such as lack of experience in fish breeding and poor economic returns to cash and labor investments, coupled with poor fish yields. Efforts to increase production from small-scale pond aquaculture have focused primarily on increasing either the surface area or the yield per area of ponds already in use. Such efforts have been receiving financial aid from donor agencies and other institutions to supplement the modest support coming from the states and governments.

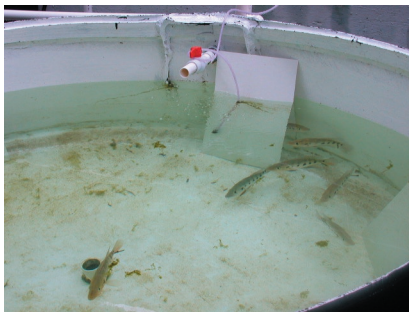
Fish farming in Kenya has a history of more than 50 years, yet the culture of tilapia and catfish remains primarily at the subsistence level. The potential for economically viable and sustainable commercial aquaculture has remained largely unrealized—ponds produce low yields, limited by the natural carrying capacity of the water body. Recently however, we have witnessed changes as some small-scale fish farmers have begun turning subsistence aquaculture into

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Ohio State Aquaculture Laboratory Expands Research Ties with Universidad Juárez Autónoma de Tabasco

By Mary Ann G. Abiado, The Ohio State University

Konrad Dabrowski, US Principal Investigator (PI) at The Ohio State University, visited Universidad Juárez Autónoma de Tabasco (UJAT), Mexico, from 26 to 29 October 2003. During the visit he discussed and planned the experiments for the project "Use of phytochemicals as an environmentally-friendly method to sex-reverse Nile tilapia" with Host Country PIs Wilfrido Contreras-Sánchez and Gabriel Márquez Couturier. Dabrowski gave a presentation to UJAT's academic community on "New developments in diet formulations for larval fish: peptides and growth enhancers."



Petenia splendida, one of several different native cichlids maintained at UJAT, in a flow-through circular tank as part of UJAT's initiative to develop propagation techniques for aquaculture and stocking practices.

Tilapia and other tropical cichlids are considered excellent aquaculture



UJAT's tropical gar broodstock rearing program.



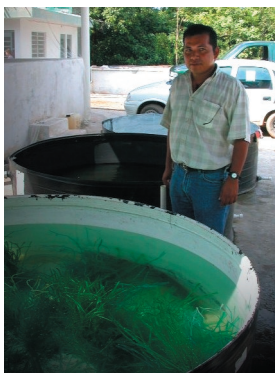
Tropical gar larvae at the UJAT aquaculture facility.

species in Mexico and other Latin American countries. The potential use of phytochemicals for sex reversal in tilapia could boost the marketability of this fish locally and internationally without the risk of potential human toxicity and environmental pollution caused by unregulated use of the synthetic androgen, 17 α -methyltestosterone.

Ohio State and UJAT will diversify collaborative ties to include nutritional studies on amino acid and fatty acid requirements of larval and juvenile tropical gar (*Atractosteus spatula* or *Lepisosteus tropicus*) and other candidate species for the local aquaculture industry and for recreational fisheries in Mexico. Ohio State's Aquaculture Laboratory has the facilities to determine amino acid and fatty acid concentrations of fish feeds and frozen fish tissues.

New aspects of the research on nutrition and diet formulation of tilapia and nutritional requirements of garfish have enormous practical applications to the fish farmers and to fish stocking programs implemented by the State of Tabasco. Numerous

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AquaBriefs

The Aquaculture CRSP is pleased to announce the inauguration of the new USAID Mission-CRSP Ambassador Program. The goal of the program is to increase Mission awareness of the CRSP—that is, of the breadth of the CRSP network and the broad array of technical services and expertise available to Missions via the CRSP. As CRSP Ambassadors to the missions, researchers, primarily host country nationals, will serve as country and regional resource persons on aquaculture and related water issues. Kenya first, then Mexico, and now Thailand, Cambodia, Viet Nam, and Bangladesh are among the first countries with CRSP Ambassadors. Other countries are slated to come online soon.

Barry Costa-Pierce, Director of Rhode Island Sea Grant as well as Associate Director of the Coastal Resources Institute at the University of Rhode Island, visited Oregon State University in October at the invitation of the Aquaculture CRSP. Costa-Pierce spoke to an OSU audience in a lecture based on his 2002 book "Ecological Aquaculture." Costa-Pierce served as chair of the special panel commissioned by USAID in 2003 to conduct a review of the global fisheries and aquaculture subsector.

Bureau for Economic Growth, Agriculture, and Trade: Office of Natural Resources Management: Water: Aquaculture CRSP is one way of depicting our "location" at USAID. As a partner in the Water Team, the Aquaculture CRSP has invited Barry Costa-Pierce to make a presentation, "Aquaculture Status and Trends," in late January at a Water Team discussion group. The CRSP plans to invite other guest speakers to the same forum throughout the year.

The Aquaculture CRSP Annual Meeting will take place this year on March 6, 2004, following the annual meeting of the World Aquaculture Society in Honolulu, Hawaii. Main topics for discussion among the members of the Technical Committee will be policy issues and the updating of a series of white papers. 

Farming in Kenya

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profitable small-scale enterprises. The widespread adoption of up-to-date fish farming technologies, especially in Kenya, has resulted in a sizable increase in pond production and has transformed many low-yield fish ponds into productive systems.

Supported by the Aquaculture Collaborative Research Support Program (CRSP), research at Moi University and Sagana Fish Farm has begun to identify alternative management practices and technologies that may be suitable for the region. Researchers have not assumed, however, that the results obtained under controlled experimental conditions are directly transferable to farms in the area. On-farm testing has therefore been undertaken as the logical step for transferring research-based technologies to the farm. On-farm testing of various alternatives has allowed farmers to

assess their costs and benefits under local conditions as well as to receive instructions and training in basic pond management skills. The conduct of such trials has also provided opportunities for project personnel to train and work with fisheries extension officers involved in trials at various locations, thus complementing training they have received in short courses offered by the Aquaculture CRSPs Kenya Project.

Results reported here were from on-farm trials conducted in collaboration between the Government of Kenya Fisheries Department, Moi University's Department of Fisheries, and the Aquaculture CRSP.

In phase one of the trials, thirty farmers were selected to participate in on-farm trials in four districts of Central Province and one district of Eastern Province, Kenya, in 1999–2000. Phase two of the trials (in the

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JIM BOWMAN

With help from Fisheries Officer Paddington of the Kenya Fisheries Department, fish farmer Jimmy Nabwera of Western Kenya has expanded his operation from one or two tilapia ponds to now include a water supply reservoir, several new ponds, and a small hatchery facility. Due to market preferences, he has also been shifting part of his effort from Nile tilapia to African catfish production.

Domestic Marketing Strategies for Small-Scale Farmers in Nicaragua

By Ivano Neira and Carole Engle, University of Arkansas at Pine Bluff

Rural farmers need to enter into the marketplace with appropriate products in order to obtain adequate returns on investment and sweat equity. In this way, farmers directly benefit from micro-enterprise. Moreover, concomitant trickle-up effects contribute to the wider community. The A CRSP has supported research in Nicaragua to better understand markets and marketing approaches. These

studies determined preferred sizes for tilapia in restaurants, supermarkets, and outdoor markets. Thus producers can time harvests in order to optimize product size for sale at specific venues.

Much of the tilapia supplied to markets in Nicaragua is caught wild from lakes and reservoirs. Larger tilapia are processed as frozen fillets and either exported to the United States or sold to Nicaraguan supermarkets. Small wild-caught tilapia are sold in local restaurants and supermarkets or are exported as fresh whole tilapia to other Central American countries.

Supermarkets in Nicaragua, on average, preferred larger tilapia products than did restaurants and open-air markets (Neira, 2002). This was true for fresh fillets in supermarkets (271 g), restaurants (87 g), and open-air markets (144 g) and for fresh whole-dressed fish in supermarkets (1,130 g), restaurants (294 g), and open-air markets (451 g), and frozen fillets (169 g in supermarkets and 96 g in restaurants). However, restaurants paid higher prices (average \$3.10 per kg) for tilapia than did supermarkets (\$2.96 per kg). Open-air markets paid the lowest prices (\$2.00 per kg). Neira

(2002) found similar trends for prices of fresh whole-dressed fish and frozen fillets. As one might expect, frozen fillets were more preferred by supermarkets than restaurants.

Thus, the most promising markets for small-scale tilapia farmers appear to be restaurants and supermarkets because these outlets pay higher prices for fish than vendors in open-air markets.

An earlier survey found that larger restaurants that considered tilapia to be a high-quality product and that offered ceviche on the menu were those that tended to sell tilapia. Restaurants that did not sell tilapia appeared to be newer, smaller restaurants specializing in seafood. The most promising restaurant markets for tilapia farmers appeared to be older established restaurants that offered a variety of different types of food on the menu and, for example, served steaks.

The challenge for tilapia farmers will be to raise the size of tilapia required to produce the preferred sizes of fillets. To produce the size preferred by restaurants (87 g) will require farms to produce 580 g tilapia.

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IVANO NEIRA

Most tilapia sold in markets is sold as fresh fillets.

Graduate Student Profile: Emmanuel Vera Cruz

By Ian Courter

After graduating high school in 1980, Emmanuel Vera Cruz recognized that aquaculture presented an opportunity to conduct research in a new and rapidly developing field. Native to the Philippines, he saw many ways to improve aquaculture in his country. This inspired him to attain a Masters degree from Central Luzon State University (CLSU) in 1991, and he currently pursues his doctorate in Aquaculture from Florida International University (FIU).

According to Vera Cruz, the Philippines are gifted with an abundance of available land and water resources ideal for many types of aquaculture. However, the conflicts between aquaculture and other forms of agriculture have slowed growth and limited the resources available to aquaculturists. Vera Cruz believes that disputes over land, feeds, and labor have been key factors in limiting the growth of aquaculture in the Philippines. In addition, pollution of important bodies of water caused by poor aquaculture practices and industrial contaminants also suppress aquaculture's popularity and

productivity in the region.

Vera Cruz hopes to play an important role in remedying some of the problems with aquaculture in the Philippines. The CRSP project he is involved with titled, "Cost Containment Options for Tilapia Production in Central Luzon, Republic of the Philippines," is uncovering ways to reduce operating costs and increase the profit of tilapia farming. To date, the project has successfully evaluated the methods and technologies available to local aquaculturists. One finding was that traditional feeding quantities might be greater than necessary to optimize profitability.

All production studies encounter a similar problem—not enough time or resources to collect adequate data. Conventional methods of growth rate analysis require tedious measurements of body weight over time. Another CRSP investigation that Vera Cruz is working on could provide the solution. The idea is that IGF-I measurements can assess growth rate much more quickly than conventional body size measurements. The project is still underway.

With help from his advisor Christopher Brown of FIU and collaborating researcher Russell Borski of North Carolina State University, Vera Cruz

hopes to overcome the challenges of assessing the correlation between tissue concentration of IGF-I and growth rate. To do this, a complex RNase protection assay will be performed. Although difficult to precisely execute, the assay is the most exciting aspect of his research thus far. Before analyzing tissue samples from the field, Vera Cruz will establish the accuracy of the procedure on tissues with known



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Ohio State Aquaculture

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town meetings and workshops are planned to discuss the best approaches for technology transfer of the current research results. 🐟



MARY ANN G. ABIADO

Jacques Rinchart and Kyle Ware from Ohio State's Aquaculture Laboratory measure fatty acid concentration of fish tissues.

concentrations of IGF-I.

After graduation, Vera Cruz plans on continuing his research on Nile tilapia. He believes that, "Nile tilapia are the most promising freshwater fish species in the Philippines for the new millennium." Vera Cruz will return home after his project is finished at FIU. He hopes to continue his research at the CLSU, Freshwater Aquaculture Center in the Philippines. 🐟



D.G. VERA CRUZ

Emmanuel Vera Cruz

Graduate's Corner

Congratulations to George Owiti Osure for the successful defense of his Master's thesis in September 2003 at Auburn University, Auburn, Alabama. Osure was first featured in *Aquanews* in the Graduate Student Profile (Vol. 18 No. – Fall 2003). His accomplishments include receiving the Best M.S. Student Award given annually by the Department of Fisheries and Allied Aquaculture. Osure's major professor was CRSP Principal Investigator Ron Phelps at Auburn. Osure is especially keen to see aquaculture realize its potential to benefit Kenya socially and environmentally. Once back in Kenya, he will resume working at the Kenya Department of Fisheries and aims to obtain funding for a Ph.D. project. We wish him every success with his future career in aquaculture.

Evaluation of Reproductive and Growth Performance and Microsatellite Variability of Four Strains of Nile Tilapia (*Oreochromis niloticus*, L.)

(abstract of George Osure's M.S. thesis)

Tilapia have gained recognition as important aquaculture species in tropical and sub-tropical climates and have become one of the most abundantly produced fish in aquaculture. Nile tilapia, native to various regions in Africa, is one of the primary species being cultured. Much of the stocks being cultured are based on a limited number of collections from the wild, which may differ in their reproductive and growth characteristics. An evaluation of reproductive and growth characteristics and microsatellite variability of four strains of *O. niloticus* was done at Auburn University, studying three domesticated strains (Egypt, Ivory Coast and Sagana) and one wild (Lake Victoria) strain. In the first part of the study, strains were evaluated as to their reproductive characteristics and growth potential at different life stages and under different management conditions. Brood fish were stocked into individual 2 m³ hapas suspended in 20 m² concrete tanks at the ratio of 3 males to 7 females. Four replicate hapas were used per strain. Hapas were checked every 7 days for females holding eggs or sac fry in the mouth. Females holding eggs or sac fry were removed and transferred to the hatchery for weighing, counting and subsequent incubation of eggs and sac fry in 40-L aquaria until hatching. Growth was evaluated at primary and secondary nursery stages. In the secondary nursery stage, growth was studied in outdoor concrete tanks and indoor aquaria on a recirculating system. Genetic analysis was done using microsatellite markers. Thirteen primer pairs of *O. niloticus* were obtained from earlier work done by Lee and Kocher (1996) for use in amplification reactions. Amplification products were then subjected to electrophoresis on 7% acrylamide gel followed by manual scoring of alleles. Results obtained on reproductive characteristics showed no significant differences ($P > 0.05$) among the four strains for relative fecundity (eggs/g female weight). However, significant differences among strains in spawning and incubation successes were observed. There were no significant differences in growth performance among the strains ($P > 0.05$). However, significant growth differences were observed across production systems at the secondary nursery stage. Genetic analysis showed moderate overall strain differentiation with an overall F_{ST} value of 0.18. All four strains showed some heterozygote deficiency when tested for Hardy-Weinberg equilibrium with observed heterozygosities falling short of expected values.

Aquaculture CRSP Awards

The Aquaculture CRSP is pleased to announce the awardees in the Pre-Conference World Aquaculture Society (WAS) 2004 Awards for Aquaculture CRSP Students and Pre-Conference WAS 2004 Awards for Aquaculture CRSP Professionals. Seven student and three professional awards were given. Student eligibility criteria included involvement in a CRSP project since 1996, the beginning of the current grant, with preference given to students presently pursuing a degree. Professional eligibility criteria included CRSP involvement, with preference given to those

presenting direct impacts of CRSP work and those presenting value-added research with CRSP work as its foundation. Awardees' names are listed below, along with their abstract entry title to 2004 WAS.

Congratulations to all.

Student Awards Recipients

Fred Chu-Koo, Southern Illinois University, Carbondale—Christopher Kohler, Major Professor—for: Chu-Koo, F.W., C. Kohler, W. Camargo, L. Rodriguez, and F. Alcantara. Seed Dispersal by Frugivorous Amazonian Fish.

Eddie Boy T. Jimenez, Central

Luzon State University, Philippines—Remedios Bolivar, Major Professor—for:

Jimenez, E.B.T., R. Bolivar, and C.

Brown. Cost of Containment Option in Semi-Intensive Tilapia Culture: Evaluation of Alternate Day Feeding Strategy.

Maria Esther Palacios, The Ohio State University—Konrad Dabrowski, Major Professor—for:

Ostaszewska, T., M.E. Palacios, and K. Dabrowski. Growth and Morphological Changes in Digestive Tract of Rainbow Trout and Paku Due to Fish Meal Protein Replacement with Soybean Products.

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Nicaraguan Markets

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The even larger size of fillet preferred by supermarkets make this outlet even less feasible. In addition to preferences for larger fillets, processing costs are higher to fillet smaller fish.

Tilapia growers, especially small-scale producers, will likely benefit from development of markets for whole-dressed tilapia products that can be produced more cheaply and moved at higher volumes. However, this will only be possible if consumer fears related to product source can be alleviated. Tilapia farmers could perhaps take advantage of the negative perceptions of wild-caught tilapia by differentiating their farm-raised product from the wild-caught fish associated with contamination fears and off-flavor. Radio and other advertising programs could be used for farm-raised tilapia to compete effectively with native Nicaraguan species in the whole-dressed form.

Issues related to quality of fish and seafood need to be addressed on a broad-scale in Nicaragua. Buyers and consumers alike appear not to have a clear idea of how to handle fish properly. The government could conduct broad-based consumer education programs that emphasize the quality of farm-raised tilapia. Manuals and other printed materials with guidance on proper fish handling as well as educational meetings would be of great

benefit.

Surveyed restaurants and supermarkets indicated that they would be very likely to offer farm-raised tilapia if negative perceptions about off-flavor and fear of contamination of wild-caught tilapia were changed. Tilapia farmers and processors in Nicaragua will need to guarantee and ensure the flavor, quality, and safety of their product and promote these attributes to gain market share.

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IVANO NEIRA

Fisherman fishing for wild tilapia in Lake Nicaragua, the second largest of the country's natural lakes.

Climbing Perch

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food or larvae at this stage.

A. testudineus is omnivorous but shows definite preference for insects. The scope of its natural food, however, is very wide. It can vary from a diet of filamentous algae to purely carnivorous. Pandey (1987) mentions that the alimentary canal structure indicates the fish has a tendency towards carnivorous and predatory habits. This fish feeds within the water column as well as on the bottom and has a short and slightly coiled intestine (Mookerjee and Majumdar, 1946).

A. testudineus can be cultured in monoculture, or in polyculture systems with *Clarias batrachus* or *Heteropneustes fossilis* or both. It can also be grown in composite fish culture ponds together with carps. Since the fish has a tendency to "walk out" of ponds, dykes should be sufficiently steep (75 degrees or more) to prevent escape of the fish.

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Farming in Kenya

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western region of Kenya) began with a visit to the six districts selected for the trial. Pre-trial workshops included farmers, extension agents, Kenyan and US CRSP personnel, and students working on research projects in both phases. These were held to discuss and select management schemes for testing, to agree on how the trials would be conducted, and to plan for proper record keeping during the

trial period. Ponds for the trials were stocked, and sampling was conducted on a monthly basis. Post-trial workshops were held to evaluate the results of these trials.

Fifty-two ponds were stocked in Central and Eastern provinces, while 28 ponds were stocked in Western and Rift Valley provinces. Both stockings were done with monosex male tilapia (*Oreochromis niloticus*), mixed-sex tilapia, and/or catfish (*Clarias gariepinus*). Stocking densities were 2 fish per m² for tilapia, 2 fish per 10 m² for catfish

stocked with tilapia, and 1 fish per m² for catfish stocked alone. Management schemes tested included high, medium, and low management levels. Ponds were sampled for fish growth at four- to six-week intervals, and farmers kept records of input type and weight, input costs, pond water additions, fish mortality, and fish sampling data. The trials lasted from 7 to 11 months.

As a result of their participation in these trials, farmers learned that

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improved management could indeed lead to increased production, something of which they were not convinced prior to the trials. The average increase in fish harvested in Central and Eastern provinces during these trials was 330 percent (3.5 t ha^{-1} , as compared with an estimate of just over 1 t ha^{-1} prior to the trials). Almost two-thirds of the ponds reported net revenues exceeding KSh 250,000 $\text{ha}^{-1} \text{ yr}^{-1}$; the average being KSh 310,832 $\text{ha}^{-1} \text{ yr}^{-1}$. Farmers also concluded that increasing the sizes of their ponds would contribute to increases in production.

Of the total 28 ponds stocked in Western and Rift Valley provinces, two ponds had dried up during the course of the trial and were eliminated from the list. Only one pond had gross annualized production of less than $5 \text{ t ha}^{-1} \text{ yr}^{-1}$. The overall average was $7.8 \text{ t ha}^{-1} \text{ yr}^{-1}$. Fish yield from this trial was 224 to 873 percent higher compared to the reported yields for the year preceding the trial. The average increase was 480 percent. Net annualized revenue (not counting fingerling costs) averaged KSh 494,000 $\text{ha}^{-1} \text{ yr}^{-1}$, which is higher than for Central or Eastern provinces. Pond records showed that 80 percent of the fish ponds netted over KSh 250,000 $\text{ha}^{-1} \text{ yr}^{-1}$.

When fingerling costs are included, average net annualized revenue was KSh 438,000 $\text{ha}^{-1} \text{ yr}^{-1}$. Most western region ponds were in warmer areas compared to Central Province. Four of the districts reported afternoon water temperatures of 28°C , whereas only one of the districts in Central (Kirinyaga) province had such warm water. Several farmers noted that sugarcane—the main cash crop in the region—nets them less than one-tenth this amount and has a growing cycle of 26 to 30 months.

Despite farmers having paid little attention to keeping records on expenditures in previous years, they claimed an enormous increase in net revenues, as many of them had never made any money from their fish ponds before. One farmer who did keep financial records had a six-fold increase in net revenues from his two ponds.

After talking with other farmers and researchers during the post-trial meeting, farmers quickly realized that they could have used cheaper ingredients and improved their results. The cost of inputs per kilogram of fish yield was very instructive. The highest input costs resulted from the use of dairy meal as the main feed ingredient. Dairy meal contains about the same amount of protein as wheat bran but costs twice as much. In previous aquaculture projects, use of dairy meal had been a prominent extension recommendation. Cost of feed and fertilizer averaged KSh 22 per kg of fish yield, reflecting cheaper prices for inputs. Because there were few examples of low and medium management intensity, it is difficult to draw conclusions. However, it is clear that spending more can actually result in greater net revenues, not just higher fish yields.

Although clarias monoculture resulted in the greatest fish yields, it brought in relatively low net revenues. Tilapia monoculture resulted in lower gross annualized yields but higher net revenue than clarias monoculture. The best overall performance was achieved where tilapia and clarias were stocked together. Farmers who practiced partial harvests had greater fish yields and higher net revenues than those who harvested all at once. It is possible, however, that the farmers who practice partial harvests are more experienced managers, as suggested by the high management level of all ponds in the partial harvest option. All of the low and medium management ponds fell under the total harvest category. The partial harvest option (followed by draining) should be considered and tested by researchers when designing their experiments and promoted by the extension service.

Increased tilapia-catfish produc-



JIM BOWMAN

Jimmy Nabwera's expansion effort has included construction of a small hatchery facility, which he uses to spawn African catfish. Participants in a CRSP-sponsored training course are being shown Nabwera's hatchery and spawning procedures during a field trip in May 2003.

tion will require that all nutritional requirements be met by the ration fed to fish. A combination of on-farm inputs, together with a fertilization regime, can be used at reduced cost to intensify yields. In addition, development of a cost-effective fish feed may increase profitability of fish farming in the region and stimulate commercial aquaculture enterprises. A general lack of business planning advice for fish farming in Kenya makes it difficult for investors to plan for a fish farm as an enterprise. Sample enterprise budgets for commercial-scale fish farms allow banks to make decisions on lending.

Farmers, extensionists, and researchers learned a number of lessons about technology dissemination, adoption, and development of small-scale enterprises in both regions of Kenya. The study showed that with better management, farmers' production could increase by over 300%. It was also observed that frequent visitation increased farmers' confidence and stimulated intensified management. Most farmers, irrespective of the region, expressed satisfaction with the technology and were in favor of expanding operations. They also expressed their desire to continue farming fish using the most economic feeds for better and higher returns. Farmers recommended that problems of credit non-availability and inadequate supply of fingerlings be given priority in future efforts. 🐟

Notice of Publication

Notices of Publication announce recently published work carried out under Aquaculture CRSP sponsorship. To receive a full copy of a report, please contact the author(s) directly.

CRSP RESEARCH REPORT 03-196

MINIMIZING ENVIRONMENTAL IMPACTS AND REUSE OF POND EFFLUENTS AND MUD

Yang Yi and C. Kwei Lin
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A wide range of aquaculture systems is practiced in Asia, predominantly in semi-intensive systems with fertilization and intensive systems with formulated feeds in pond culture. This paper describes various means to minimize environmental impacts and reuse pond effluents and bottom mud, based on a series of pond experiments of the most commonly cultured species in Thailand, hybrid catfish (*Clarias macrocephalus* × *Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus*). Experiment 1 was designed to improve feeding efficiency through optimization of feeding regime to reduce nutrient inputs in Nile tilapia culture; the results show that there were no significant differences in fish yield among daily feed rations at 50%, 75%, and 100% satiation, but the nutrient loading was escalated with increasing rations. The second experiment on hybrid catfish and Nile tilapia culture in cage-cum-pond systems shows that major nutrient input from formulated feed could be effectively recycled in a closed pond where hybrid catfish were cultured intensively with formulated feed in cages and Nile tilapia with natural food in an open pond. The third experiment was conducted to determine appropriate harvest methods and draining treatments for reducing pollutants from Nile tilapia ponds; the results show that liming pond water a day before draining and gradually draining ponds to a 25-cm depth during harvest was most effective. An experiment conducted to reuse effluents from hybrid catfish culture to fertilize rice crops demonstrated that the rice crop removed 32% total nitrogen (TN) and 24% total phosphorus (TP) from the effluents, with rice production comparable to that which received regular fertilization regime. The last experiment was to determine the efficiency of rooted aquatic plants in extracting nutrients from pond mud. The results show that the economic aquatic plants, such as lotus (*Nelumbo nucifera*), were able to remove 300 kg N and 43 kg P/ha/year from pond substrates.

This abstract is excerpted from the original paper, which was published in *Aquaculture*, 226:57–68.

CRSP RESEARCH REPORT 03-197

A COMPARATIVE ANALYSIS OF THE FIXED-INPUT, COMPUTER MODELING, AND ALGAL BIOASSAY APPROACHES FOR IDENTIFYING POND FERTILIZATION REQUIREMENTS FOR SEMI-INTENSIVE AQUACULTURE

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This paper compares three different strategies/treatments for determining fertilization rates for producing natural foods in semi-intensive aquaculture ponds. The first strategy used a predetermined, fixed-input rate of nitrogen (N) and phosphorus (P) based on results from previous yield trials. The second strategy was based on algal nutrient concentrations, and used biweekly water quality measurements in combination with a microcomputer-based expert system, PONDCLASS[®], to determine fertilization rates. The third approach, the algal bioassay fertilization strategy (ABFS), was based on algal growth responses to nutrient [i.e., N, P, and carbon (C)] enrichment, and used weekly, pond-specific algal bioassays to determine both nutrient requirements and associated rates of nutrient inputs. The three fertilization strategies were applied to Nile tilapia (*Oreochromis niloticus*) growout ponds over a 120-day period, with five ponds per treatment. All ponds were fertilized weekly with urea, triple superphosphate, agricultural lime, and/or chicken manure in amounts determined by each strategy.

Results indicated that net fish yields (NFYs) were not significantly different ($P = 0.094$) between treatments, with the fixed-input treatment giving the highest but most variable yields. Average NFYs ± S.E. (standard error) for the 120-day growout period were 2124 ± 276 , 1476 ± 151 , and 1651 ± 133 kg ha⁻¹ for the fixed-input strategy, PONDCLASS[®], and ABFS treatments, respectively. The relatively lower NFYs for PONDCLASS[®] and ABFS indicate that neither approach maximized fish production.

Nitrogen utilization efficiencies of fertilizer inputs were similar for all three strategies. Although the fixed-input approach used approximately 20% more N than the other two approaches, mean algal productivities and NFYs were also proportionally higher with this treatment. This result is consistent with the observation that algal productivities in PONDCLASS[®] and ABFS ponds were nearly always limited by N availability.

However, both P utilization and fertilization cost efficiencies were significantly better with PONDCLASS[®] and ABFS than with the fixed-input treatment. The fixed-input approach not only used a higher P input rate than necessary, it did not account for ecological differences between ponds

within the same treatment (e.g., nutrient and light limitation of algal productivity, inorganic turbidity, etc.), which can affect a pond's response to fertilization. In particular, the fixed-input treatment did not add carbon to compensate for nonuniform losses in alkalinity, which resulted in relatively high soluble P concentrations in treatment ponds where C availability apparently limited algal productivity. Including C fertilization in the fixed-input treatment would have likely reduced NFY variability and improved P utilization efficiency in those ponds.

Because both PONDCLASS® and the ABFS adjusted pond-specific fertilization requirements throughout the study, they provided increased fertilization efficiencies and profitability over the fixed-input strategy. However, the ABFS is more practical than PONDCLASS® for rural application because it is far simpler and does not require water chemistry, computers, laboratory equipment, technical expertise, or electricity to implement. Based on this study, the recommended fertilization strategy designed to achieve cost-efficient, consistently high yields is a modified ABFS approach that uses a fixed-input fertilization rate for N, and algal bioassays to determine time-specific and pond-specific fertilization requirements for P and C.

This abstract is excerpted from the original paper, which was published in *Aquaculture*, 228: 189–214.

CRSP Awards

...from p. 5

Gustavo Rodriguez, The Ohio State University—Konrad Dabrowski, Major Professor—for:

Rodriguez, G., K.J. Lee, W. Contreras, K. Park, and K. Dabrowski. Evaluation of Two Phytochemicals, Genistein, and Quercetin as Possible Sex Differentiation-Affecting Agents in *Tilapia Nilotica* by Dietary Administration.

Kam Silapajarn, Auburn University—Claude Boyd, Major Professor—for:

Silapajarn, K. and C. Boyd. Particle Size and Reaction of Agricultural Limestone.

Orawan Silapajarn, Auburn University—Claude Boyd, Major Professor—for:

Silapajarn, O. and C. Boyd. Nitrogen and Phosphorus Concentrations and Loads in a Stream Receiving Catfish Farm Effluents.

Elizabeth Trejos-Castillo, Auburn University—Joseph Molnar, Major Professor—for:

Trejos-Castillo, E. and J. Molnar. Income, Food Security, and Poverty Reduction: Case Studies of Small-scale Aquaculture Producers in Santa Barbara, Honduras.

Professional Awards Recipients

Suyapa Meyer Triminio for:

Meyer, S., J. Molnar, and D. Meyer. *Tilapia* Fingerling Producers in Honduras: Characteristics, Practices and Needs.

Christopher Knud-Hansen for:

CRSP RESEARCH REPORT 03-198

APPLICATION OF GIS AND REMOTE SENSING FOR ASSESSING WATERSHED PONDS FOR AQUACULTURE DEVELOPMENT IN NGUYEN, VIETNAM

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Asian Institute of Technology
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Nguyen Xuan Cuong and Le Thanh Luu
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This study was conducted in Dai Tu district of Thai Nguyen province during November 2001–January 2003 to assess the aquaculture development potential for watershed ponds by integrating socio-economic and environmental data into GIS database, detecting land use change, and identifying and estimating potential areas for aquaculture development in watershed ponds. The socio-economic and environmental data were collected using pre-test questionnaires and field measurements. Three SPOT multi-spectral band satellite images were used to detect land use change during three periods of 1994–1998, 1994–2002, and 1998–2002. For land suitability evaluation, the suitability ratings were established according to FAO classification in terms of suitability of land for defined uses. Aquaculture production and economic returns from interviewed farmers were used to verify the results and comparisons among different land suitability levels.

The present study has predicted that about 4.7% (2,725 ha) of the total land area of 57,618 ha in Dai Tu district are suitable sites for watershed pond construction, compared to the existing 404 ha watershed ponds. The present study has demonstrated the usefulness of integration of remote sensing, GIS and attribute data to select suitable sites for the development of watershed ponds, and the importance to be a useful tool for planners to develop strategic plans for aquaculture development.

This abstract is excerpted from the original paper, which was published online at <<http://gisdevelopment.net/application/nrm/water/overview/ma03166.htm>>.

Knud-Hansen, C., Y. Derun, Y. Yi, and T. Batterson. Potential for Using Clinoptilolite Zeolites for Ammonia-N Transfer and Retention in Integrated Aquaculture Systems.

Ivano Neira for:

Neira, I. and C. Engle. Restaurant Markets for Aquaculture Products in Peru: A Descriptive Analysis. 

Announcement:
Aquaculture at AAAS 2004
14 February 2004
Seattle, Washington

ERSP researcher Joseph Molnar, Auburn University, is the organizer of a special aquaculture session at this year's American Association for the Advancement of Science meeting in Seattle, Washington. The session, "Aquaculture: Recent Advances in Fish Culture, Breeding and the Mitigation of Environmental Impact," will be held in the afternoon of Saturday, 14 February 2004.

With over a quarter of the fish consumed worldwide already being raised in ponds or tanks (mostly in China), an international debate grows over questions as to whether the aquaculture industry can really take fishing pressure off the world's oceans. Vast expanses of coastal shrimp ponds dominate coastlines in Thailand and Ecuador; net cage operations now supply most the world's salmon along the shores of Norway, Chile, and British Columbia. With a growing world population and marine fisheries in

decline, fisheries experts have long hoped that aquaculture might one day take up the slack. Knowledge of fish genomes may facilitate the inheritance of economically important traits, determine genotype and environment interactions, develop breeding strategies for improving reproduction, accelerate growth, and improve feed efficiency.

Feeds for many farmed species generally contain high levels of fishmeal from species generally not used for human consumption. New approaches to feeding will ensure that fishmeal is used more sparingly to improve the economic sustainability of aquaculture. In most producer countries, farmed shrimp is almost entirely an export crop and it is also a very important source of foreign exchange. Over one-third of the shrimp consumed worldwide is now raised in ponds like those that nearly define the Gulf of Thailand eastern coastline. Mangrove destruction and aquaculture effluents have created many environmental problems, particularly during periods of rapid expansion of new industries. While some maintain

that the aquaculture industries have matured, others maintain that many problematic practices continue. The symposium will feature discussion from speakers with diverse views of aquacultural development, focusing on how scientific advances may enhance its prospects and mitigate its pitfalls.

Confirmed speakers and their presentations include:

John Liu, Auburn University, "Mapping the Catfish Genome: DNA Marker Technologies, Linkage Mapping and Functional Analysis."

Chhorn Lim, U.S. Department of Agriculture/ Agricultural Research Service, "New Directions in Fish Feeds and Feeding: Long Term Implications."

Claude E. Boyd, Auburn University, "Overcoming the Environmental Barriers to Aquacultural Development."

Mark Prein, WorldFish Center, "The Growing Significance of Aquaculture in World Food Security."

Nguyen Thanh Phuong, Can Tho University, "Shrimp Farming in Vietnam: An Overview."

Announcement and Call for Papers: IIFET 2004 Conference

26-29 July 2004
Tokyo, Japan

The International Institute of Fisheries Economics and Trade (IIFET) has issued its second call for abstracts for our next biennial conference, IIFET 2004 Japan: What are Responsible Fisheries?

Conference topics on a wide variety of seafood markets, fishery management, and aquaculture-related issues will attract the world's foremost fisheries economists from academia, industry, government management agencies, and international agencies. Seafood processing, marketing, and consumption issues, medical and ornamental substances from the sea, and international seafood trade issues will be covered, as well as policy issues including capacity reduction, fishery

management by cooperatives, ecosystems approaches to management, and bio-economic models.

The conference will be held at the Tokyo University of Fisheries, 26-29 July 2004. Additional options will include a pre-conference professional tour 21-23 July visiting fishery management/marketing cooperatives, and 24 July visiting Tsukiji market and other links in the Japanese seafood market chain in Tokyo, plus a post-conference symposium.

Please consider submitting an abstract and/or joining us as an audience member. Anyone with an interest in the economics of fisheries and aquaculture is welcome to participate. A limited amount of funding will be available to provide grants to individuals from developing countries who submit abstracts for presentation on aquaculture-economics related topics.

IIFET is an international profes-

sional association open to anyone with an interest in the economic aspects of fisheries management, seafood markets, and aquaculture. Our primary goal is to provide a neutral international forum for the exchange of information, ideas, data, and solutions, among individuals from academia, industry, government, and international organizations. For more information on IIFET, or to join, please visit <<http://oregonstate.edu/Dept/IIFET>>.



Announcement: Latin American Tilapia Workshop

8-11 June 2004

Puerto Vallarta, Mexico

The Aquaculture CRSP recently received notice of the First Latin America Tilapia Workshop to be held 8-11 June 2004 in Puerto Vallarta, Mexico. The theme of this exciting event is the Present Situation on Technology, Development and Market Perspectives for Tilapia and Byproducts.

The four-day workshop offers a unique opportunity for participants to share experiences, knowledge, and publications with top tilapia specialists from throughout the Americas, including members of the Latin American Association of Tilapia Producers (LAATP).

The workshop comprises five sections in which speakers will present topics that represent priorities of the LAATP. Each section will be chaired by a special guest who is a recognized professional in the tilapia sector.

The sections are:

- Genetics and Reproduction;
- New Reproduction Technologies;
- Nutritional Developments;
- Pathology and Aquafarming Health;
- Processing and Marketing; and
- Norms and Financing for the Sector.

Each section will include participants reporting on their own research, state-of-the-art technology, statistics, and the current status of tilapia production in their native country or region. To date, colleagues from Bolivia, Brazil, Colombia, Costa Rica, United States, France, Honduras, Mexico, Peru, and Venezuela have confirmed their attendance.

The cost of the workshop is \$250 (members) or \$300 (non-members), and \$1,000 for exhibitors with a display booth. Mexican nationals with State and Federal Government affiliations will be able to attend at a cost of \$150, subject to availability. Small and medium producers and Mexican technicians working in the private sector or for FIRA will be eligible for assistance.

The workshop will be held at the Hotel Plaza Pelicanos in Puerto Vallarta. The hotel offers a preferred rate for groups booking in advance.

Participants without reservations will be subject to room availability at the regular rate. Alternatively, other hotels are nearby.

Only registered participants can take advantage of the hotel's all-inclusive plan. This includes room (with air-conditioning, telephone, and en suite bathroom) and meals (breakfast, lunch, and dinner). Complimentary drinks and afternoon snacks are offered. Hotel amenities include nightly stage shows, four bars, two restaurants, and two snack bars. Additionally, guests have a full range of activities to choose from during the day.

Please direct all correspondence regarding the event, including registration, to the event coordinators:

Luis Fernando Castillo
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Announcement and Call for Papers: ISTA 6

Sept 12-16, 2004

Manila, Philippines

The Sixth International Symposium on Tilapia in Aquaculture will be held at the Philippines International Convention Center and the Westin Philippine Plaza in Manila. The ISTAs are held every four years and are the only international conference devoted to this rapidly growing industry. Past symposia have highlighted the advances in various regions of the world, and now after 16 years it will return to Asia.

ISTA 6 will be hosted by the Bureau of Fisheries and Aquatic Resources of the Philippines Department of Agriculture. Other major sponsors include the Aquaculture CRSP, the World Aquaculture Society, Schering-Plough Aquaculture, Global Aquaculture Alliance, and FYD International. Cen-

tral Luzon State University and the University of Arizona will assist with planning and organization.

The focus of the meeting will be the exploding trade in tilapia products and the role of Asia, and especially the Philippines, as a center of advancement in technology as well as production for the international markets. The conference will include technical presentations, producer workshops, an industry trade show, and farm tours.

Social events will include a welcome reception at the Westin Plaza with its spectacular location on Manila Bay across the street from the Convention Center. It will also include a dinner at Intramedios, the magnificently restored old city with its forts, museums, galleries, and restaurants.

The Proceedings of the ISTAs have been one of the most important sources of information on tilapia

aquaculture and the advances in the science and industry over the last 20 years. This tradition will continue with the Proceedings being prepared in book and electronic form. Prospective authors are invited to submit manuscripts to:

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Deputy Director
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Central Luzon State University
Munoz, Nueva Ecija 3120
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Phone: (044) 456-0681; (044) 456-0680
Fax: (044) 456-0681
Email: rbolivar@mozcom.com

Please submit manuscripts in electronic file form. Microsoft Word for PC is the preferred format. Additional conference details and author instructions are available at <<http://ag.arizona.edu/azaqua/ista/announce2.htm>>.

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AQUANEWS

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