



AQUAFISH COLLABORATIVE RESEARCH SUPPORT PROGRAM NEWSLETTER

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POLYCULTURE OF FRESHWATER PRAWNS WITH THE NUTRIENT-DENSE SMALL FISH MOLA: A SOLUTION FOR INCOME AND HOUSEHOLD NUTRITION IN BANGLADESH

By Jim Diana and Md. Abdul Wahab



Seining a Mola-Prawn pond in Fulpur, Bangladesh. Photo by Shariful Islam

The AquaFish CRSP project in Bangladesh was implemented to develop an innovative, sustainable polyculture technology for all-male freshwater prawns and a small fish known locally as mola (*Amblypharyngodon mola*) to increase the average productivity of high-value prawns for export and to provide mola for household consumption. The project idea was conceived during the late Dr. Yang Yi's last visit to Bangladesh, when he saw that prawns were being cultured in small-scale household systems in monoculture, depriving the family of fish for household consumption throughout the culture period. Through the efforts of Bangladesh Agricultural University (BAU), the University of Michigan, and the AquaFish CRSP research team, the management of prawn culture has progressed from one focused on export sales of the high-value prawn to one that is optimized for production of an exportable product (prawns) while providing fish for farm family consumption.

Bangladesh is rich in inland waters that are suitable for culturing giant freshwater prawns (*Macrobrachium rosenbergii*). In response to the high export potential of cultured prawns, there is an initiative to increase production up to 60,000 mt in 80,000 ha of low-lying floodplains and homestead ponds over the next 10 years. A recent survey showed that annual prawn yields are in the range of 300-

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600 kg/ha, which is relatively low. This production can be increased through improved management and diversification of technologies. All-male prawn culture may be one of the options to increase production, but this needs verification through on-station and on-farm trials comparing it to mixed-sex and all-female populations.

The country also faces the dual challenge of feeding its own people and increasing export earnings through the development of new products and technologies. Polyculture of freshwater prawns (for the export market) in the same ponds with the nutrient-dense small fish mola (for household consumption) may be an innovative option. Mola has been found to contain concentrations of vitamin-a and other essential micronutrients up to 50 times higher than most fishes consumed by the Bangladeshis. If mola and prawns could be cultured together, the farmers may have the opportunity to harvest mola for family consumption throughout the year without affecting the production of the cash crop, the prawn. Mola is an omnivorous surface feeder, which can improve the culture environment for prawns by grazing on phytoplankton blooms, thus reducing oxygen deficiency problems. Moreover, its feces may be enriched with bacteria, which would serve as a good food source for the detritivorous prawns.

The project was set out to address the following three specific objectives through a series of studies carried out at BAU's Fisheries Field Laboratory:

- To compare the growth and production performances of all-male and all-female freshwater prawns in pond culture systems;
- To evaluate the effects of adding mola at different densities on pond ecology and the production of freshwater prawns and the total production of both species in polyculture; and
- To understand the effects of selective harvesting of prawns and partial harvesting of mola on cash crop production and on family nutrition.



Nutrient-rich Mola harvested from a pond. Photo by Shariful Islam.

In addition, an alternate polyculture technology including prawns, mola, and two carp species with optimized stocking densities of each species has been tested and validated in rural farms in Fulpur Sub District, Mymensingh.

The production performances of all-male and all-female freshwater prawns in monocultures were evaluated simultaneously with addition of mola into polyculture at different densities with freshwater prawn. The experiment had five treatments: all male prawn + 1 mola/m², all male prawn + 1.5 mola/m², all male prawn + 2 mola/m², only male prawn, and only female prawn (T₁, T₂, T₃, T₄ and T₅, respectively). Prawn stocking densities were the same (3 juvenile/m²) in all treatments, which had been optimized earlier. The survival of prawns in monoculture irrespective

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of gender was lower than in polyculture with mola. Net production of prawns and mola in treatment 3 was 562 kg/ha. All growth parameters and net production of all-female prawn was significantly lower ($P < 0.05$) than growth and production in all-male monoculture and in polyculture treatments at different densities of mola.

The addition of mola at different densities had no effect on survival, weight gain, or production performance of the freshwater prawns. Therefore, mola may be stocked as an additional species with freshwater prawns to provide higher total production and improved family nutrition, simultaneously generating additional income.

In order to more fully utilize the production potential of the polyculture ponds, the effects of adding silver carp (*Hypophthalmichthys molitrix*) and catla (*Catla catla*) to mola-prawn polyculture were also evaluated. The experiment had five treatments: T_1 (prawn and mola), T_2 (prawn, mola and catla), T_3 (prawn, mola and silver carp), T_4 (prawn, mola, catla, and silver carp), and T_5 (only mola). The stocking density of mola was varied to produce approximately the same total fish biomass in all treatments. Stocking densities were 40 juvenile prawns and 2 carp/m². Survival of freshwater prawns in the prawn-mola-carp polyculture system was higher when prawns and mola were stocked with silver carp and catla or with silver carp alone, compared with prawns with only mola or with mola and catla. Net production of prawns was significantly higher with silver carp and with silver carp-catla, as compared with only mola or mola-catla. The balanced stocking densities of prawn-mola with catla-silver carp developed synergies and resulted higher net yield (622 kg/ha).

The effects of selective harvesting (SH) and claw ablation (CA) of blue-clawed prawns in all-male prawn-fish polyculture system were also studied. Ponds were stocked with all-male prawns, silver carp, catla and mola at 12,000, 2,000, 500, and 20,000 per ha, respectively. Over a 137-day culture period, SH resulted in a higher

($P < 0.05$) net production of freshwater prawn (437 kg/ha) followed by CA (354 kg/ha) and co-culture (322 kg/ha). The combined net production of prawn plus fish was also higher in SH (1,244 kg/ha).

Polyculture of prawns with mola and small numbers of filter feeding carps like silver carp and catla may create an ecologically balanced pond culture system, where synergies take place that result in higher total production than does monoculture of any of the species. All-male prawn cultures that are selectively harvested at the appearance of blue claw results in higher production than the other management options tested. Results also indicate that mola should be partially harvested regularly using a lift net or small seine net to keep its population

under control and provide family nutrition year round. The prawns can then be considered a cash crop, being sold at a higher price as an export item to provide family income.

Through this series of experiments, Bangladesh has developed an all-male prawn production technology and has established that selective

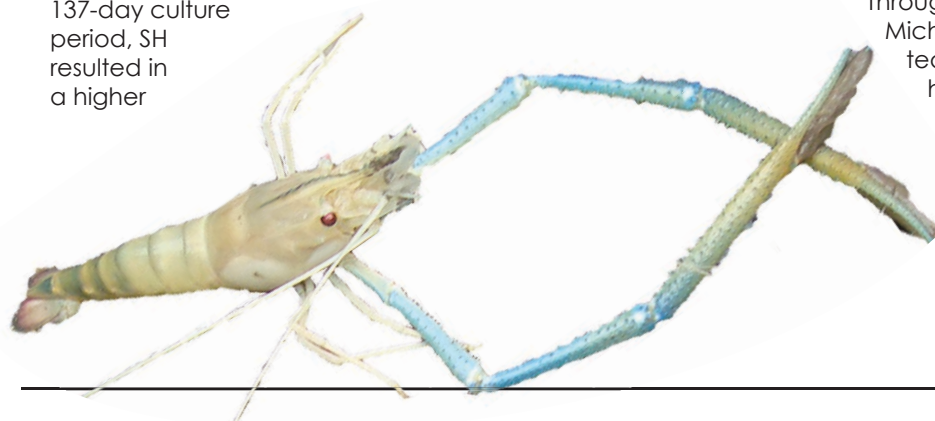
harvesting is a better management technique for increased prawn production. Through production of the nutrient-rich mola and partial harvesting using a lift net, household consumption can be increased to secure family nutrition.

Freshwater prawn and mola polyculture technology has been widely accepted by extension agencies like DoF, WorldFish Center, and Winrock International for large-scale dissemination using their countrywide networks. The technology has spilled over to West Bengal and Nepal and is in the process of expansion there. A training and extension manual in the Bangla language has been prepared by the WorldFish Center with the technical assistance of the BAU research team for countrywide dissemination of the PRAWN-MOLA culture technology. After these two trials, efforts were made to improve harvesting strategies of prawn and mola for higher production as well as better economic and nutritional performance.

Through the efforts of BAU, the University of Michigan, and the AquaFish CRSP research team, the management of prawn culture has progressed from one focused only on export sales to one that is optimized for large-scale dissemination among small-scale farmers. The technology provides a comparable or higher income for farmers, additionally providing household food as well.

"BAU researchers have demonstrated 'Prawn-Mola' culture technology in my farm. I can now regularly feed my family with mola-curry and sell prawn in the market."

Prawn farmer Israfil



GOINGS-ON IN THE POND...



The Association of Public and Land-Grant Universities (APLU) recently published the report "Feeding 10 Billion: A Dialogue Between Feed the Future and the International Research Community" under USAID leadership and in coordination with USDA. The document represents a new phase in the relationship between USAID and the higher institution research community, of which AquaFish CRSP is a part. The report can be found here: www.aplu.org/document.doc?id=3664

AquaFish CRSP is co-sponsoring the 16th Biennial Conference of the International Institute for Fisheries Economics & Trade in Dar es Salaam, Tanzania. IIFET 2012 Tanzania: Visual Possibilities: The Economics of Sustainable Fisheries, Aquaculture, and Seafood Trade will be held on 16-20 July 2012.

Congratulations to **Mohottala G. Kularatne** on winning the IIFET 2012 Developing Country Aquaculture Economics Best Student Paper Award for his paper, "Reservoir Water Re-Allocation in Community Welfare." Funding for this award is provided in part by AquaFish CRSP contributions to the conference.

The Horticulture CRSP has compiled a flyer for the CRSP Council that showcases the impressive caliber of the CRSP PIs. Please find the flyer here: bit.ly/P7MeZA

The AquaFish Management Team has also created a similar flyer specific to AquaFish researchers, which can be found here: aquafishcrsp.oregonstate.edu/researcher_survey

The AquaFish CRSP team at North Carolina State University, Central Luzon State University in the Philippines, and the NOAA Milford Laboratory in Connecticut have produced a series of seven podcasts on tilapia aquaculture from the NCSU "Practical Feeding Strategies" project. The podcasts are available through the following link: itunes.apple.com/us/itunes-u/tilapia-podcasts/id380416353

The CRSP digest website was recently launched, where you will find information on all the CRSPs including research achievements, success stories, publications, and videos. Look for more in the next newsletter and take a peak at the new website here: www.crsps.net

For meeting and employment opportunities visit our Education & Employment Opportunities network EdOpNet database online at aquafishcrsp.oregonstate.edu/edop.php or visit lists.oregonstate.edu/mailman/listinfo/edopnet to subscribe to receive opportunity listings monthly via email.

Milestones

The AquaFish CRSP Management Team would like to acknowledge and congratulate Dr. Jim Bowman on his recent retirement after many years of dedicated work, which dates back to 1984 when he started his CRSP funded PhD at Oregon State University. Jim has made countless invaluable contributions to the program and has been a major asset to our team in Oregon. He has always taken great care in all he does and has fostered great friendships along the way. Though Jim will remain involved in CRSP work on a part time basis, his everyday presence at OSU will be missed. Congratulations to Jim from the Management Team and the entire CRSP community.



AQUAFISH CRSP AIR BREATHING FISHES RESEARCH

By Stephanie Ichien and Remedios Bolivar

Air breathing fishes represent a unique biological group. While they belong to diverse genera, all have developed the ability to obtain oxygen from the air, allowing them to survive in waters exhibiting anoxic conditions. This characteristic allows them to cope with a variety of environmental conditions and makes them more resilient to environmental change. As aquatic habitats become degraded and climate change shifts global temperatures upwards, the value of these fish will become apparent owing to their ability to survive poor water quality conditions and in some cases even extended drought. Whether for human consumption, the aquarium trade, or biodiversity enhancement, the culture of species resilient to climate change may be pivotal for diversifying sustainable solutions in aquaculture. However, this varied group of fishes has not been well studied and there are many challenges to be overcome in the process of developing them as culture species.

Air breathers are a diverse group of fishes from a range of environments and possessing a variety of mechanisms for breathing air. They fall mainly into one of two categories—obligate air breathers, which must breathe air, and facultative air breathers, which can rely on their gills for oxygen until it becomes necessary to breathe air. In recognition of their importance, the AquaFish CRSP director, Dr. Hillary Egna organized a symposium dedicated to this group of fishes on 18 April 2011 in Shanghai, China. The outcome of the symposium

...Air breathing fishes continued on page 5.

...Air breathing fishes continued from page 4.

was a set of seven supplemental CRSP investigations, each aiming to characterize one of these species and its natural habitat. Five of the seven initial investigations were completed in early 2012, with research on two of them—the pacific fat sleeper (*Dormitator latifrons*) and the gar (*Atractosteus* spp.) continuing on and a third on lungfish (*Protopterus* spp) positioned for continuation. The seven studies include the following:

Prospects and Potential of the African Lungfish (*Protopterus* spp): An Alternative Source of Fishing and Fish Farming Livelihoods in Uganda

Auburn University and the Aquaculture Research and Development Center of the National Fisheries Resources Research Institute (Uganda)

Effects of Environmental Conditions on Gills and Gas Bladder Development in Bimodal-Breathers, Gar (*Lepisosteus* spp.), Pirarucu (*Arapaima gigas*) and Bowfin (*Amia calva*)

University of Hawaii, the Ohio State University, Sao Paulo State University (Brazil), and Jagiellonian University, Krakow (Poland)

Sustainable Feed and Improved Stocking Densities for Gar (*Atractosteus* spp.) Culture

University of Michigan and Universidad Juarez Autonoma de Tabasco (Mexico)

Effect of Different Temperature and Salinity Levels on Stress Response of Marble Goby (*Oxyleotris marmorata*) Fingerlings

Nong Lam University (Vietnam)

Development of Improved Culture Techniques on Gouramis (*Trichogaster pectoralis*, *T. trichopterus*, and *Osphronemus goramy*) for Small-scale Rural Freshwater Aquaculture, Aquarium Industry, and Stock Enhancement in the Philippines

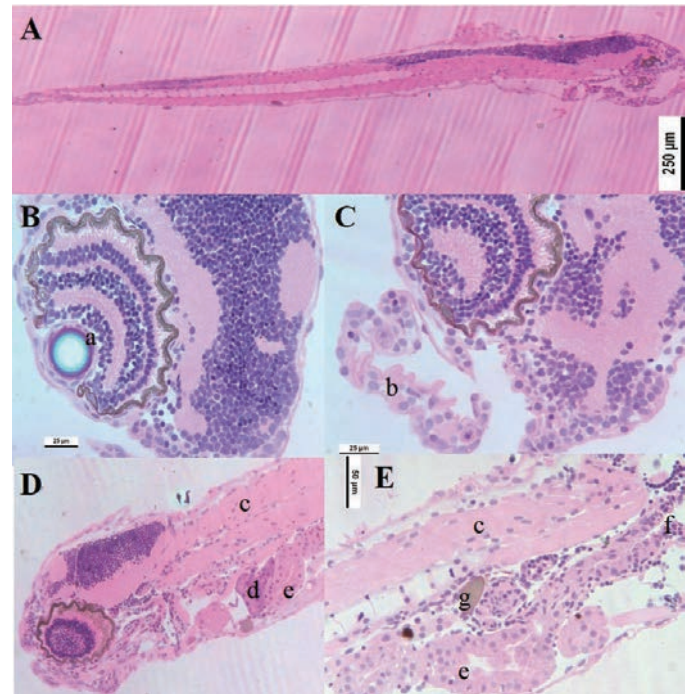
Freshwater Aquaculture Center, College of Fisheries, Central Luzon State University (Philippines) and Mindanao State University (Philippines)

Sustainable Snakehead (*Channa striata*) Aquaculture Development in Cambodia

Inland Fisheries Research and Development Institute (Cambodia) and Freshwater Aquaculture Research and Development Center (Cambodia)



150 cm 25 kg alligator gar. Photo courtesy of Jim Diana and Solomon David.



Chame (*Dormitator latifrons*), 5dph. **A:** whole larvae, **B and C:** head, **D and E:** digestive tract; **a:** eye, **b:** lower jaw, **c:** muscle fibers, **d:** pancreas, **e:** stomach, **f:** esophagus, and **g:** remnants of yolk. Image courtesy of Guillermo Rodriguez

Improvements in Spawning Control, Larval Growth, and Survival of Pacific Fat Sleeper (*Dormitator latifrons*)

University of Hawaii, Universidad Autonoma de Sinaloa (Mexico), Sao Paulo State University (Brazil), and the Ohio State University

With the first phase of work on air breathing fishes mostly complete and research continuing on for some, here we highlight some of the research accomplishments for this special group. In Cambodia, researchers identified at least 35 populations of striped snakehead (*Channa striata*) from Tonle Sap (Great Lake) and collected 703 live breeders for fin clippings to be used for genetic characterizations. Future work in Cambodia will identify traits favorable for a snakehead breeding program. Similarly, CRSP researchers working to develop improved culture techniques for gouramis in the Philippines collected samples for genetic characterization and discovered intra-specific differences between two major clades within the snakeskin gourami population. In Mexico and Ecuador, AquaFish CRSP researchers were able to document the embryonic development of larval pacific fat sleepers (chame) and processed samples of larvae for histological analysis in an effort to determine optimal breeding protocols for each larval stage in this species' development. Lastly, work on ideal stocking density for Cuban gar has revealed the best growth at the lowest density (25 fish/m³) starting with gars weight on average 13.00 g and 15.66 cm in length

Final research reports for the air breathing fishes investigations can be found on the AquaFish CRSP website at: aquafishcrsp.oregonstate.edu/Air%20Breathing%20Fish/



AQUAFISH CRSP STUDENT CORNER...

GRADUATE STUDENT PROFILE: LING CAO

By Stephanie Ichien and Jim Bowman
Photo below, courtesy of Ling Cao

From an early age Ling Cao has understood the importance of healthy natural water resources and the relationships between the health of aquatic ecosystems and the health of human communities. She has since nurtured a long-lasting interest in aquatic sciences and sustainable food production. Under the guidance of her major professor, AquaFish CRSP Lead Project PI Dr. Jim Diana, Ling recently completed her PhD in the School of Natural Resources and Environment at the University of Michigan. She started her PhD program at UM in 2007 and completed it in December of 2011. Her research on sustainable shrimp aquaculture in rural areas of Asia focused specifically on the environmental impacts and economic performance of rural shrimp aquaculture. Ling's dissertation, entitled "Farming Shrimp for the Future: A Sustainability Analysis of Shrimp Farming in China," consisted of a life-cycle assessment of shrimp production, mathematical modeling of nutrient dynamics, and a socioeconomic analysis of system profitability. Ling hopes that the results of her research will improve the well being of rural communities, and that she can help rural farmers optimize their aquaculture systems for environmental sustainability, economic viability, and social acceptability.

Ling has been involved with the CRSP for over five years and continues to build on her skills as an aquatic research scientist. Ling first became involved with CRSP work in 2005, as a master's student under the former Aquaculture CRSP, when she was the only student among 34 presenters at a two-day Aquaculture CRSP Workshop at Huazhong Agricultural University in Wuhan, China. At the workshop, Ling presented a talk titled "Current Status of Pond Aquaculture and Waste Water Management in China," in which she pointed out the need to manage wastewater more efficiently for more sustainable freshwater aquaculture. As a result of this talk, Ling received CRSP funding to study the impacts of phytase in aquaculture feeds at the Asian Institute of Technology. Ling's focus in the research was to evaluate the role of phytase in increasing phosphorous retention in fish and thus reducing phosphorous loading in waters receiving pond effluents. In 2007, Ling was sponsored by the CRSP to present this work at the World Aquaculture Society annual conference in San Antonio, Texas. There she met her current major professor, who invited her to pursue a PhD with support from the AquaFish CRSP UM project.

Ling grew up in Chongqing, Southern China, where her time spent fishing and cruising on the local reservoir sparked an interest in aquatic sciences and sustainable food production. From excursions with her father and brother, she recalls: "Waterfowl danced and sang around us, and water in the reservoir was clean and fresh—today this pristine setting is no more." As intense fish farming around the reservoir replaced rice farming, water quality became severely degraded. Ling comments, "... the song birds from my youth are no longer seen or heard around the reservoir." While she was growing up, Ling's father was an active member of a pioneering group of citizens concerned with protecting their natural water resources. He taught Ling how to measure water quality and about the importance of healthy aquatic ecosystems. From these experiences, she developed an academic interest in aquatic resources and has carried that through her undergraduate and graduate work in Asia and her PhD program in the US.

"Water fowl danced and sang around us, and water in the reservoir was clean and fresh—today this pristine setting is no more."

When asked about the challenges and successes of aquaculture, Ling's response makes it clear that she is an insightful researcher and has been pursuing a line of research that is very meaningful to her and her country: "Aquaculture

provides important trade and livelihood opportunities for poor rural farmers in many developing countries. In addition to providing a significant source of export revenue, it also constitutes a vital component of domestic food consumption and trade."



...Ling Cao continued on page 7.

...AQUAFISH CRSP STUDENT CORNER

KUDOS TO SAMMY MACHARIA

Congratulations to Sammy Macharia from Kenya for successfully completing Auburn University's Certification of Aquaculture Professional (CAP) program. AquaFish CRSP sponsored Sammy to pursue the certification, and he is the first in Africa to complete the course. Kenya has one of Africa's fastest growing aquaculture sectors and will truly benefit from young knowledgeable professionals such as Sammy. Congratulations to Sammy and to everyone who made this possible.

...Ling Cao continued from page 6.

"Aquaculture is regarded as one avenue to mitigate the threats to the world's fisheries by taking at least some of the pressure off wild fish stocks while supporting livelihoods and food production. However, serious environmental concerns have been raised related to aquaculture production, such as water pollution, invasive species, increased salinity and the destruction of mangrove forests."

"The expansion of shrimp farming, in particular, has generated global concerns over negative environmental impacts and economic issues caused by direct discharge of effluent from shrimp farms."

In her research Ling took a comprehensive look at the sustainability of the shrimp aquaculture industry, with the hopes of addressing some of these issues and improving the ecological, economical, and social well-being of rural communities. She began by using a life cycle assessment to identify key stages in the shrimp production life cycle that have significant impacts on the environment. Next, Ling used mathematical models to characterize nutrient dynamics and to quantify the eutrophication pollution potential of shrimp farming. Finally, in the last stage of her research, she applied a socio-economic analysis to determine the profitability potential of implementing more sustainable aquaculture practices by rural small-scale farmers. The overall outcomes of the research will include generating a direct evaluation and comparison of the different shrimp culture systems, making information on environmental impact mitigation measures available to policy makers, and guiding shrimp farmers in implementing environmentally friendly aquaculture management practices.

Over the course of her graduate programs, Ling has become a great asset to the AquaFish CRSP community, contributing to and learning from collaborations with experts and fish farmers from around the world. Now that she has finished her PhD, Ling hopes to remain in academia, teaching and pursuing her research interests. Her aim is to continue working on designing and implementing more sustainable aquaculture practices, using the results to improve the livelihoods of rural farmers.

NAIM SIDROTUN AWARDED 2012 UNESCO-L'OREAL INTERNATIONAL FELLOWSHIP

Naim Sidrotun was partially funded by the CRSP to pursue her PhD at the University of Arizona. Working under AquaFish CRSP Lead Project PI Dr. Kevin Fitzsimmons, Naim has been studying shrimp-tilapia-seaweed polyculture. Recently she was awarded the 2012 UNESCO-L'Oreal International fellowship to continue her research at the Harvard Medical School and was presented with the award at a ceremony in Paris, France this spring. The UNESCO-L'Oreal International Fellowship Program was created in 2000 to encourage women working in life sciences at the doctoral or post-doctoral levels. Naim is one of just 15 women selected for this award and has since been featured in several news publications and a short video on her accomplishments. For more on Naim see her feature in the AquaFish CRSP quarterly newsletter, AquaNews: Summer-Fall 2011 issue: aquafishcrsp.oregonstate.edu/AquaNewsArchives.php



The 15 UNESCO-L'Oréal International Fellows for 2012, with Naim Sidrotun in the front on the left in blue. (Photo © Julien Chatelin / CAPA Pictures for the L'Oréal Foundation via www.unesco.org)

View Naim's video feature here: vimeo.com/36843301

View articles on Naim

The Jakarta Globe: www.thejakartaglobe.com/lifeandtimes/marine-biologist-is-a-giant-in-world-of-shrimp-medicine/509009

Jakarta Post: www.thejakartapost.com/news/2012/04/22/women-top.html

For more information on the UNESCO-L'Oreal International Fellowship Program: www.unesco.org/new/en/natural-sciences/priority-areas/gender-and-science/for-women-in-science-programme/2012-fellowships/





SMALL-SCALE CHANGES COULD MAKE LONG-TERM IMPROVEMENTS IN ASIAN AQUACULTURE

Story and Photo by Peg Herring

Iloilo, Philippines - Shrimp monoculture in Southeast Asia has had a checkered reputation in the past, and has been blamed for contributing to the reduction of mangroves, diminished water quality, and the spread of shrimp diseases. To address these problems, researchers are helping small-scale fish farmers in coastal parts of the Philippines and Indonesia forge a cleaner, more profitable future through the practice of polyculture.

With support from the AquaFish CRSP, researchers are teaching small farmers sustainable polyculture technologies that are mangrove-friendly and keep from loading coastal waters with pollution. Mirroring the diversity of species being promoted in polyculture, the CRSP research team itself represents several U.S., Filipino, and Indonesian agencies and universities. Evelyn Ayson is part of the AquaFish CRSP Filipino team. A fisheries scientist with the Southeast Asian Fisheries Development Center in Iloilo, Ayson heads the research division of SEAFDEC's aquaculture department.

Designing a polyculture system requires knowledge of which aquatic organisms are compatible. Much experimental work relevant to this question is conducted at SEAFDEC's Igang Mariculture Park in Guimaras, where floating cages just offshore harbor nurseries of everything from microscopic larval abalone to grouper broodstock the size of small whales.

"We are testing dozens of species for polyculture in brackish water ponds and marine cages," said Ayson.

First, the animals need to get along, especially in open-water cage culture. For example, sea cucumbers (bottom-dwelling mollusks prized in Asian cuisine) are intimidated by rabbitfish that sometimes invade the cages and force the mollusks to hide under the sand and stop feeding. Similarly, pufferfish, which also are not part of the polyculture study, feed on sea cucumbers. Pufferfish share the same marine habitat and have, on occasion, made their way into the cages and devoured Ayson's experiments at Igang.

Eventually, what researchers learn here is used to teach polyculture methods to small-scale and subsistence fish farmers in the Philippines and Indonesia. Focusing on communities hit hard by natural disaster or poverty, the AquaFish CRSP has co-sponsored a series of workshops on seaweed culture to audiences of local fish farmers.

Seaweeds can also be used in polyculture to help absorb dissolved nitrogen and phosphorus that can build up in water from the uneaten feed and waste that accumulate around fish cages. Seaweeds are valuable as a source of agar, a thickening agent for candy, and in highly refined form, a laboratory medium for medical research.

At a recent workshop in Aceh, Indonesia, where the 2005 tsunami wiped out many of the shrimp monoculture ponds, fish farmers learned about seaweed varieties and the basics of planting, harvesting, drying, and marketing. None of these farmers could hope to individually harvest enough seaweed to attract a significant market, but working as a collective, it could be possible.

"We are training farmers how to process their raw seaweed into more marketable forms and providing them with a new opportunity for income, especially small businesses operated by women," said Russell Borski, a professor of biology at North Carolina State University in Raleigh, who is the U.S. lead researcher on this CRSP project.

This workshop was one of several dozen extension training sessions the AquaFish CRSP research team facilitates each year. Another workshop focuses on culturing sea cucumber, both as a valuable seafood product and as an important scavenger in polyculture systems.

That's the twin goal of the AquaFish CRSP research, according to Borski. "It's about finding sustainable solutions and creating meaningful work for the poorest people of the world."



NOTICES OF PUBLICATION

Notices of Publication announce recently published work carried out under AquaFish CRSP sponsorship. To receive a full copy of a report, please contact the author(s) directly. All past and present Notices of Publication can be found on the AquaFish CRSP website at:
aquafishcrsp.oregonstate.edu/publications.php

Full Notices of Publication may be found at the AquaFish CRSP website along with all past and present Notices of Publication at: aquafishcrsp.oregonstate.edu/publications.php.

Why Tilapia is Becoming the Most Important Food Fish on the Planet (11-283)

Kevin Fitzsimmons, Rafael Martinez-Garcia and Pablo Gonzalez-Alanis

University of Arizona, Tucson, AZ, USA

The associated abstract was excerpted from the original paper, which was published in Better Science, Better Fish, Better Life: Proceedings of the Ninth International Symposium on Tilapia in Aquaculture (2011) [Edited By: Liu Liping and Kevin Fitzsimmons] pp 8-17

Intensity of Freshwater Use for Aquaculture in Different Countries (11-284)

Claude E. Boyd and Li Li

Department of Fisheries and Allied Aquacultures
 Auburn University, Alabama 36849 USA

The associated abstract was excerpted from the original paper, which was published in Better Science, Better Fish, Better Life: Proceedings of the Ninth International Symposium on Tilapia in Aquaculture (2011) [Edited By: Liu Liping and Kevin Fitzsimmons] pp 68-74

Impacts of the Introduction of Alien Tilapias (*Oreochromis spp.*) on the Fisheries and Biodiversity of Indigenous Species in Tri An Reservoir, Vietnam (11-285)

Le Thanh Hung, Vu Cam Luong, Nguyen Phu Hoa, James Diana

The associated abstract was excerpted from the original paper, which was published in Better Science, Better Fish, Better Life: Proceedings of the Ninth International Symposium on Tilapia in Aquaculture (2011) [Edited By: Liu Liping and Kevin Fitzsimmons] pp 75-85

Duration of Appetite Inhibition Predicts Social Dominance in Nile Tilapia, *Oreochromis niloticus* L. (11-286)

Emmanuel M. Vera Cruz¹, Madelin B. Valdez¹, Remedios B. Bolivar¹, and Russell J. Borski²

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 27695, USA

The associated abstract was excerpted from the original paper, which was published in Better Science, Better Fish, Better Life: Proceedings of the Ninth International Symposium on Tilapia in Aquaculture (2011) [Edited By: Liu Liping and Kevin Fitzsimmons] pp 86-94

Fishmeal-Free Diets Improve the Cost Effectiveness of Culturing Nile Tilapia (*Oreochromis niloticus* L.) in Ponds Under an Alternate Day Feeding Strategy (11-287)

Russell J. Borski¹, Remedios B. Bolivar², Eddie Boy T. Jimenez², Roberto Miguel V. Sayco², Reginor Lyzza B. Argueza², Charles R. Stark³, and Peter R. Ferrel³

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³Department of Poultry Science, North Carolina State
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The associated abstract was excerpted from the original paper, which was published in Better Science, Better Fish, Better Life: Proceedings of the Ninth International Symposium on Tilapia in Aquaculture (2011) [Edited By: Liu Liping and Kevin Fitzsimmons] pp 95-101

Masculinization of Nile Tilapia (*Oreochromis niloticus* L.) Using Lypholized Testes from Carabao (*Bubalus bubalis carabanesis* L.) Bull (*Bos indicus* L.) and Boar (*Sus domesticus* L.) (11-288)

Ramjie Y. Odin¹ and Remedios B. Bolivar²

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How to Produce Billions of High Quality Tilapia Fry (11-289)

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Improving the Supply Chain of Tilapia Industry in the Philippines (11-290)

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Development of Sustainable Aquaculture Practices in Tabasco, Mexico using Novel IAA Technology (11-291)

Rafael Martínez- García¹, María Fernanda Cifuentes-Alonso¹, Maximiano Antonio Estrada Botello², Abel Santiago Lopez¹ Torres, María de Jesús Contreras-García¹, Alejandro Macdonal-Vera¹, Estuardo González-Arévalo¹, Wilfrido Miguel Contreras-Sánchez¹, Kevin Fitzsimmons³

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Constraints and Opportunities in Cage Aquaculture in Ghana (11-292)

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What Influences the Success of Aquacultural Research Projects?

Steven Buccola, Lin Qin, and Rolf Fare

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Methods for Assessing Economic, Environmental and Social Impacts of Aquaculture Technologies: Adoption of Integrated Agriculture-Aquaculture in Malawi (11-294)

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Value Chain of Cultured Snakehead fish in the Mekong Delta of Vietnam (11-295)

Le Xuan Sinh²; R.S. Pomeroy³ & Do Minh Chung¹

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Use of Gonadotropin Releasing Hormone Analogs on the Induced Reproduction of Chame Dormitator latifrons

Gustavo A. Rodriguez M. de O.^{1*}, Eva A. Medina H¹, Jeniffer Velazquez S¹, Vanesa Lopez L¹, Cristobal Roman R¹, Konrad Dabrowski², Eladio Gaxiola Camacho¹, Maria C. Haws³.

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Supplemental Feeding of Nile Tilapia (*Oreochromis niloticus* L.) in Fertilized Ponds Using Combined Feed Reduction Strategies (11-297)

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Growth performance, survival, feed utilization and nutrient utilization of African catfish (*Clarias gariepinus*) larvae co-fed Artemia and a micro-diet containing freshwater atyid shrimp (*Caridina nilotica*) during weaning (11-298)

V. Chepkirui-boit¹, C.C Ngugi¹, J. Bowman², E. Oyoo-okoth^{1,3}, J. Rasowo⁴, J. Mugo-bundi¹ & L. Cherop¹

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UPCOMING MEETINGS AND EVENTS...

The AquaFish CRSP promotes workshops and meetings designed to facilitate increased knowledge and communication in aquaculture. Meetings and workshops coming up include...

IIFET 2012 Tanzania: Visual Possibilities: The Economics of Sustainable Fisheries, Aquaculture, and Seafood Trade

16-20 July 2012

The University of Dar es Salaam

Dar es Salaam, Tanzania

www.xcdsystem.com/iifet2012/

The Aquaculture Roundtable Series (TARS) 2012 Shrimp Aquaculture-Shaping the Value Chain

15-16 August 2012

JW Marriott Phuket Resort & Spa

Phuket, Thailand

<http://www.tarsaquaculture.com/>

The Ninth International Conference on Recirculating Aquaculture

24-26 August 2012

The Hotel Roanoke and Conference Center

Roanoke, Virginia

<http://www.recircqua.com/>

Aqua 2012: Global Aquaculture Securing Our Future

1-5 September 2012

Prague, Czech Republic

www.was.org/WasMeetings/meetings/Default.aspx?code=Aqua2012



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