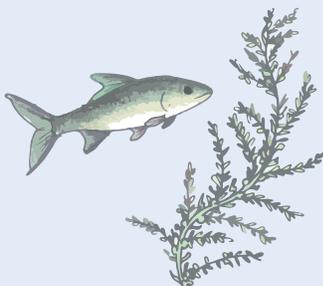




IN THIS ISSUE ...

- Polyculture Systems Explored in Nepal and Bangladesh to Increase Productivity, Overall Income for Fish Farmers 1
- Goings-On In the Pond 2
- PONDerings 3
- Researchers Help AFU'S Aquaculture and Fisheries Program Blossom 4
- World Aquaculture Society: Aquaculture America Meeting Goes All in for Aquaculture 7
- AquaFish Student Corner: Graduate Student Profile 8
- AquaFish Alumni Corner: Where Are They Now? 10
- Notices of Publication 12
- Upcoming Meetings and Events 12



POLY CULTURE SYSTEMS EXPLORED IN NEPAL AND BANGLADESH TO INCREASE PRODUCTIVITY, OVERALL INCOME FOR FISH FARMERS

By Morgan Chow, AquaFish Innovation Lab



AquaFish Innovation Lab researchers in Bangladesh are investigating polyculture of mola with carp and freshwater prawns. (Photo courtesy of AquaFish Innovation Lab)

Dedicating space to produce a single crop is an agricultural practice called monoculture, but growing a single crop doesn't always maximize yields.

Polyculture, the practice of growing multiple crops in a specific area, can boost productivity of one species while allowing for additional benefits from multiple other species.

In aquaculture, some polyculture systems have been found to increase overall productivity, possibly improve

Polyculture continued on page 2 ...

... Polyculture continued from page 1

water quality, and increase the farmer's overall income. AquaFish has conducted research on a variety of polyculture systems around the world, with recent work in Nepal and Bangladesh.

In Nepal, AquaFish researchers are studying the value of tilapia and sahar polyculture. Sahar has been found to be successful at controlling excessive tilapia recruitment while simultaneously increasing overall productivity of sahar, a high-valued indigenous fish. Results show that a carp-tilapia-sahar polyculture system may offer benefits beyond that of widely used carp monoculture.

AquaFish research in Nepal also explores alternate feeding strategies in polyculture systems, and the potential environmental and economic benefits of reducing feed inputs by half in tilapia-carp polyculture.

Adding substrate content for periphyton enhancement in polyculture systems also can provide environmental and economic benefits. Periphyton, a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus, removes excess nutrients, adds oxygen, and cleans discharged water. As a periphyton feeder, carp's growth is enhanced with the presence of this substrate. AquaFish researchers are testing the productivity change in carp and small indigenous fish (SIS) polyculture systems with and without periphyton.

Carp-SIS polyculture leads to increased consumption of nutrient-rich SIS, which can help improve the health and nutrition — including vitamin A, calcium, zinc, and iron. Because SIS are eaten whole, there is no waste or loss of nutrients. Also, SIS are self-recruiting and can be harvested weekly. Study results found that carp growth and production was improved by the presence of periphyton.

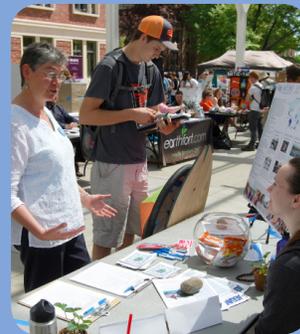
AquaFish Host Country Project PI Dr. Madhav Shrestha said the real challenge is to figure out how to increase productivity without a big change in the system.

Polyculture continued on page 3 ...

Goings-On In the Pond ...



EARTH DAY OUTREACH



AquaFish Innovation Lab Management Team staff, including Jenny Hawkins (seated right), spoke with students and other visitors about AquaFish's work and mission during Oregon State University's 16th annual Beyond Earth Day Community Fair on 19 April 2016. (Photo courtesy of AquaFish Innovation Lab)

2016 ANNUAL MEETING

AquaFish Innovation Lab partners and Management Team came together in April for AquaFish's 2016 Annual Meeting in Surabaya, Indonesia.

The meeting was held 24-26 April 2016, in conjunction with the World Aquaculture Society's Asian-Pacific Aquaculture conference, which ran 26-29 April.

Participants included AquaFish External Program Advisory Council members, Management Team, principal investigators and Regional Centers of Excellence coordinators.

Events included an AquaFish Program Meeting, Impact Assessment Workshop, poster exhibition, and technical sessions. Look for news about the Annual Meeting to come in a future AquaNews issue.

11TH ASIA FISHERIES AND AQUACULTURE FORUM GOLD SPONSOR

AquaFish will continue to support the Asia Fisheries and Aquaculture Forum as a gold sponsor for this year's meeting, 11AFAF. Sponsorship will include support for the Yang Yi Young Scientist Fellowship, which will be awarded to two recipients at the meeting. AquaFish has offered support for the meeting since 2007, and looks forward to being involved in the international platform on sustainable fisheries and aquaculture in the Asia-Pacific region.

... Polyculture continued from page 2

In Bangladesh, AquaFish researchers are investigating ways to culture nutrient-rich mola fish with high-value freshwater prawns and carp. The northwest region of Bangladesh, the study's focus area, lacks crop diversification and could substantially benefit from incorporating both species with traditional carp-farming practices.

The work aims to identify a stocking density for mola and prawn integration into carp farming by evaluating production performance, market returns, and environmental quality in comparison to monocultured carp. Mola, a SIS, is particularly rich in vitamin A and minerals, yet production remains low while demand is steadily growing. Freshwater prawns are high-value export commodities that are traditionally cultured in modified rice fields in some parts of Bangladesh, yet unsuccessful in others. This research focuses on the nutritional and economic benefits to rural farmers, specifically women and children.

Findings indicate that mola can provide an enhanced source of income and nutrition for household families that traditionally practice carp polyculture. The research also raises the possibility that cage culture of prawns in pond polyculture systems has the potential to increase incomes for farmers, albeit the growth rate of prawns in cages is lower than that seen in pond-raised animals.

Additionally, mud from mola-prawn, carp-prawn, and mola-carp-prawn polyculture systems was used to grow vegetables. Findings revealed that mud from the mola-carp-prawn polyculture systems had higher amounts of organic matter for vegetable growth than the other systems.

The polyculture research in Nepal and Bangladesh provides the opportunity to bring added nutritional and economic benefits to farmer households.

And, as Dr. Shrestha said, simple interventions in existing systems will make adaptation easier for farmers.



PONDERINGS ...

AQUAFISH'S FIRST EVER WORLD SCRAMBLE

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A H P U S M S K C W C S M
W I U G A N D A F A T L I
L P P O N D A S N O R P C
M E O A F T F K U L S P R
F R M Q N L F E E D S N O
E I L U N G F I S H Z E B
R P I A O C A G E T E P E
V H S C R S P S T P R A S
I Y N U T R I T I O N L D
E T A L D I O E B U M A K
T O S T P O L I C Y S F E
N N I U F G H A N A G R N
A S A R H I C D P A V I Y
M L G E N D E R T I N C A
T A N Z A N I A M R A A S
  
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How to play:

Find and circle all of the words listed below in the word scramble above. Words can be found written vertically, horizontally from left to right, and diagonally from top to bottom.

Words:

Ghana	Snakehead
Tanzania	Pond
Kenya	Tilapia
Nepal	Periphyton
Vietnam	Carp
Uganda	Cage
Asia	CRSPS
Africa	Aquaculture
Microbes	Feeds
Pangasius	Policy
Lungfish	Gender

RESEARCHERS HELP AFU'S AQUACULTURE AND FISHERIES PROGRAM BLOSSOM



Drs. Sunila Rai (in red) and Madhav Shrestha (end, far right) pose with AquaFish Innovation Lab Director Dr. Hillary Egna (left of Rai) and others in Nepal in 2013. (Photo courtesy of AquaFish Innovation Lab)

By Susannah L. Bodman, AquaFish Innovation Lab

The aquaculture program at Nepal's Agriculture and Forestry University (AFU), and two AquaFish Innovation Lab researchers have played key roles in developing the program and AFU as a leading research institution in Nepal.

Dr. Sunila Rai is assistant dean of academics with AFU's Veterinary Science and Fisheries department (VSF), and Dr. Madhav Shrestha is the coordinator/dean of AFU's graduate school. AquaNews asked Drs. Rai and Shrestha about their experiences at AFU, building the program and their work in aquaculture. Here are profiles of each and what they had to say about AFU and aquaculture:



Dr. Sunila Rai

Dr. Sunila Rai is a fisheries scientist whose graduate education was supported by Aquaculture CRSP and AquaFish CRSP. She earned both a Master's degree and a Doctorate from Thailand's Asian Institute of Technology.

Rai continued on page 5 ...



Dr. Madhav Shrestha

Throughout his career, Dr. Madhav Shrestha has been dedicated to agricultural and aquacultural development in Nepal.

Dr. Shrestha first studied fisheries at Tribhuvan University (TU) in 1979 before moving on to the Aquaculture and Aquatic Resources

Shrestha continued on page 6 ...

... Rai continued from page 4

After completing her degrees, Dr. Rai worked as the head of the Institute for Agriculture and Animal Sciences' Aquaculture Department at AFU (formerly part of Tribhuvan University) in Chitwan, Nepal, where she conducted research for enhancing carp production in polyculture ponds. (See also a profile about Dr. Rai in the [winter 2015 issue of AquaNews](#).)

During her time at AFU, Dr. Rai witnessed the institute's transition to AFU; its infrastructure development, including a central office; and the diversification of academic programs, such as its Bachelor of Science program in fisheries.

In her role as an assistant dean at AFU, Dr. Rai said her goals include promoting academic excellence through quality teaching in undergraduate and post-graduate programs.

And for the future of the undergraduate (B.Sc.) fisheries program, Dr. Rai sees growth. Although the program is just two years old, it's already attracting students, including nearly 500 applicants this year for 16 seats, she said.

The program will continue to grow, Dr. Rai said, because of government policies that prioritize aquaculture and increased fish consumption because of increased attention on health and nutrition.

The program has further emerged as a leader in gender-balanced education, with a 50-50 ratio of male and female students, she said. Dr. Rai, it should be noted, began pursuing her own education and career in fisheries and aquaculture science partly because of a need to address the gender gap in aquaculture in Nepal.

And two years on for the fisheries program, it's about to graduate its first undergraduate class, some of whom may continue their studies through AFU's Master of Science degree in fisheries.

Current enrollment in AFU's fisheries program stands at 45 students at the B.Sc. level and 14 pursuing M.Sc. degrees. Four more students graduated with Master's degrees in December



A woman sells fish in Nepal in 2013. Agriculture and Forestry University is researching several fish species and polyculture technologies with the goal of helping small-scale fish farmers improve income and nutrition, Dr. Sunila Rai said. (Photo courtesy of AquaFish Innovation Lab)

2015, and students in the B.Sc. program are expected to begin graduating at the end of 2017.

As for the aquaculture program's shift from Tribhuvan to AFU, the change did result in the loss of some aquaculture courses at satellite campuses and some senior faculty members, but it also brought more focus and priority to agriculture and aquaculture, Dr. Rai said.

Whereas AFU specializes in agriculture and forestry, Tribhuvan is a multidisciplinary university with priority given to medicine, engineering, science and technology, she said.

And having a university like AFU so focused on agriculture and aquaculture has benefits, especially in terms of addressing the issues facing aquaculture growth in Nepal.

"AFU is working on tilapia production technology to fill (a need for) fast-growing species, domestication and breeding of sahar, native species as a step for biodiversity conservation, and development and outreach of carp-SIS [small indigenous fish species] polyculture technology for small-scale farmers to improve household income and nutrition," Dr. Rai said.

... Shrestha continued from page 4



Dr. Sunila Rai, AquaFish Innovation Lab Director Hillary Egna and Dr. Madhav Shrestha (left to right) tour Agriculture and Forestry University's fish pond in Nepal in 2013 along with other AFU faculty. (Photo courtesy of AquaFish Innovation Lab)

Management program at the Asian Institute of Technology (AIT), from which he earned a Master of Science degree in 1989 and a doctorate in 1994.

He became a professor of aquaculture at the Institute for Agriculture and Animal Sciences in 2011 while it was still part of TU. The following year, AFU was established, and the institute and Dr. Shrestha transitioned to the new university, where he is both an aquaculture professor and coordinator/dean of the Post-Graduate Studies Centre, AFU's grad school.

Dr. Shrestha also co-managed the expansion of a women-led aquaculture project in Nepal for Aquaculture Without Frontiers from 2009 to 2011 in collaboration with AIT, has launched many collaborative projects with AquaFish, and was recognized in 2011 by Nepal's prime minister for his contributions to Nepalese agriculture and aquaculture.

At AFU, Dr. Shrestha has seen programs expand to encompass undergraduate degrees in agriculture, veterinary science, forestry and fisheries within three academic areas: Agriculture; Forestry; and Animal Science, Veterinary Science and Fisheries. A variety of graduate studies also are offered in each of those academic areas.

"The aquaculture program has grown substantially after the separation from Tribhuvan University," Dr. Shrestha said. "There were only two courses of aquaculture [for undergraduate

MORE SUCCESS IN NEPAL

Beyond Agriculture and Forestry University, AquaFish Innovation Lab researchers are positioned to have an impact on the growth of aquaculture in Nepal. Host Country Co-PI Dr. Rama Nanda Mishra became the director of Nepal's Directorate of Fisheries Development, where he plans, monitors, and evaluates overall fisheries development in the nation. Of aquaculture in Nepal, he said training is still needed.

— SLB

degrees in Agriculture and Animal Science, Veterinary Science and Fisheries] along with the M.Sc. program at TU. Since the AFU program started, TU does not have an M.Sc. Fisheries program."

Today, the main focus areas for aquaculture research at AFU are "development of small-scale sustainable aquaculture for household nutrition and supplemental income, commercial aquaculture for increased productivity and production, promotion of native species in aquaculture production, quality seed production of native and commercial species, and sustainable management of natural waters," Dr. Shrestha said.

And in addition to the AFU aforementioned current 45 undergraduate and 14 Master's degree students, Dr. Shrestha said three students also are pursuing doctorates.

As for the impact these students and AFU's aquaculture research may have on the growth of fish farming in Nepal, Dr. Shrestha pointed to four areas:

- Increasing productivity of the existing semi-intensive carps polyculture system;
- Developing seed production of commercially cultured species;
- Developing enhanced fisheries management for sustaining or increasing fish catch; and
- Household nutrition-based aquaculture.

Shrestha continued on page 11 ...

WAS: AQUACULTURE AMERICA MEETING GOES ALL IN FOR AQUACULTURE



AquaFish US Project PI Dr. Russell Borski presents work at Aquaculture America. (Photo courtesy of Caleb Price)

By Caleb Price, AquaFish Innovation Lab

The World Aquaculture Society (WAS) brought fish farming to the desert during its recent Triennial, which combined the annual meetings of the National Aquaculture Association, the Fish Culture Section of the American Fisheries Society, and the National Shellfish Association.

Aquaculture America, the annual meeting of the WAS US Chapter, also was held in conjunction with the Triennial, 22-26 February 2016 in Las Vegas, Nevada, US. AquaFish Innovation Lab participated in the Aquaculture America conference, with many past and current AquaFish partners in attendance.

AquaFish US Project PI Dr. Russell Borski and two of his AquaFish-supported graduate students from North Carolina State University presented on AquaFish research in Bangladesh. Other presentations included research on leptin regulation and function in tilapia, and the effects of pulsed feeding strategies on growth performance and nutrient absorption efficiency in tilapia pond culture. Implications of both of these areas of research are important to enhancing growth and production of important fish cultivars.

AquaFish partners from Purdue University, led by Dr. Kwamena Quagraine, presented on the health and cultural factors that impact

household food security in Tanzania. Results of this research indicate that, contrary to expectations, fish-farming households in Tanzania actually consume slightly less fish than households that do not farm fish, suggesting that fish may be more valued by small-scale Tanzanian fish farmers as a market commodity rather than as a source of nutrition.

AquaFish US Co-PI Dr. Kevin Fitzsimmons, of the University of Arizona, also chaired a session on tilapia that included presenters from China, Iran, India, Mexico, the Philippines, Japan, and the US. Dr. Fitzsimmons is involved with Auburn University's 2013-15 investigation to develop low-cost aquaponic systems in Kenya. The AquaFish Management Team presented three posters showcasing AquaFish research on improved feeding strategies and feed ingredients; the development of cell-phone technologies to increase aquaculture market networks; and building educational capacity at the individual, community, and institutional levels.

Academic and professional conferences such as this offer great opportunities to showcase the work that AquaFish students and partners are doing to improve food security and livelihoods in Africa and Asia, as well as expand on the diverse network of aquaculture specialists that AquaFish has cultivated over the years.



AQUAFISH STUDENT CORNER

GRADUATE STUDENT PROFILE: NGUYEN THI CAM DUYEN

By Susannah L. Bodman,
AquaFish Innovation Lab

What's the right amount of dietary methionine and lysine needed to raise snakehead?

Nguyen Thi Cam Duyen is trying to find out.

Duyen, an AquaFish-supported Master's degree candidate in aquaculture at Vietnam's Can Tho University, is experimenting with the two essential amino acids in an effort to determine the dietary requirements of snakehead (*Channa striata*). Methionine and lysine are protein building blocks that are important in the development, growth and functioning of vertebrates, including fish.

Duyen's research is part of a broader effort supported by AquaFish Innovation Lab to develop formulated feeds that can replace the use of low-value, threatened fish as snakehead food. And understanding how much lysine and methionine a fish species like snakehead needs means nutritious feeds can be created that help farmed fish grow to a desired standard for market that's also cost-effective for the farmer.

Development of formulated feeds also has been a key condition for the recent lifting of a nearly 12-year-old ban on farming snakehead in Cambodia (see box page 9). The Cambodian government imposed the ban in September 2004 to protect wild populations of small, low-value freshwater fish, many of which are juveniles of commercially important species and threatened by overharvesting. Overharvesting further limited the availability of these fish to rural, poor Cambodians who depend on them for food.

Meanwhile, in neighboring Vietnam, aquaculture overall is growing rapidly, with snakehead gaining popularity because of its high-market value.



Nguyen Thi Cam Duyen, a student at Can Tho University in Vietnam, is investigating some of the nutritional needs of snakehead as part of wider efforts to develop formulated feeds for the fish. (Photo courtesy of Nguyen Thi Cam Duyen)

As such, continued development of formulated feeds that will support renewed snakehead farming could benefit both farmers and consumers within the Mekong River basin. And Duyen's research plays a role in helping to design such feeds.

"I hope [our] findings on methionine and lysine requirements for snakehead will contribute to the optimization of diet for snakehead, which will improve [the] growth of snakehead, reduce production cost and environmental impact, [and] increase profits for snakehead farmers in the Mekong River basin," Duyen said.

Duyen, who earned her undergraduate degree in aquatic resources management at Can Tho in 2010, said she hopes to complete her research in June 2016.

Profile continued on page 9 ...

AQUAFISH STUDENT CORNER

... Profile continued from page 8



Nguyen Thi Cam Duyen hopes her work will ultimately help snakehead farmers and the environment in the Mekong River basin. (Photo courtesy of Nguyen Thi Cam Duyen)

When asked what got her interested in aquaculture, Duyen has a straightforward answer: "It is simply that I love fish."

And that love of fish may carry her through to a doctoral degree one day, as she said she wishes to continue studying fish nutrition. In the near future, Duyen has related plans. "I am going to work in [an] animal feed-processing company, where I am able to apply new knowledge [and] experience in the aquaculture industry," she said.

And that industry has an important role to play in her native Vietnam, where it's rapidly growing thanks to high production and high-value exports, she said.

As of 2004, total aquaculture production in Vietnam surpassed 1.15 million tons, with significant production increases in shrimp and catfish, which are considered the nation's two major aquacultural products, according to the Food and Agriculture Organization of the United States (FAO; <http://goo.gl/NxdfoQ>).

Six years later, the tonnage more than doubled to 2.7 million, according to an FAO value-chain analysis report (<http://goo.gl/MuVrGa>).

According to the same report, value of fisheries exports, including fish catch and

CAMBODIA LIFTS SNAKEHEAD BAN

Cambodia's nearly 12-year-old snakehead farming ban has been lifted, following a request from the nation's Ministry of Agriculture.

Farmers will again be able to breed the carnivorous fish but under forthcoming conditions that focus on sustainable management.

New Agriculture Minister Veng Sakhon requested the ban's lifting, citing the need to create income opportunities as well as the development of processed fish feeds that replace the need to harvest and use other wild and threatened fish species as food for snakehead. AquaFish Innovation Lab and partners have been working to develop formulated feeds for snakehead.

You can read more about the ban's lifting from The Cambodian Daily, an independent newspaper, at <https://goo.gl/OMtXzA> and in a future issue of AquaNews.

— SLB

aquaculture, jumped from about \$2.4 billion USD in 2004 to more than \$5 billion USD in 2010.

However, there is work ahead to strengthen Vietnam's aquaculture industry. "The main challenges are to improve the local fish aquaculture, e.g., snakehead, which contribute to fish consumption in the local market [and to control disease] in aquaculture with the improvement of fish health management practices," Duyen said.

Duyen, who comes from Vietnam's Tra Vinh Province, has been involved in AquaFish work for about a year. Dr. Tran Thi Thanh Hien of Can Tho is her major professor in her graduate studies.

"I have had a chance to learn new knowledge on feed formulation as well as experimental set up," Duyen said. "This is also an opportunity for me to discuss, exchange research ideas and other related works within the project."



AQUAFISH ALUMNI CORNER

WHERE ARE THEY NOW?: NARAYAN PRASAD PANDIT

By Susannah L. Bodman,
AquaFish Innovation Lab

It was a pair for firsts — both for Dr. Narayan Prasad Pandit and the Aquaculture Collaborative Research Support Program (Aquaculture CRSP).

For Dr. Pandit, “Polyculture of grass carp and Nile tilapia with Napier grass as a sole nutrient input in the subtropical climate of Nepal” was the research project for his first Master’s degree.

It was also one of the first Aquaculture CRSP-supported projects in Nepal, he said.

Thanks to Aquaculture CRSP support, Dr. Pandit earned his first Master’s degree in 2003 from Tribhuvan University’s Institute of Agriculture and Animal Science (IAAS; now known as Agriculture and Forestry University, or AFU), from which he also earned an undergraduate degree in agriculture in 2000.

Dr. Pandit went on to earn a second Master’s degree from the University of the Ryukyus in Japan in 2010 with major professor Dr. Masaru Nakamura, completing the thesis “Effect of high temperature on reproductive physiology of the Nile tilapia, *Oreochromis niloticus*.”

And in 2014, Dr. Pandit earned a Ph.D. from Shanghai Ocean University in China with the research “Identification, characterization and expression analysis of immune genes within the TNF and IL superfamilies in grass carp, *Ctenopharyngodon idella*.” Since earning his Ph.D. degree, Dr. Pandit has been involved with several AquaFish research projects through AquaFish Host Country Project PI Dr. Madhav Shrestha, of AFU, who was his major professor during graduate school.

“Growing up in a farmer’s family, the seeds of my interest in agriculture were sown during my



Dr. Narayan Prasad Pandit comes from a farming family and says he pursued graduate studies in aquaculture with a desire to inspire future generations of aquaculturists. Dr. Pandit’s hometown is Bharatpur, Chitwan, Nepal. (Photo courtesy of Narayan Prasad Pandit)

childhood,” Dr. Pandit said. “Thus, I decided to enroll at [IAAS], which is near my hometown, to study agriculture. After completing my Bachelor’s degree in agriculture at IAAS, I met Dr. [Shrestha], who inspired me to study [for a] Master’s degree in aquaculture. At that time, I wanted to be a great aquaculture scientist and inspire new generations of aquaculture researchers through my accomplishments and teaching.”

In fact, Dr. Pandit said teaching and inspiring students is one of the most enjoyable aspects of his aquaculture-related work.

Today, Dr. Pandit guides students as an assistant professor of aquaculture and fisheries at AFU in Nepal and is working on AquaFish-supported projects: “Two small indigenous species to improve sustainability in typical polyculture systems in Nepal” and “Household fish ponds in Nepal: Their impact on fish consumption and health of women and children and their constraints determined by value chain analysis.” The projects focus on climate change adaptations, marketing and economics.

Pandit continued on page 11 ...

AQUAFISH ALUMNI CORNER

... Pandit continued from page 10



Dr. Narayan Prasad Pandit (center) says Nepal's aquaculture workforce will soon expand, thanks to degree programs at AFU. (Photo courtesy of Narayan Prasad Pandit)

In terms of future research projects, Dr. Pandit's interests lie in exploring eco-friendly technologies for controlling reproduction in Nile tilapia.

And for the future of Nepal's aquaculture industry, the challenges that Dr. Pandit sees ahead involve making better use of resources, growing a technical aquaculture workforce and raising awareness of the importance of fish.

Efforts to grow the workforce are already underway, and Dr. Pandit said a lot of manpower will soon come to the aquaculture sector, thanks to the Bachelor's degree program in fisheries and aquaculture at AFU. The university's first group of students is set to graduate in 2017.

Along with the pending expansion in technical labor, Dr. Pandit said the country also has vast water resources and diverse climatic conditions operating in the sector's favor, creating opportunities to farm a variety of fish species in both warm and cold waters.

And it's Nepal's water resources that first attracted Dr. Pandit to his field of research.

"Actually, I love water and become very happy when I see natural water resources," he said.



... Shrestha continued from page 6

And looking to the future of fisheries studies at AFU, Dr. Shrestha said eventually that area will split off into its own academic program with at least three departments.

Whatever the future holds, the creation alone of AFU — the only technical university in Nepal — has been a boon for aquaculture and fisheries expansion for the country. Its inception was eagerly awaited by the Nepalese government as well as the nation's rapidly expanding aquaculture private sector, Dr. Shrestha said. And that eagerness likely stems from the promise AFU presents to Nepal.

"The aquaculture and fisheries program of AFU will be able to provide the required human resources for the overall development of aquaculture and fisheries in the country," he said.



IN MEMORIAM — DR. RUBEN SEVILLEJA



Dr. Sevilleja (right) with AquaFish Director Dr. Hillary Egna (left) and AquaFish RCE Coordinator Dr. Remedios Bolivar (middle) at CLSU in 2014. (Photo credit Morgan Chow)

Dr. Ruben Sevilleja, the former President of Central Luzon State University and a member of the CRSP family for more than 20 years, passed away on 29 May 2016. Dr. Sevilleja served as CLSU's President for two terms, and before that served as the Director of CLSU's Freshwater Aquaculture Center and Vice President for Academic Affairs. Originally from Ilocos Sur Province in the Philippines, Dr. Sevilleja was a dedicated leader in aquaculture and education, and a strong supporter of the growing aquaculture sector. AquaFish sends its most sincere regards to Dr. Sevilleja's family, friends, and colleagues.

— MC

Notices of Publication

Notices of Publication announce recently published peer-reviewed work carried out with AquaFish support. To receive a full copy of a publication, please contact the author(s) directly. All past and present Notices of Publication can be found on the AquaFish website at: aquafish.oregonstate.edu/nop.php

Effects of dietary levels of essential oil (EO) extract from bitter lemon (*Citrus limon*) fruit peels on growth, biochemical, haemato-immunological parameters and disease resistance in Juvenile *Labeo victorinus* fingerlings challenged with *Aeromonas hydrophila* (16-356).

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Essential oils (EOs) are used in the food industry because of their biological activity. We evaluated the effects of administration of essential oil (EO) extracted from bitter lemon (*Citrus limon*) fruit peels on the growth performance, biochemical, haemato-immunological parameters and possible disease resistance in fingerlings (4 weeks old) *Labeo victorinus* challenged with *Aeromonas hydrophila*. Fish were divided into five groups and fed diets supplemented with *C. limon* fruit peels EO extract at 1%, 2%, 5% and 8% [as fed basis] and treatment compared with control group fed diet without *C. limon* fruit peels EO extract. The experiment was executed in triplicate. Concentration of plasma cortisol, glucose, triglyceride and cholesterol decreased while that of total protein and albumin increased as dietary inclusion of the EO extract of *C. limon* fruit peels was increased from 2% to 5%. Meanwhile haemato-immunological parameters including red blood cell (RBC), white blood cell (WBC) counts, haematocrit (Htc), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC) and neutrophils increased with increasing dietary inclusion from 1% to 5% inclusion of *C. limon* fruit peels EO extract. Serum immunoglobulins, lysozyme activity and respiratory burst increased with increasing dietary levels up to 5% inclusion of EO extract of *C. limon* fruit peels. We demonstrate that formulation of feeds

by incorporating up to 5% the EO extract from *C. limon* fruit peels significantly improved biochemical, haematological and immunological response in juvenile fish resulting to lower mortality than the untreated groups and appear to be effective antibacterial against *A. hydrophila*.

This abstract was excerpted from the original paper, which was published in *Aquaculture Research* (2016), 1-13.

Upcoming Meetings and Events ...

International Institute of Fisheries, Economics, and Trade Conference 2016

12-15 July 2016

Aberdeen, Scotland

www.iifet-2016.org

11th Asian Fisheries and Aquaculture Forum, Asian Fisheries Society

3-7 August 2016

Bangkok, Thailand

www.asianfisheriessociety.org/events.php

6th Global Symposium on Gender in Aquaculture and Fisheries

3-7 August 2016

Bangkok, Thailand

www.genderaquafish.org

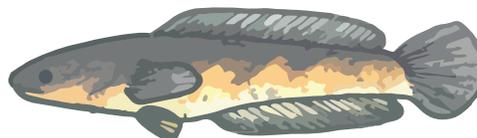
LACQUA16

28 November–1 December 2016

Lima, Peru

www.marevent.com/LACQUAA2016_PERU.html

For more meeting and employment opportunities visit our Education & Employment Opportunities network database online, EdOpNet, at aquafishcrsp.oregonstate.edu/edop.php



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INNOVATION LAB

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