AQUA 2018

Montpellier, France

25 – 29 August 2018

Proceedings

Sessions Organized and Chaired by Dr. Hillary Egna

Proceedings Assembled by Briana Goodwin

AquaFish Innovation Lab Management Office
Oregon State University
Strand Agriculture Hall
Corvallis, OR USA

Email: aquafish@oregonstate.edu
Website: http:// aquafishcrsp.oregonstate.edu

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The mission of the AquaFish Innovation Lab is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach in aquatic resources. Bringing together resources from Host Country institutions and US universities, the AquaFish Innovation Lab emphasizes sustainable solutions in aquaculture and fisheries for improving health, building wealth, conserving natural environments for future generations, and strengthening poorer countries' ability to self-govern.

Acknowledgements
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AquaFish Innovation Lab
College of Agricultural Sciences
Oregon State University
Strand Agriculture Hall
Corvallis, Oregon 97330-1643 USA

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PREAMBLE

AQUA 2018
Montpellier, France
25 – 29 August 2018
Sessions organized by Dr. Hillary Egna

At the AQUA 2018 Conference held 25-29 August 2018 in Montpellier, France, AquaFish Innovation Lab held four panels to provide perspectives on the future of sustainable aquaculture. The panels, chaired by Dr. Hillary Egna, brought together 32 AquaFish Innovation Lab researchers to participate in the panel from around the world. A new session format for this session, the panels offered the opportunity for engaging conversation among panel participants and more interaction with meeting attendees. In addition to the four panel discussions, AquaFish IL-supported researchers presented 25 posters or oral presentations at the conference.

AquaFish Innovation Lab Session Agendas

A Conversation With the AquaFish Innovation Lab on the Future of Sustainable Aquaculture

Chair: Dr. Hillary Egna

Monday, August 27, 2018, 11:00-14:00

11:00 Shared Lessons for Low Aquaculture Food Producing Countries
Diana Asero (Uganda), Kwamena Quagrainie (USA), Madhav Shrestha (Nepal), Hap Navy (Cambodia), and Nazael Madalla (Tanzania)

Tuesday, August 28, 2018, 14:00 - 12:30

14:00 What is Needed now in 2018 to Make Aquaculture a Vital Enterprise for Smallholders in Africa?
Gertrude Atukunda, Daniel Adjei-Boateng, Narriman Jiddawi, Enos Mac'Were, and Abudala Napuru

15:05 Emerging Technologies from AquaFish Innovation Lab Research
Pham Minh Duc, Nen Phanna, Shahroz Mahean Haque, Sunil Rai, and John Walakira

16:10 Shared Lessons from High-Producing Asian and LAC Countries for High Producing African Countries
Phu Hoa, Yuan Derun, Md. Abdul Wahab, Oludare Adeogun, Victoria Tarus

17:10 Session Summary
James Bukenya, Russell Borski, Wilfrido Contreras

AquaFish Innovation Lab Session
Panel Descriptions and Presentations

Not all presenters had accompanying slides with their presentation. Slides from those that did are included below.

Shared Lessons for Low Aquaculture Food Producing Countries
Monday, 27 August from 11:00-14:00
Chair: Hillary Egna
Co-Chair: Stephanie Ichien
Moderator: Nancy Gitonga (Kenya)
Panelists: Diana Asero (Uganda), Kwamena Quagrainie (USA), Madhav Shrestha (Nepal), Hap Navy (Cambodia), and Nazael Madalla (Tanzania)
Rapporteur: Rebecca Lochmann (USA)

Selected prompted questions:

1. Are the low aquaculture food producing countries becoming more aware of the potential contribution of aquaculture to socio-economic development in their countries?
    a. If so what can be done to facilitate application of proven technologies to expedite aquaculture growth?
2. What is the role of government in aquaculture growth? Would advocacy to policy makers about the importance of aquaculture's contribution to food security and employment creation help with the prioritization of the sector? If so, what would be the best strategy for the advocacy?
3. What is the role of Universities, research institutions, and the private sector in the promotion of aquaculture growth?

Shared Lessons for Low Aquaculture Food Producing Countries: Lesson from Nepal

Madhav K Shrestha

Scenario of Agriculture/Aquaculture distribution

- Population dependent on Agriculture sector:
  - > 85% till last 15 years; about 65% by now
- Land holding
  - 15-20% landlords holding >80% land; 80% family holds 20% land
  - Small-scale dominated agriculture
- Similar situation in aquaculture – small scale dominated aquaculture
  - Though aquaculture initiated in 1960's, expansion started since 1990's
  - Per caput fish production in 1980: 220 g/year
  - Carps polyculture remained culture system with semi-intensive culture with fertilizer and minimum feeding
  - Advocated as small-scale aquaculture for food and nutrition security for rural poor (donors and government)
  - Production consumed as household level, perhaps no sale and no income
  - National production remained low, created market for fish supplying countries
  - Frozen fish, canned fish, dried fish from Thailand, China, Vietnam; fresh fish from India and Bangladesh

Constraints of small-scale aquaculture

- Limitation of agriculture land of less than 0.5 ha total for all farming
- Pond size limited to 100- 500 m^2.
- Poor irrigation facility / seasonal pods.
- Limited agriculture by-products to use as feed and fertilizer – sharing with crop, livestock and fish
- Limited production, promoted as food and nutrition security and no market sale

Initiation of Commercial Aquaculture

- Big farmers either leasing lands or digging pond by themselves started some where 10- 15 years back and that initiated commercial aquaculture
- Commercial aquaculture with Clarias catfish, Pangasius catfish, talipia and trout has been increasing though they share around 5% of the total carps production.
- Now per caput production of fish in 2017: 3.93 kg/year
- In 15 years of time aquaculture production increased from 35,000 mt to 84,000 mt; capture fisheries increased from 18,000 mt to 21,000 mt and, 21000 mt remained since last 10 years.

Required Model:

Categorization of aquaculture in Country

- Small-scale family run aquaculture
- Medium-scale family run semi-commercial aquaculture
- Commercial aquaculture

Support required (Either from Donor or from government)

- Commercialization small-scale aquaculture
  - Enhanced production → 30% produce for household food and nutrition security → 70% linked to market
- Semi-commercial → 90-100 % sale to local or city market
- Commercial → City market
- Support to develop wet markets and linking to small to large scale production should be the objectives of the aquaculture policy of the country

A Conversation with the AquaFish Innovation Lab on the Future Sustainable Aquaculture

Lessons for Low Aquaculture Food Producing in Cambodia

HAP Navy, Deputy Director
Inland Fisheries Research and Development Institute (IFReDI), FiA, Cambodia

Montpellier, France – August 25 -29, 2018

General Overview Aquaculture Economic

- The fisheries sector contributes about 12 percent to gross domestic product (GDP).
- Aquaculture is becoming economically more important as a way of increasing local fish production for food security.
- But Aquaculture production is still very small compared to capture fisheries; it contributed in value approximately USD240 million to the fisheries sector.
- Compared with other agricultural sectors such rice, rubber, fruits and vegetables, aquaculture is one of the most productive in terms of income per hectare per annum and return on investment.

General Overview Aquaculture Economic (Cont.)

- In order to create a road map for the development of the Cambodian aquaculture, the Government formulated the National Strategic Plan for Aquaculture Development in Cambodia (2014 – 2030) in the early 2014.
- The promotion of sustainable aquaculture development is one of the priorities, where the aim is to increase aquaculture production to 185 000 tonnes by 2019.
- However, owing in part to the growing population, environment change and construction of hydropower dams, the fish populations and biodiversity have declined. (FAO, 2018)

Why Low Aquaculture Food Producing in Cambodia?

Technical Aspects

- Lack of applied research capabilities for technology testing and adaptation of freshwater aquaculture for fish farmers
- Inadequate technology, mainly concerning breeding and larval rearing of indigenous fish and also feeding, particularly for intensive culture in pond, cages or pen, has caused failure and loss
- Lack of fish feeds/feed ingredients for a significant expansion of traditional pond/cage/pen culture of carnivorous/omnivorous fish species.

Scale of Aquaculture

- Most of aquaculture operation is in small-scale
- Also lack of traditions in low-input ponds and rice-fish culture methods among the small farmers.
- Lack of efficient extension services, including equipment and extension materials to support rural farmers
- The capacity of producing total fish product per individual farmer is still low due to lack of local expertise with inadequate professional training and experience at local level

Market Aspects

- Cambodian people still depending food source of fish more from natural than farm
- Lack of marketing and distribution channels
- Aquaculture cooperatives or producer organizations have not been organized yet which contributes to a weak bargaining status of individual fish farmers
- The exchanges of information between related organizations/agencies are not adequate and there has been a lack of coordination efforts.
- Research institutions, universities, non-government and government agencies implementing extension services in aquaculture rarely coordinate with each other.

Quest for Affordable Aquafeeds

Nazael A. Madalla
Department of Animal, Aquaculture & Range Sciences
Sokoine University of Agriculture
Tanzania
nmadalla@sua.ac.tz

Why Fish?

- High rates of undernutrition amongst under five, pregnant women and other vulnerable groups
  - High prevalence of stunting (34%) among under five
  - Micronutrient deficiencies, including vitamin A, iron, folate, and iodine.
- Mostly due to monotonous diets based on starchy staple crops
  - Animal-source foods rich in high-quality protein and important micronutrients are unaffordable to majority
- Low per capita intake **7.6 kg (20)**, 15 kg meat (50), 47 liters milk (200) and 106 eggs (300) (MALF, 2017; FAO, 2016)
  - Yet fish contributes about 30% of the total animal protein intake

Why Low Fish Consumption?

- Low fish production
  - Capture fisheries stagnated at around 300,000 MT
  - Low aquaculture production estimated at 10,000 MT
- Need for massive expansion of aquaculture
  - To meet demand for further 400,000 MT per annum in response to annual population growth of 2.7% and increasing per capita consumption from 7.6 to 9.6 kg
- Transformation of current subsistence aquaculture into productive commercial aquaculture
- This requires quality affordable aquafeeds *inter alia*

Towards Affordable Aquafeeds

- Use of unconventional feed ingredients
  - Avoid or minimise use of ingredients which conflict with human food security
- Enhancement of natural food production in ponds
  - Make use of filter feeding ability of tilapiine species
- Restricted feeding strategies
  - Take advantage of "compensatory growth" which allows fish to catch up in terms of weight following a short period of starvation or low quality diet

Promising Results

- Use of unconventional feed ingredients
  - Moringa leaf meal and housefly maggots
- Enhancement of natural food production in ponds
  - Fertilisation and half ration
- Restricted feeding strategies
  - Skip – a – day vs. Low/High protein diets

Funding for this research was provided by the

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What is Needed Now in 2018 to Make Aquaculture a Vital Enterprise for Smallholders in Africa?
Tuesday, August 28 from 14:00 -15:00
Chair: Hillary Egna
Co-Chair: Tran Thi Thanh Hien (Vietnam)
Moderator: Nikita Gopal (India)
Panelists: Gertrude Atukunda (Uganda), Daniel Adjei-Boateng (Ghana), Renalda Munubi (Tanzania), Enos Mac'Were (Kenya), and Abudala Napuru (Uganda)
Rapporteur: James Bukenya (USA)

Selected prompted questions:

1. Is smallholder aquaculture the answer? Does every country need to grow its own fish?
2. In your experience, how has smallholder aquaculture improved household food security, especially for women and children?
3. Do you think that smallholder aquaculture can attract serious entrepreneurs? Who captures the benefit from smallholder aquaculture?
4. What is the role of government in smallholder aquaculture growth? Would advocacy to policy makers about the importance of aquaculture's contribution to food security and employment creation help with the prioritization of the sector? If so, what would be the best strategy for the advocacy?

What is Needed in 2018 to Make Aquaculture a Vital Enterprise for Smallholders in Africa?

Renalda N. Munubi

SOKOINE UNIVERSITY OF AGRICULTURE

Supporting Environment

Seed

Reliable and high quality seeds

Feed

High quality/quantity of feed

Appropriate research and extension

Access to finance

Logistics and Marketing

Reduction of transactional costs along the value chain

Appropriate policies and regulatory

THANK YOU

Highlights

- Low investment due to poor seeds/feed; lack of credits and practical information
- Markets –pricing, product, people, cheap import fatigue
- "You can't do today's job with yesterday's methods and be in business tomorrow"
- Paradigm shift to Value Chain approach – analyzing & strengthening the actors?

Agenda

- Strengthening the people towards
group saving

- Develop an entrepreneurial competence in Building a Sustainable Aquaculture business
- Innovative (think differently &how to ensure you stay ahead of the competition.
- Clearly defined Vision, Mission & Values
- Adopt GAP and build on Key Success Factors
- Comprehending parameter like CC, SD & ABW at harvest and liking them to marketing
- Clusters-Value Chain-within specialize in hatchery, feed distribution, value addition etc

What is Needed Now in 2018 to Make Aquaculture a Vital Enterprise for Smallholders in Africa?

Abudala Napuru
AQUA 2018, Montpellier, France
Email: abudala.napuru@gmail.com

Can you breed it and feed it?

Start with quality brood stock & BS management

Start with quality fry management

Start w/ quality feed; pellet composition: correct ingredients and size of crumble & pellet

Start with quality fry

Fry size can vary in same batch

Start with quality feed management; storage and ventilation

Start with quality fry meal

Start with quality pellet size

Can you sell it and finance it?

Fish in a basket in market | Fish on sawdust in market | Fish on ice in the market

Farmers need to get their fish to market-somehow

Fish purchased pond side

Financing is <u>almost impossible</u> for a farmer to get. Interest rates of 25-35% make it even more difficult.

Can you manage it? Staff training & extension

Sampling

Transporting on Oxygen

Training farmers

Emerging Technologies from AquaFish Innovation Lab Research
Tuesday, August 28 from 15:05 -16:10
Chair: Hillary Egna
Co-Chair: Judith Amadiva (Kenya)
Moderator: Kay Lwintun (Myanmar)
Panelists: Pham Minh Duc (Vietnam), Nen Phanna (Cambodia), Shahroz Mahean Haque (Bangladesh), Sunil Rai (Nepal), and John Walakira (Uganda)
Rapporteur: Russell Borski (USA)

Selected prompted questions:

1. What is the very next step to get this technology to the users and consumers? What is needed to scale it? Can it be scaled? What are the limitations to scaling?
2. What industry partnerships have been/will be key in the next steps for each technology?
3. How can these technologies be packaged to attract serious entrepreneurs into the sector?
4. For your technology what are the attendant negative environmental or social considerations? How can these be mitigated?

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AQUAFISH INNOVATION LAB

Montpellier, France 25-29 August 2018

EMERGING TECHNOLOGIES

DEVELOPMENT OF PELLET FEED FOR SNAKEHEAD (*Channa striata*) IN VIETNAM AND CAMBODIA

Pham Minh Duc

Can Tho University, Vietnam

www.ctu.edu.vn

CANTHO UNIVERSITY

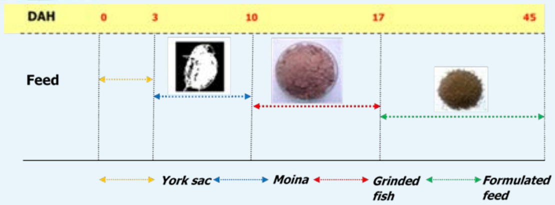
Why develop pellet feed for snakehead?

- ❑ In the 1990’s, snakehead farms have started to operate in Vietnam
- ❑ Fingerling snakehead collected from the wild and fed them by trash-fish (FCR = 4)
- ❑ Snakehead can not accept pellet feed

→ **This point is difficult to develop sustainable snakehead culture**

www.ctu.edu.vn

1. Technology for the weaning of snakehead based on formulated feed



- **Traditional method: using live food: Moina,…and then trashfish**
- **Emerging technology: 17 DHA replace trashfish by formulated feed (FF) with 10% every day until get 100% of FF**

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2. Technology for feed formulation to snakehead

Lab research:

- Study on nutrition snakehead requirements.
- Study on using plant ingredients >>> reduced fish meal >>> aquatic resource protection >>> **reduced feed cost >>> limited environment pollution.**
- Study on additives >>> increasing grow rate, survival rate, fish health, and feed efficiency.

On-farm trial

Transfer feed formulation

Transfer snakehead culture using pellet feed to farmers

Transfer technology to Cambodia

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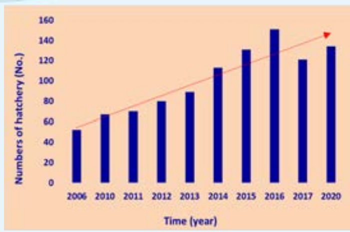
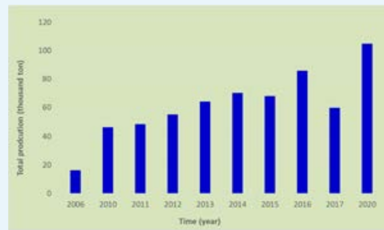
Snakehead sustainable development



Hatchery development



Production snakehead

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Bangladesh Project: Enhancing Aquaculture Production Efficiency, Sustainability and Adaptive Measures to Climate Change Impacts in Bangladesh

Goal: Better environmental management of aquatic resources to enhance production of seafoods and improve income and nutrition for the people of Bangladesh

Pulse feeding strategies to improve growth performance, gastrointestinal nutrient absorption, efficiency, and establishment of beneficial gut flora in tilapia monoculture

Objectives

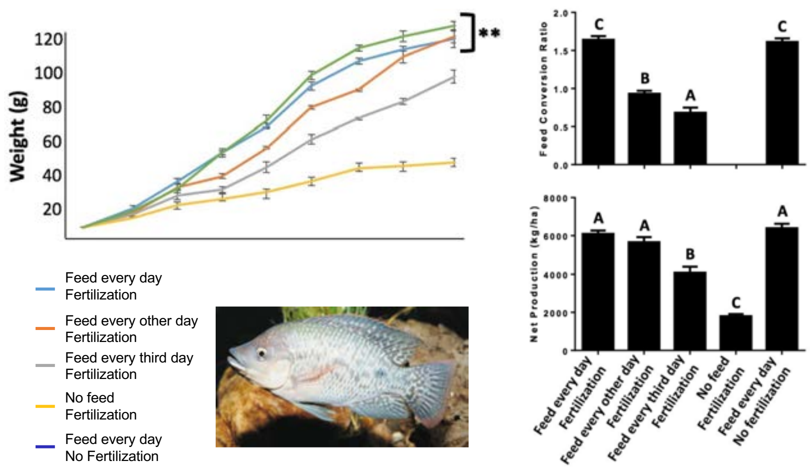
- Evaluate pulse feeding (every 1, 2 and 3 days) on tilapia production
- Identify factors influence nutrient uptake efficiency
- Identify pulse feeding impacts on gut microbial communities identified in gut feces using metagenomics

Location: BAU, NCSU (Raleigh, NC USA)

Treatment/ Factors	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Stocking Density	5 fish/m^2	5 fish/m^2	5 fish/m^2	5 fish/m^2	5 fish/m^2
Feeding strategy	daily feeding	alternate day feeding	feeding every 3rd day	no feeding	daily feeding
Pond Fertilization	4:1 (N:P), Weekly	4:1 (N:P), weekly	4:1 (N:P), Weekly	4:1 (N:P), Weekly	no fertilization

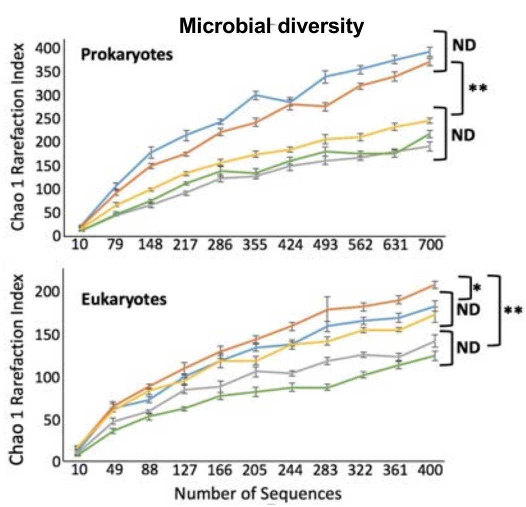
Supplemental feeds provided on alternate day yields the best fish production with improved fish feed efficiency

- Alternate-day feeding is the best way to feed tilapia in semi-intensive pond culture systems – increases returns by 125%



Alternate-day feeding enhances diversity of gut microbes

- Gut microbes are essential to efficient digestion of nutrients, energy homeostasis, innate immunity, maintenance and growth of epithelium

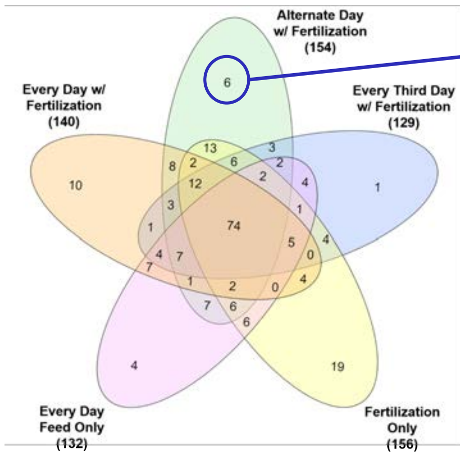


Feed every day Fertilization
Feed every other day Fertilization
Feed every third day Fertilization
No feed Fertilization
Feed every day No Fertilization

Enhanced diversity of microbes may lead to better assimilation of food

Identified gut microbiomes affects the fish's ability to:

- ➢ maintain physiological homeostasis
- ➢ process and better utilize nutrients making them available to the fish
- ➢ regulate health and wellbeing of the fish

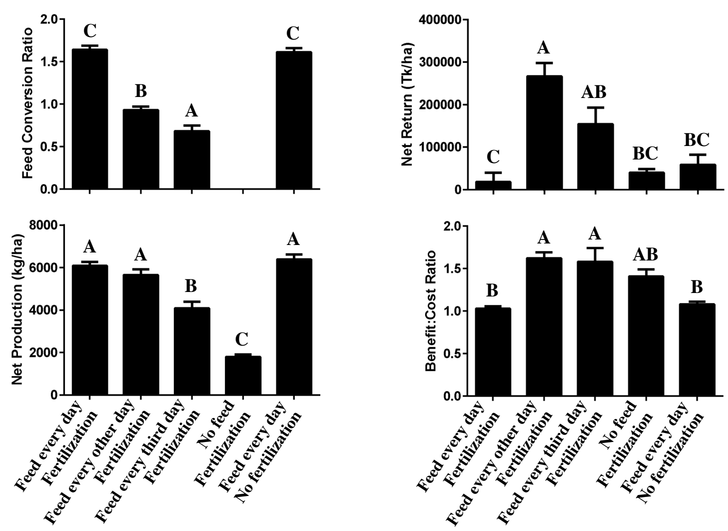


Bacteria that:

- have antimicrobial and antitumor effects = **Family Nocardioidacea**
- directly modulate the gut function of their hosts = **Family Bacteroidaceae**
- produce antioxidant compounds = **Genus *Sphingomonas***

- **May serve as future probiotics?**

Results – Economic Metrics



Letters designate statistical differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

Specifically, this strategy of feeding has no negative effects on growth, survivability, or production and produces the greatest net return on investments.

In previous AquaFish Innovation Lab studies, we found that tilapia fed on alternate days in fertilized ponds produced similar growth and survival, but improved feed efficiency by 100%, compared with fish fed daily. Fish also had a higher diversity of microbes in their intestines that may benefit nutrient processing and uptake.

will lead to enhanced feed efficiency with minimal impact on growth and survival of the fish. If successful, this refined strategy will be tested in tilapia pond culture in Bangladesh using the alternate day feeding strategy, an approach that could provide substantial costs savings for tilapia farmers in Bangladesh while also mitigating negative environmental impacts associated with excessive nutrient loading

This work also suggests for the first time that combined feeding and fertilization produces the greatest biodiversity of microbes in the intestine, which could contribute to enhanced feed efficiency and overall health of tilapia, particularly those subjected to more moderate feeding strategies NCSU) and Bangladesh Agricultural University (BAU) performed experiments in order to examine how alternate-day feeding strategies affect nutrient absorption in Nile tilapia. Gut microbiomes — or communities of bacteria and other microscopic organisms that live in digestive tracts — are essential for fish health as they contribute to efficient absorption of nutrients, maintaining energy balance, and immunity. The NCSU-BAU study characterized the bacterial gut community in tilapia to determine its impact on feed efficiency under different feeding regimes. A genetic analysis of the fecal material of tilapia identified 145 families of prokaryotic bacteria (cellular organisms without membranes or nuclei) and 132 eukaryotic organisms (cellular or multicellular organisms whose cells contain membrane-bound nuclei and other structures). The highest diversity of eukaryotes was found in fish that were fed every other day (also known as

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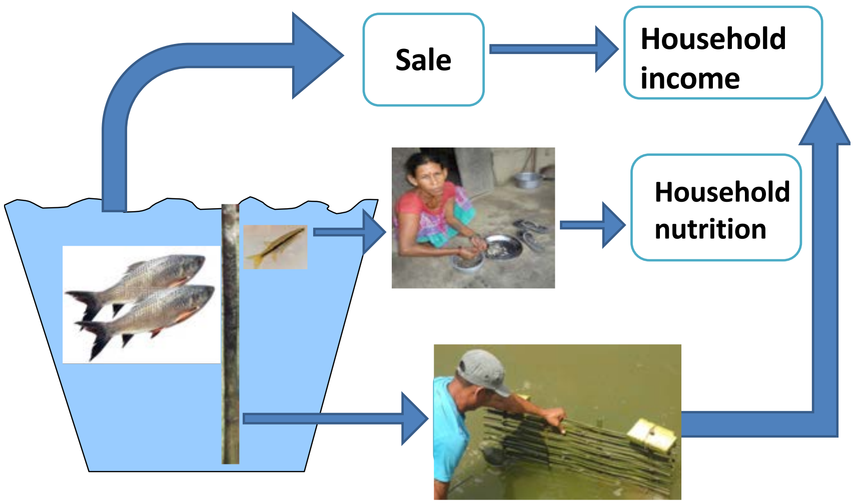
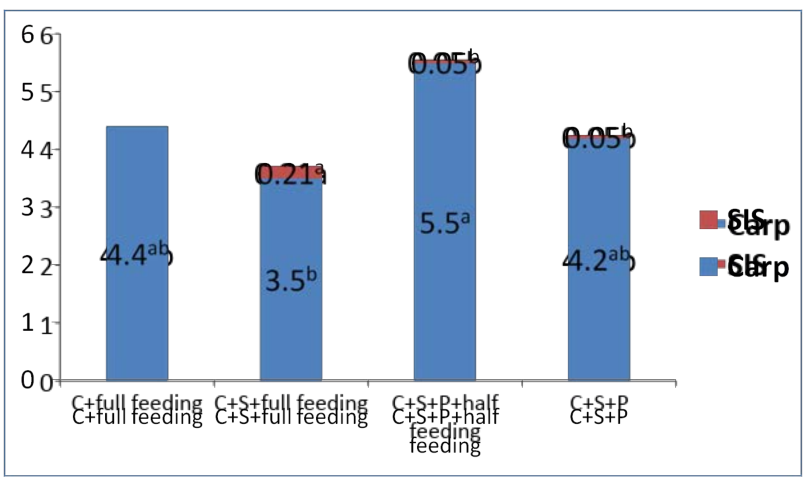
AquaFish Innovation Lab: A USAID initiative to increase sustainable production of seafoods to feed the future
Feed the Future Innovation Lab
AquaFish Innovation Lab
NC STATE UNIVERSITY
Dr. Shahroz Mahean Haque
Professor Department of Fisheries Management
Bangladesh Agricultural University, Mymensingh
HC Lead PI of AquaFish Innovation Lab Project
USAID
AQUAFISH INNOVATION LAB

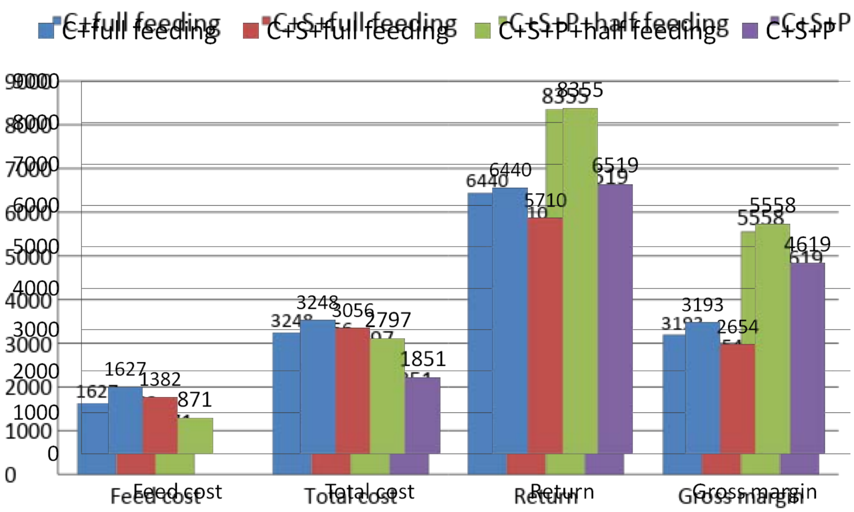
Carp – Small fish polyculture in periphyton enhanced system



Net yield of carp and SIS (t/ha/yr)



Gross margin analysis in different treatments (Rs/100 m²/210 days)



Sunila Rai, Kamala Gharti, Madhav Shrestha, Sabita Jha, Rajan Poudel, Rahul Ranjan, James Diana, Hillary Egna

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Shared Lessons from High-Producing Asian and LAC Countries for High Producing African Countries
Tuesday, August 28 from 16:10-17:15
Chair: Hillary Egna
Co-Chair: Nelson Agbo (Ghana)
Moderator: Maymyat Noe Lwin (Myanmar)
Panelists: Phu Hoa (Vietnam), Yuan Derun (Thailand), Md. Abdul Wahab (Bangladesh), Oludare Adeogun (Nigeria), and Victoria Tarus (Kenya)
Rapporteur: Wilfrido Contreras (Mexico)

Selected prompted questions:

1. The Southeast Asian and Latin American countries have vastly increased productivity in some of their aquaculture operations. Who are the high producers in your country or region? What lessons from these improvements in productivity could be shared with our African colleagues?
2. How or why did the industry grow from small to large when it took off? What changed for smallholders when aquaculture took off (e.g. policies, investment in capacity)? What was it that allowed aquaculture to take off?
3. What mistakes have been made as SEA and LAC countries increased their productivity (diseases, effluents, uneven markets, etc.)? What role does government play in regulating environmental impacts from the aquaculture industry in your country or region?
4. How do changes in global trade regulations (such as imported fish from china or feeds from the US and Brazil) impact the aquaculture industry in your country or region? Or create opportunities?

Shared Lessons from High-Producing Asian and LAC Countries for High Producing African countries

Assoc. Prof. Dr. NGUYEN PHU HOA
NONG LAM UNIVERSITY – HO CHI MINH CITY
VIET NAM

Shared Lessons from Viet Nam

AQUACULTURE ACHIEVEMENT

- Become exporter of Pangasius catfish, tiger and white leg shrimp
- Developing aquaculture of

FISH CULTURE	Tilapia, Snake head fish, Climbing perch, Carps, Swamp eel, Marble goby, Featherback fish, etc. Sea bass, Cobia
CRUSTACEAN CULTURE	Giant freshwater prawn, mud crab, lobster
MOLLUSC CULTURE	Clam, Cockle, Oyster

HOW WE GET THESE ACHIEVEMENTS

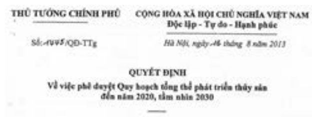
- Devoutness, hard working and williningness in applying advanced technology (RAS, Biofloc, intensive aquaculture, etc.) and management (community – based management)
- Got support from NGO's, international funds, University and Institution: enhancing human capacity, financial support, lab investment, etc.: AquaFish Innovation Lab (USAID) as one of important contributions.
- Strong support and awareness from Government, Universities, Institutions and Private Companies.
- Follow international rules in culture and processing practices (BMP, Global GAP, etc.,)
- More other..

CHALLENGES

- Competitors from Asian countries
- Climate change ➡ salinity instrusion ➡ lack of freshwater for shrimp culture
- Convert rice field or mangrove forest into shrimp ponds
- Impact on environments: causing organic poll
- Strick rules from USA, EU, etc.
- More …

SOLUTIONS

- Introducing **friendly-environmental aquaculture** to farmers through trainings (University and Research Institution involvements)
- **Research needs in international Collaboration**: in the fields of reproduction, healthy seeds, feed production, probiotics, culture techniques, environmental monitoring, etc. that will be adapted to climate changes, oriented to sustainable aquaculture
- Encouraging the cooperation: Scientist – Entrepreuners – Farmers – Government Officers
- Government supports:


THỦ TƯỚNG CHÍNH PHỦ

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Số: 1445/QĐ-TTg

Hà Nội, ngày 16 tháng 8 năm 2013

QUYẾT ĐỊNH
Về việc phê duyệt Quy hoạch tổng thể phát triển thủy sản đến năm 2020, tầm nhìn 2030

Decision of Prime Minister in 2013: Fisheries General Planning to 2020 and 2030

Oriented to sustainable aquaculture

- Aquaculture area for Mekong delta in 2020: 805,460 ha
- Planning production: 2,976, 420 tons
- Target species: tiger shrimp, white leg shrimp, catfish, tilapia, giant freshwater prawn, marine fish (sea bass and grouper), mollusk (clam, cockle)


BỘ NÔNG NGHIỆP VÀ PHÁT TRIỂN NÔNG THÔN

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Số: 2760/QĐ-BNN-TCTS

Hà Nội, ngày 22 tháng 11 năm 2013

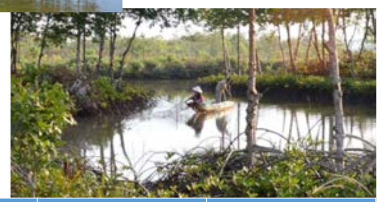
QUYẾT ĐỊNH
Phê duyệt "Đề án tái cơ cấu ngành thủy sản theo hướng nâng cao giá trị gia tăng và phát triển bền vững"

Decision of Minister, Ministry of Agriculture and Rural Development (MARD) in 2013

"Fisheries restructure to increase value added products and to orient sustainable development"

- Protect and conserve fisheries resources: establish sanctuaries, recovery ecosystems for corals, seaweeds, mangrove, etc.
- Diversify the cultured species in different ecosystems
- Develop the environmental monitoring systems and aquatic animals ' health warning systems.

Mangrove - shrimp



Type of culture	Area in 2020 (ha)	Area in 2030 (ha)
Ecological culture (mangrove – shrimp/extensive)	95,000	115,000
Improved extensive culture	200,000	135,000

Rice - Shrimp

Type of culture	Area in 2020 (ha)	Area in 2030 (ha)
Rice - Shrimp	200,000	250,000

Rice - Prawn

Special thanks to

- **[Prof. Dr. Yang Yi]**
- **Prof. Dr. James Diana**
- **Dr. Hillary Egna**

Thanks to AquaFish Innovation Lab
for supporting AQUA 2018 attendance

Funding for this research was provided by the

AQUAFISH INNOVATION LAB

The AquaFish Innovation Lab is supported in part by United States Agency for International Development (USAID) Cooperative Agreement No. EPP-A-00-06-00012-00 and by contributions from participating institutions.

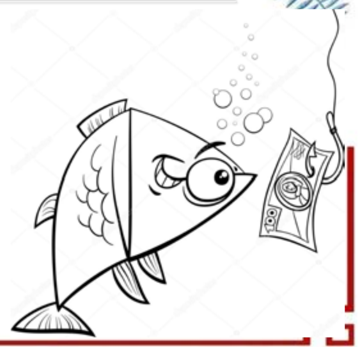
A Conversation with AquaFish Innovation Lab
on the future of Sustainable Aquaculture

Shared Lessons from High Producing Countries

YUAN Derun, NACA
Le Corum Conference Centre, Montpellier, France
28 August 2018

Develop profitable models

- **Does it make enough money?**
  - It is money not necessarily fish!
  - More attractive than other potential livelihood



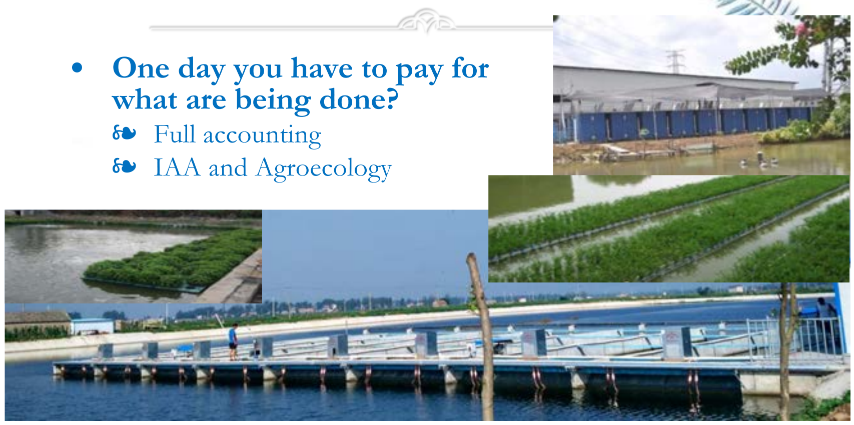
https://depositphotos.com/61824637/stock-illustration-fishing-with-money-cartoon-illustration.html

Establish marketing chains

- **Can farmers sell their produce?**

Make it environmentally compatible

- **One day you have to pay for what are being done?**
  - Full accounting
  - IAA and Agroecology



AQUAFISH INNOVATION LAB

Lessons from Bangladesh

USAID

NC STATE UNIVERSITY OSU

USAID AQUAFISH INNOVATION LAB

AquaFish Lab Tells the Stories of Bangladesh

- BD produces about 4.2 million MT of fish, ranked 4th, 56% from aquaculture
- Key to the success -- polyculture IMC & Asian carps– maximizing pond prodn (2.3 million MT)
- Tilapia prodn in monoculture & polyculture with carps – 275K MT
- Semi-intensive production of *Pangasisus* catfish – 300K MT
- Emerging poly-technologies: carp--air-breathing fish, carp-SIS (mola), prawn-mola/dyke cropping, F/W prawn-Tilapia, periphyton-based (*Acadja!*) & hyposaline aquaculture
- **BAU** developed technologies & trained graduates students – nation got both!!
- BAU led 4 universities & collaborated with 2 NGOs, DoF, BFRI & WorldFish- for dissemination
- It targets 7 million MT over next 10 years.

Future Fisheries

Future xxx Lab/Activity: Climate resilient aquaculture for Asia & Africa

- Seeds for aquaculture - focus on Tilapia & low trophic endemic species – hatchery 1st!
- Affordable feed development -Tilapia*, Pangasius,* local species – priority activity!!
- Predator-prey (African catfish-tilapia), green-water systems, finger ponds, *Acadja ??*
- Support seaweed & shell fish research, e.g. crab, mollusks (oyster, clam & mussel)
- Coastal aquaculture of fin-fish & support BD's dream - **Blue Economy!**
- Integrated aqua-horticulture technology of nutrient-rich fish with n-r vegetables
- Address challenges of emerging threats to aqua diseases- hatchery & grow-out systems

- Mentor, supervisors & friends- treasures in my life – THANK YOU!!

AquaFish Innovation Lab Supported Researchers
Abstracts and Presentations

Some posters were not available for inclusion in this proceedings at the time of publications.

Unlocking the Potential of African Lungfish (*Protopterus aethiopicus*) to Improve Nutrition and Livelihoods of Vulnerable Communities in Uganda: Captive Seed Production

J. Walakira*, C. Aruho, M. Njeri, B. Kimera, E. Ganda, L. Nakasiga, G. Atukunda, B. Readings, R. Borski, H. Egna and J. Molnar

National Fisheries Resources Research Institute, Uganda.

The African lungfish (*Protopterus aethiopicus*) supports many communities in Uganda, and has aquaculture potential. It's an air-breathing fish that can withstand stressful water quality conditions in the wild. Fish farmers can access from natural environments, which is not environmentally sustainable. This project reveals the genetic diversity of *P. aethiopicus* collected from Lakes Wamala, Kyoga, Nawampasa, Bisina, Edward and George based on Next Generation Sequence platform. The hatchability of this fish in captivity is 21.7 ± 7.2 % (SD) while its mean fecundity is 1922.41 ±1227.6. Wild-caught lungfish broods could spawn in-door facilities when subjected to artificial hormones (HCG and LHRH), and eggs optimally hatched at 27°C saline-water. Its larvae can be weaned to artificial and live diets after the 16th Day post-hatch: when its digestive system is fully developed. This research has enhanced our knowledge base to artificially produce lungfish, which will also restore biodiversity Uganda. However, additional research will address low-cost captive breeding technologies that are adaptable to smallholding farmers.

UNLOCKING THE POTENTIAL OF AFRICAN LUNGFISH (*Protopterus aethiopicus*) TO IMPROVE NUTRITION AND LIVELIHOODS OF VULNERABLE COMMUNITIES IN UGANDA: CAPTIVE SEED PRODUCTION

J. Walakira*, C. Aruho, M. Njeri, B. Kimera, E. Ganda, L. Nakasiga, G. Atukunda, B. Readings, R. Borski, H. Egna and J. Molnar

[*] **National Agricultural Research Organisation , National Fisheries Resources Research Institute.**

1. Introduction

The African lungfish (*P. aethiopicus*) is a high value species in the great lakes region. Lungfish-aquaculture requires year round supply of quality seed through development of appropriate breeding technologies. Its domestication require knowledge on its reproductive biology and protocols for captivity by farmers. Therefore, this study seeks to develop sustainable breeding and appropriate culture techniques for African lungfish species.

Figure 1: African lungfish Seed

2. Methods and Materials

This study seeks to develop sustainable breeding and appropriate culture techniques. Samples from two Lakes (Bisina & Wamala) were assessed to understand breeding and spawning strategies. Ripe wild caught brood-stock were subjected to HCG and LRHa hormones to spawn in captivity. Larvae (0-1g) nursed in aquaria tanks, stocked at 1g/L of aerated water were fed to artemia, Moina and dry feeds (CP 45%).

3. Results

It's an air-breathing fish that can withstand stressful water quality conditions in the wild. Fish farmers can access from natural environments, which is not environmentally sustainable. This project reveals the low genetic diversity of *P. aethiopicus* collected from Lakes Wamala, Kyoga, Nawampasa, Bisina, Edward and George based on Next Generation Sequence platform. The hatchability of this fish in captivity is 21.7 ± 7.2 % (SD) while its mean fecundity is 1922.41 ±1227.6. Wild-caught lungfish broods could spawn in-door facilities when subjected to artificial hormones (HCG and LHRH), and eggs optimally hatched at 27°C saline-water. Its larvae can be weaned to artificial and live diets after the 16th Day post-hatch: when its digestive system is fully developed. Fingerlings fed *ad libitum* can reach market size of 400-700g in seven months.

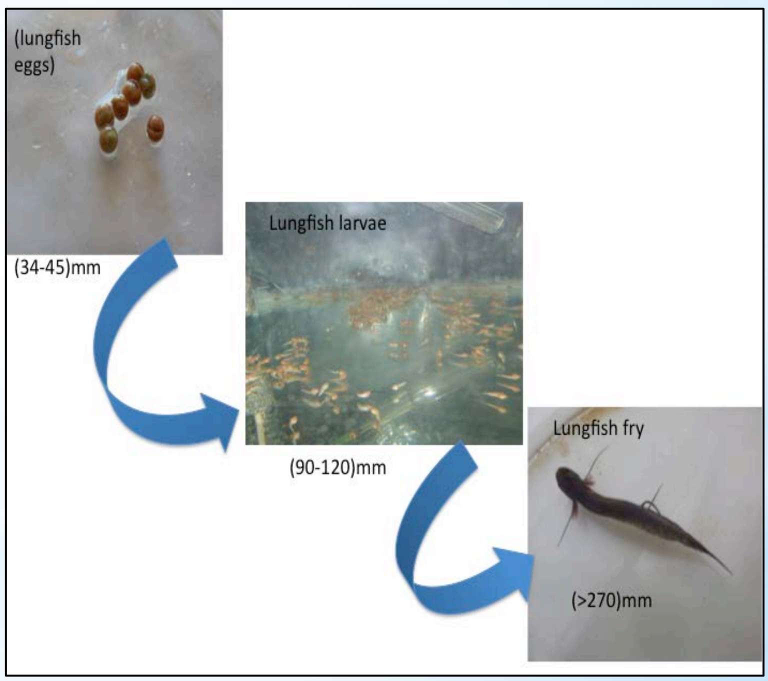


Figure 2: Captive production of African lungfish fry

4. Recommendations

Fish farmers can produce lungfish seed and raise it in aquaculture systems using artificial hormones and live feed, respectively.

Acknowledgement

AquaFish Innovation Lab, USAID From the American People

Contact: johnwalakira2003@gmail.com

Seed Production and Culture of Snakehead *Channa striata* in the Mekong Delta Vietnam

Bui Minh Tam[1*], Tran Thi Thanh Hien[1], Pham Minh Duc[1], Pham Thanh Liem[1], Nguyen Hong Quyet Thang[1], Nguyen Van Khanh[1]

[1]College of Aquaculture and Fisheries, Can Tho University
Can Tho city, Viet Nam

Snakehead feeding with pellet are cultured widely in Vietnam, especially in the Mekong Delta. Snakehead production increases from 5,300 ton in 2002 to 40,000 ton in 2009. In 2012 and 2013, total productions of Tra Vinh, An Giang and Dong Thap provinces are 35,818 and 36,140 tonnes, respectively (Aquaculture Agencies of these provinces). Snakehead hatchery are expand quickly due to seed quality tend to reduce. The objectives are continuing to compare the domestication and wild strains of Vietnam snakehead *C. striata* brooders. The 1st experiment was carried out with crosses and backcross between domesticated and wild strains. Broodstock with egg maturation at the same stage was selected for induced spawning in order to simultaneously produce batches of larvae for the weaning experiment. Male and female broodstocks from wild and domesticated sources were stimulated with HCG and distributed randomly in fiber tank (0.3 m^3/tank). The crosses were as follows: (1) Domesticated female (♀) x Domesticated male (♂); (2) Domesticated female (♀) x Wild male (♂); (3) Wild female (♀) x Wild male (♂); and (4) Wild female (♀) x Domesticated male (♂). Each treatment was replicated with 10 pairs. The values of fecundity, fertilization rate and hatching rate of treatment 3 (Wild female x wild male) gave the highest data comparing with other treatments. Although the spawning rate is lower than with others. So the egg quality of wild snakehead are still better than with domesticated snakehead. The 2nd experiment was done with nursing their crosses from larvae to fingerling. After yolk absorption at 3 days after hatching (dah), larvae from each treatments was fed with live *Moina* for 7 consecutive days till 10 day-old larvae (dah), and then larvae was fed with a mixture of dead *Moina* and ground freshwater small-sized fish (replacing *Moina* by 20% per day) for 7 days more till 17 day-old larvae (dah). Larvae start weaning on formulated feed at 17 day with replacement of trash fish by 10% per day until freshwater small-sized fish was completely replaced by formulated feed. Formulated feed contains 40-50% crude protein. The growth of larvae crossing between wild male and domesticated female gain performances better than other crosses. These larvae can gain good characteristics from wild male and high growth from domesticated female. The survival rate of treatment 1 (domesticated female x domesticated male) give highest value (45.5%) comparing with treatment 2, 3 and 4 at values of 41.3, 41.0 and 42.0%, respectively. The 3rd experiment was to compare the growth among hybridizations. After nursing 45 days, the seed was stocked in hapa for grow out. Snakehead was fed with commercial pellet with crude protein of 35-40%. The results showed that the growth of female wild gave higher values compare with other treatments.

AQUA 2018

SEED PRODUCTION AND CULTURE OF SNAKEHEAD *Channa striata* IN VIETNAM

Bui Minh Tam, Tran Thi Thanh Hien, Pham Minh Duc, Pham Thanh Liem , Nguyen Hong Quyet Thang, Nguyen Van Khanh
College of Aquaculture and Fisheries, Can Tho University, Can Tho city, Viet Nam
*Email: bmtam@ctu.edu.vn

Introduction

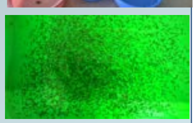
- Snakehead feeding with pellet are cultured widely in Vietnam, especially in the Mekong Delta. Snakehead production in the Mekong Delta increased rapidly from 15,958 tons in 2006 to 85,630 tons in 2016. The seed quality tends to reduce because of inbreeding. Survival rate from larvae to fingerling is very low due to diseases and low resistance.
- The objectives are continuing to compare the domestication and wild strains of Vietnam snakehead *C. striata* brooders. The 1st experiment was carried out with crosses and backcross between domesticated and wild strains. The 2nd experiment was done with nursing their crosses from larvae to fingerling. The 3rd experiment was to compare the growth among hybridizations

Results

(i) Comparation of breeding parameters on crosses and backcross between domesticated and wild strains

Table 1: breeding parameters among snakehead strains

Treatment	Spawning rate (%)	Fecundity (egg/kg)	Fertilization rate (%)	Hatching rate (%)
1 (DxD)	100	35,121	71.5±27.7	39.7±32.3
2 (DxW)	100	36,012	85.7±24.6	70.2±28.5
3 (WxW)	90	54,567	86.7±32.6	92.4±9.5
4 (WxD)	100	42,115	67.1±39.9	66.4±36.2



(ii) Growth and survival rate of snakehead strains after 45 days

Figure 1: Feeding regime during 45 days

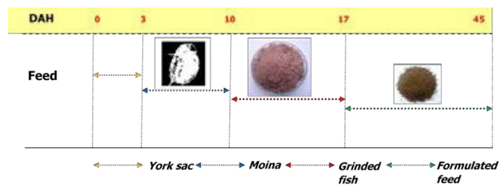


Table 2: Growth and survival rate of different strains

Treatment	Initial length (cm)	Final length (cm)	Initial weight (g)	Final weight (g)	Survival rate (%)
1 (DxD)	0.608	4.61±0.78	0.0021	1.15±0.54	45.6±16.9
2 (DxW)	0.581	4.66±1.17	0.0020	1.13±0.63	41.3±10.0
3 (WxW)	0.601	4.59±0.87	0.0019	1.04±0.50	41.0±15.5
4 (WxD)	0.589	5.12±1.18	0.0020	1.50±0.81	42.0±11.8

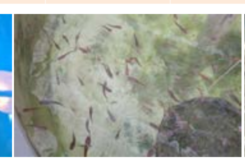
(iii) Growth and survival rate of snakehead strains after 5 months

Table 3: Growth of different strains after 5 months

Parameters	1 (DxD)	2 (DxW)	3 (WxW)	4 (WxD)
P_o(g)	$0,391\pm0,039^{a}$	$0,395\pm0,049^{a}$	$0,466\pm0,003^{b}$	$0,434\pm0,050^{ab}$
P_f (g)	$402,82\pm30,34^{c}$	$306,16\pm23,95^{b}$	$160,49\pm4,12^{a}$	$323,13\pm39,02^{b}$
WG (g)	$402,42\pm30,35^{c}$	$305,77\pm23,97^{b}$	$160,02\pm4,11^{a}$	$322,70\pm39,81^{b}$
DWG (g/day)	$3,35\pm0,25^{c}$	$2,55\pm0,20^{b}$	$1,33\pm0,03^{a}$	$2,69\pm0,33^{b}$
SGR (%/day)	$5,78\pm0,01^{c}$	$5,55\pm0,01^{b}$	$4,87\pm0,01^{a}$	$5,51\pm0,01^{b}$

Table 4: Survival and yield of different strains after 5 months

Parameters	1 (DxD)	2 (DxW)	3 (WxW)	4 (WxD)
Survival rate (%)	$77,48 \pm 6,43^{b}$	$76,04 \pm 6,82^{ab}$	$66,98 \pm 8,80^{a}$	$74,44 \pm 5,87^{ab}$
Yield (kg/m²)	$9,57 \pm 0,24^{a}$	$23,79 \pm 1,78^{c}$	$17,13 \pm 1,21^{b}$	$17,93 \pm 1,09^{b}$



Conclusion

Fecundity of wild snakehead is higher than domesticated strains and their hybrids. The cross between female wild and domesticated male gives high values on growth after nursing 45 days. For grow out, the growth of domesticated snakehead is higher than comparing with other treatments.

Acknowledgment

Funding for this research was provided by the AquaFish Innovation Lab which is supported in part by United States Agency for International Development (USAID) Cooperative Agreement No. EPP-A-00-06-00012-00 and by contributions from participating institutions.

Sustainable use of Snakehead Genetic Resources for Aquaculture in Cambodia: Recommendations from Genetic Data

Uy Sophorn*, Duong Thuy Yen, Chheng Phen, So Nam,
Tran Thanh Thanh Hien, Robert Pomeroy, Hillary Egna

*Inland Fisheries Research and Development Institute (IFReDI),
Fisheries Administration, Ministry of Agriculture Forestry and Fisheries
#186, Preah Norodom Blbd., Sangkat Tonle Bassac, Khan Camcarmon, Phnom Penh, Cambodia

Snakehead fishes (*Channa striata*) have recently been allowed to be cultured in Cambodia after more than a decade of banning. Domestication of these species requires genetic information to maintain good genetic resources for sustainable aquaculture. For this purpose, we collected wild samples of *Channa striata* from 8 provinces in Tonle Sap Lake and lower Mekong floodplains of Cambodia including Battambang (BB), Siem Reap (SR), Pursat (PS), Kampong Thom (KT), Kampong Chhnang (CHN), Kampong Cham (KCH), Kandal (KD), Prey Veng province (PV), and 3 provinces in Mekong Delta floodplains in Vietnam including Long An (LA), Hau Giang (HG), Ca Mau province (CM). We also collected 3 domesticated population from hatcheries in Dong Thap (DT), An Giang (AG), and Hau Giang province (HG). Sequence data of two mitochondrial genes (Cytochrome b and Dloop region) revealed that wild populations of snakehead in Cambodia have higher levels of genetic diversity (especially BB and PS populations), compared to the same species in cultured conditions in Vietnam. This result combined with previous studies on a variety of aquaculture species indicate that genetic diversity can decrease along with the number of domestication generations, and thus is a good lesson for snakehead farming in Cambodia. The suitable management of broodstock should be provided to farmers to minimize genetic loss due to inbreeding and random genetic drift. In addition, genetic diversity of broodstock in hatcheries should be monitored periodically in order to have genetic improvement strategies in time.

Table. 1: Genetic diversity of three groups (Cambodian-wild, Vietmese-wild and Vietnamese-cultured) of populations based on Cytochrome b gene and Dloop gene

Cytochrome b	H	Hd	Nd	**loop**	H	Hd	Nd
CAM-Wild (N = 145)	23	0.760 ± 0.033	0.00239	CAM-Wild (N = 145)	104	0.990 ± 0.002	0.01205
VN-Wild (N = 58)	8	0.561 ± 0.003	0.00115	VN-Wild (N = 60)	29	0.936 ± 0.019	0.01058
VN-Culture (N = 59)	2	0.034 ± 0.033	0.00006	VN-Culture (N = 59)	5	0.431 ± 0.076	0.00314
Total	28	0.620 ± 0.034	0.00169	Total	130	0.946 ± 0.0106	0.01104

Notes: Haplotypes frequency (H), Haplotypes diversity (Hd) and Nucleotide diversity (Nd)

SUSTAINABLE USE OF SNAKEHEAD GENETIC RESOURCES FOR AQUACULTURE IN CAMBODIA: RECOMMENDATIONS FROM GENETIC DATA

Sophorn UY*, Thuy Yen DUONG, Phen CHHENG, Nam SO, Thanh Thanh Hien TRAN, Robert POMEROY, Hillary EGNA

* *Inland Fisheries Research and Development Institute, Fisheries Administration, Phnom Penh, Cambodia.*

Email: sophornkp@gmail.com

ABSTRACT

Snakehead fishes have recently been allowed to be cultured in Cambodia after more than a decade of banning. Domestication of these species requires genetic information to maintain good genetic resources for sustainable aquaculture. For this purpose, we collected wild samples of *Channa striata* across the Lower Mekong floodplains including Battambang, Siem Reap, Pursat, Kampong Thom, Kampong Chnang, Kampong Cham, Kandal, and Prey Veng province, and 3 domesticated and wild populations in Vietnam. Sequence data of two mitochondrial genes (Cytochrome b and Dloop region) revealed that wild populations of snakehead in Cambodia have higher levels of genetic diversity (especially BB and PS populations), compared to the same species in cultured conditions in Vietnam. This result indicate that genetic diversity of snakehead in Vietnam has decreased along with the number of domestication generations, and thus is a good lesson for snakehead farming in Cambodia. Suitable management of brood-stock should be provided to farmers to minimize genetic loss due to inbreeding and random genetic drift. In addition, genetic diversity of brood-stock in hatcheries should be monitored periodically in order to have genetic improvement strategies in time.

BACKGROUND

Aquaculture has considered as one of three pillars of the country's fisheries development in Cambodia. The government's Strategic Planning Framework for Fisheries for 2010 to 2019 considers expanding the farming of fish and other aquatic animals to sustain the country's growing population. Yet Cambodia's aquaculture development remains constrained by a 10-years government ban on farming two snakehead species native to the Lower Mekong Basin because of Cambodian and Vietnamese farmers typically feed these highly carnivorous fishes with catches of small low-value freshwater fish that are otherwise consumed by the rural poor. To release this ban, the study recommended that genetic diversity of striped snakehead collected from different locations have been assessed for further success in conducting domestication breeding, weaning and growing-out programs in Cambodia

OBJECTIVE

- To characterize and compare genetic diversity of wild snakehead populations in Cambodia to Vietnamese domesticated and wild populations.
- To provide basic information and wise recommendations for striped snakehead domestication and selection breeding and farming in Cambodia, and Viet Nam.

METHODOLOGY

Study Sites & Sample Collection

- Five locations in the Tonle Sap floodplains, Siem Reap (SR), Battambang (BB), Kampong Thom (KT), Pursat (PS), and Kampong Chnang (CHN).
- Three locations in the Mekong River floodplains, Kampong Cham (KCH), Kandal (KD), Prey Veng (PV).
- Three hatcheries in Dong Thap (DT), An Giang (AG), and Hau Giang (HG) and three wild populations in Long An (LA), Hau Giang (HG), and Ca Mau (CM), Viet Nam.
- 20 individuals per each population were clipped fins and preserved in absolute 99% of Ethanol.
- GPS coordination were recorded.

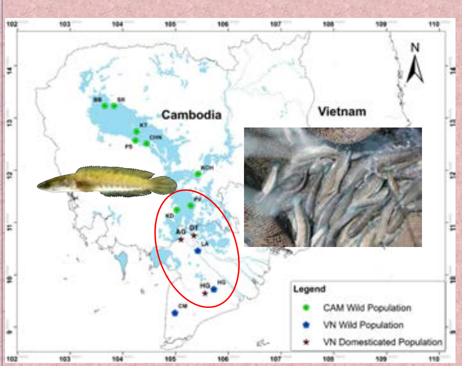


Figure1: Map of sampling sites

Extraction

- DNA was extracted using a commercial kit (Wizard® SV Genomic DNA Purification System).

PCR amplification

- Mitochondrial genes (cyt*b* & D*loop*) were amplified from 15-20 individuals of each population.
- Qualified PCR products were sequenced at First BASE Laboratories Sdn Bhd, Selangor, Malaysia.

Data Analysis

- Multiple sequences of both genes were aligned using MEGA v7.0
- Haplotype datasets were conducted using dnaSP v5.10.1.
- The estimations of DNA polymorphism, haplotype diversity (Hd), nucleotide diversity (π), Tajima test, Fu's Fs test, computing pairwise *Fst* value and probability values, AMOVA test were employed in Arlequin v3.5.

RESULTS

Genetic Diversity

- Wild population in Cambodian are highly significantly different from domesticated population and wild population in Vietnam (Table.1&2).
- Genetic diversity was highest in Cambodian wild populations, followed by Vietnamese wild and lowest in Vietnamese culture populations (Table.3&4).
- Vietnamese domesticated populations also differed (small magnitude) from Vietnamese wild populations.

Table.1: Summaries of pairwise F*st* values (◣) and probability (◥) among populations from **cyt*b*** gene, level of significance ρ<0.05

Populations	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.CAM-BB	*	0.640	0.829	0.306	0.991	0.018	0.090	0.045	0.000	0.108	0.009	0.000	0.000	0.000
2.CAM-SR	-0.024	*	0.297	0.315	0.865	0.009	0.072	0.000	0.000	0.081	0.000	0.000	0.000	0.000
3.CAM-KT	-0.029	0.003	*	0.135	0.991	0.027	0.153	0.054	0.000	0.505	0.000	0.000	0.000	0.000
4.CAM-PS	0.015	0.002	0.028	*	0.396	0.009	0.000	0.009	0.000	0.036	0.000	0.000	0.000	0.000
5.CAM-CHN	-0.043	-0.026	-0.029	-0.001	*	0.000	0.198	0.009	0.000	0.270	0.000	0.000	0.000	0.000
6.CAM-KCH	0.124	0.139	0.095	0.126	0.116	*	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000
7.CAM-KD	0.037	0.089	0.017	0.156	0.029	0.221	*	0.207	0.000	0.514	0.054	0.270	0.009	0.000
8.CAM-PV	0.129	0.172	0.082	0.218	0.111	0.313	0.036	*	0.000	0.144	0.360	0.405	0.171	0.135
9.VN-CM	0.369	0.371	0.355	0.343	0.347	0.374	0.477	0.606	*	0.000	0.000	0.000	0.000	0.000
10.VN-HG	0.017	0.066	-0.007	0.095	0.009	0.159	-0.010	0.037	0.353	*	0.000	0.009	0.009	0.000
11.VN-LS	0.289	0.334	0.209	0.377	0.250	0.450	0.104	0.372	0.718	0.132	*	0.991	0.991	0.991
12.VN-C-AG	0.280	0.326	0.201	0.368	0.244	0.441	0.114	0.033	0.712	0.131	-0.025	*	0.991	0.459
13.VN-C-DT	0.328	0.364	0.241	0.401	0.283	0.480	0.167	0.097	0.759	0.173	-0.010	-0.008	*	0.991
14.VN-C-HG	0.363	0.394	0.269	0.431	0.312	0.510	0.194	0.120	0.780	0.196	0.000	0.003	0.000	*

Table.2: Summaries of pairwise F*st* values (◣) and probability (◥) among populations from **D*loop*** gene, level of significance ρ<0.05

Populations	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.CAM-BB	*	0.153	0.018	0.135	0.036	0.009	0.054	0.036	0.009	0.009	0.000	0.000	0.000	0.000
2.CAM-SR	0.025	*	0.180	0.324	0.648	0.000	0.063	0.180	0.000	0.036	0.000	0.000	0.000	0.000
3.CAM-KT	0.070	0.015	*	0.018	0.603	0.009	0.441	0.432	0.000	0.072	0.009	0.000	0.000	0.000
4.CAM-PS	0.027	0.005	0.066	*	0.162	0.000	0.000	0.090	0.000	0.027	0.000	0.000	0.000	0.000
5.CAM-CHN	0.042	-0.013	-0.015	0.022	*	0.009	0.216	0.603	0.000	0.135	0.000	0.000	0.000	0.000
6.CAM-KCH	0.115	0.129	0.094	0.119	0.086	*	0.018	0.018	0.000	0.009	0.000	0.000	0.000	0.000
7.CAM-KD	0.056	0.052	-0.003	0.085	0.017	0.086	*	0.198	0.000	0.117	0.018	0.000	0.000	0.000
8.CAM-PV	0.047	0.019	-0.005	0.025	-0.009	0.086	0.016	*	0.000	0.495	0.000	0.000	0.000	0.000
9.VN-CM	0.090	0.179	0.212	0.162	0.161	0.219	0.132	0.151	*	0.000	0.000	0.000	0.000	0.000
10.VN-HG	0.063	0.050	0.033	0.054	0.024	0.066	0.23	0.003	0.154	*	0.018	0.000	0.000	0.000
11.VN-LS	0.226	0.208	0.130	0.218	0.173	0.171	0.127	0.134	0.359	0.071	*	0.027	0.216	0.225
12.VN-C-AG	0.395	0.399	0.321	0.379	0.377	0.343	0.311	0.307	0.559	0.210	0.073	*	0.153	0.883
13.VN-C-DT	0.389	0.393	0.312	0.371	0.372	0.342	0.303	0.301	0.554	0.232	0.036	0.049	*	0.577
14.VN-C-HG	0.363	0.359	0.276	0.345	0.333	0.307	0.271	0.267	0.524	0.188	0.024	-0.038	-0.007	*

Table.3: Summaries of genetic statistics from three groups based on **cyt*b*** gene, * indicate level of significance *ρ<0.05*.

Pops	Hap.	*Hd*	π	Tajima's test	Fu's Fs test
CAM-Wild (n = 145)	23	0.763	0.00237	-1.8428 *ρ* = 0.009**	-18.2448 *ρ* = 0.000**
VN-Wild (n = 58)	8	0.561	0.00115	-1.6135 *ρ* = 0.037*	-4.5006 *ρ* = 0.006*
VN-Culture (n = 59)	**2**	**0.034**	**0.00006**	**-1.0875 *ρ* = 0.108**	**-1.7606 *ρ* = 0.037***
Total	28	0.620	0.00169		

Table.4: Summaries of genetic statistics from three groups based on **D*loop*** gene, * indicate significance at *ρ<0.05*.

Pops.	Hap.	*Hd*	π	Tajima's test	Fu's Fs test
CAM-Wild (n = 159)	104	0.990	0.01204	-1.1753 ρ=0.106	-24.1896 ρ=0.000
VN-Wild (n = 60)	29	0.936	0.01058	-0.2695 ρ=0.479	-5.5448 ρ=0.069
VN-Culture (n = 59)	**5**	**0.431**	**0.00314**	**-0.6524 ρ=0.294**	**-4.0878 ρ=0.941**
Total	130	0.946	0.01104		

- Higher level of genetic variation generated from D*loop* gene compared to cyt*b* gene.

Genetic comparison among groups

- Genetic differences of Cambodian populations grouped as a whole were significant compared to Vietnamese cultured and wild populations.

Table.4: Summaries of pairwise F*st* values (◣) and pairwise F*st* probability (◥), among groups, level significance at ρ<0.05.

Gene	cyt*b*			D*loop*		
Groups	1	2	3	1	2	3
1. CAM-Wild	*	0.0000	0.0000	*	0.000	0.000
2. VN-Wild	0.073	*	0.0000	0.0357	*	0.000
3. VN-Culture	0.219	0.255	*	0.2670	0.2487	*

Table.5: AMOVA test, comparing genetic structure between Cambodian wild, Vietnamese wild, and Vietnamese cultured populations.

	cyt*b*			D*loop*		
	d.f	% of Variation	Sig*	d.f	% of Variation	Sig*
Among groups	2	12.29	0.0108	2	15.44	0.000
Among populations within groups	11	14.43	0.0000	11	6.67	0.000
Within populations	243	73.28	0.0000	265	77.81	0.000

CONCLUSIONS

- Genetic diversity was highest in Cambodian wild fish, followed by Vietnamese wild, once lowest in Vietnamese culture fish.
- Genetic differences of Cambodian populations grouped as a whole were significant compared to Vietnamese cultured and wild populations. However, two populations KD and PV in Mekong River floodplains did not genetically differ from Vietnamese cultured and wild populations located along Mekong River (circled, Figure. 1), except one (Ca Mau) far away from the Mekong River.
- Vietnamese cultured populations also differed (small magnitude) from Vietnamese wild populations.
- No genetic difference observed among Vietnamese cultured populations.

RECOMMEDATION

- Wild snakehead in Cambodia is a good source for domestication and farming.
- Snakehead sources in Vietnam should not be used for domestication and aquaculture in Cambodia because of lower genetic diversity.
- Genetic diversity of snakehead broodstock in Cambodia should be monitored regularly during the process of domestication and aquaculture.
- Cultured snakehead populations in Vietnam should be genetically improved.

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Effect of Iron Amino Acid Chelate Supplement in Fish Feeds on Growth Performance of Nile Tilapia *Oreochromis niloticus* and Spinach *Spinacia oleracea* in an Aquaponic System

Kenneth Rono*, Julius O. Manyala, David Lusega, Josiah A. Sabwa, Charles Ngugi, Kevin Fitzsimmons and Hillary Egna

*University of Eldoret,
P.O Box 1125, Eldoret, KENYA.

Aquaponics is an environmentally friendly production system involving reuse of waste and nutrients in production of fish and vegetables. The study was conducted at the University of Eldoret for 119 days from August-December 2016. A complete randomized design was used. The supplementation rates in fish diets constituted 30g, 20g, 10g and 0g Fe kg^{-1} respectively. Nile tilapia fry with a mean weight of 0.475 ± 0.025g and nine spinach (height 3 ± 0.131cm, 2 leaves) were stocked in 12 aquaria in an aquaponic system. The 30g Fe kg^{-1} treatment resulted in the highest fish growth performance with final weights of 11.606 ± 0.55g, and SGR of 2.516 ± 0.01 and a good FCR of 1.10 ± 0.107 compared to the other three treatment. At 30 Fe kg^{-1} treatments spinach indicated a significant growth at ($p < 0.05$) than other treatments with final mean height (52.44 ± 0.798cm) and 19 leaves. The least growth of spinach was at 0 Fe kg^{-1}treatments with final mean height, (25.36 ± 0.72cm, 9.704 ± 0.225) leaves. 30g Fe kg^{-1}treatment exhibited higher minerals content than other treatments with Phosphorus 67.51 ± 2.42 mgL^{-1}, Zinc 9.06 8± 0.45 mgL^{-1}, Iron 5.2 ± 0.218 mgL^{-1}, Manganese 7.655 ± 0.344 mgL^{-1}, Total Nitrogen 11.248 ± 0.141mgL^{-1} and Sodium 7.218 ± 0.028 mgL^{-1}. There was improved water quality at 30g Fe kg^{-1}compared to other treatments. These results revealed that 30g Fe kg^{-1} iron amino acid chelate supplementation had better nutritional attributes as feedstuff for *O. niloticus* growth than the two other dietary treatments. The study recommends the incorporation of iron amino acid chelate in on-farm formulated diets where complete diets are not easily accessible for small scale farmers.

Table 3: Fish growth data for Nile tilapia in an aquaponic

Parameters	Treatments			
	0g Fe kg^{-1}	10g Fe kg^{-1}	20g Fe kg^{-1}	30g Fe kg^{-1}
Final length	6.062±0.143^a	7.102±0.128^b	7.4578± 0.097^c	8.949±0.16^d
Final weight	4.354±0.295^a	6.207±0.318^b	7.406±0.306^c	11.606±0.55^d
Weight gain	3.879 ±0.2698^a	5.7317± 0.293^b	6.9307 ± 0.281^c	11.131±0.5248^d
Daily weight gain	0.0305± 0.002^a	0.045±0.0023^b	0.0546 ±0.002^c	0.0876±0.0041^d
SGR	1.744±0.02^a	2.023±0.012^b	2.162±0.02^c	2.516±0.01^d
Survival %	98.333±0.293^a	98.708±0.127^a	99.083±0.103^c	98.708±0.112^a
FCR	2.081±0.797^a	1.175±0.038^b	1.17±0.015^c	1.10±0.107^d

Table 2: Plant growth data for Spinach (*Spinacia oleracea*) in an aquaponic system

Parameters	0g Fe kg^{-1}	10g Fe kg^{-1}	20g Fe kg^{-1}	30g Fe kg^{-1}
Final No of leaves	9.704±0.225^a	12.85±0.16^b	15.70±0.509^c	19.33±0.392^d
Final heights (cm)	25.36±0.723^a	33.33±1.37^b	41.52±0.633^c	52.44±0.798^d
Final dry weights (g)	4.170±0.082^a	6.742±0.0445^b	23.796± 0.22^c	32.973 ± 0.25^d
weight gain (g)	30.058±1.627^a	59.16±2.277^b	106.8 ±8.957^c	113.01± 8.94^c

Potential Periphyton Substrates for Carp-SIS Polyculture

Sunila Rai*, Kamala Gharti, Madhav Shrestha, Rahul Ranjan, James Diana, Hillary Egna

*Agriculture and Forestry University
Rampur, Chitwan, Nepal

Types of substrate determine the fish production in periphyton enhanced aquaculture system. On other hand substrate interferes in partial harvesting of small indigenous fish species (SIS) in carp-SIS ponds. Farmers need periphyton substrates that increase fish production without interfering in partial harvesting. A field trial was carried out to test performance of four locally available periphyton substrates (split bamboo, whole bamboo, banana midrib and plastic bottle) in farmer's ponds at Seri and Nandapur in Nawalparasi district in Nepal for 7 months. Six carp species (Silver carp *Hypophthalmichthys molitrix*, Bighead carp *Aristichthys nobilis*, Grass carp *Ctenopharyngodon idella, C*ommon carp *Cyprinus carpio*, Rohu *Labeo rohita* and Mrigal *Cirrhinus mrigala*) were stocked at 15000 fish/hectare and SIS (Dedhuwa *Esomus danricus* and Pothi *Puntius sp.*) at unrecorded densities. Carp was fed with rice bran and mustard oil cake at 1.5% BW/day while grass carp was fed with grass and banana leaves at 50% BW/day. There was no significant effect of substrates on growth and production of carp. Combined NFY was 19% higher in plastic bottle ponds than control ponds, while NFY of SIS was 50% higher in banana midrib ponds than control and other substrate ponds. FCR was significantly better ($P<0.05$) in split bamboo ponds than control ponds. Banana midrib decayed fast and was replaced 3-4 times during experimental period. Although no oxygen deficiency was observed in the banana midrib ponds care should be taken while using banana midribs because excessive loading might cause oxygen deficiency in a pond.

Potential Periphyton Substrates for Carp-SIS Polyculture

Rai, S.[1*], Gharti, K. [1], Shrestha, M.K. [1], Ranjan, R.[1] Diana, J.S.[2], & Egna, H.[3]
[1]Agriculture and Forestry University, Chitwan, Nepal
[2]The University of Michigan, USA
[3]Oregon State University, USA

Abstract

Types of substrate determine the fish production in periphyton enhanced aquaculture system. On other hand substrate interferes in partial harvesting of small indigenous fish species (SIS) in carp-SIS ponds. Farmers need periphyton substrates that increase fish production without interfering in partial harvesting. A field trial was carried out to test performance of four locally available periphyton substrates (split bamboo, whole bamboo, banana midrib and plastic bottle) in farmer's ponds at Seri and Nandapur in Nawalparasi district in Nepal for 7 months. Six carp species (Silver carp *Hypophthalmichthys molitrix*, Bighead carp *Aristichthys nobilis*, Grass carp *Ctenopharyngodon idella*, Common carp *Cyprinus carpio*, Rohu *Labeo rohita* and Mrigal *Cirrhinus mrigala*) were stocked at 15000 fish/hectare and SIS (*Dedhuwa Esomus danricus and Pothi Puntius sp.*) at unrecorded densities. Carp was fed with rice bran and mustard oil cake at 1.5% BW/day while grass carp was fed with grass and banana leaves at 50% BW/day. There was no significant effect of substrates on growth and production of carp. Combined NFY was 19% higher in plastic bottle ponds than control ponds, while NFY of SIS was 50% higher in banana midrib ponds than control and other substrate ponds. FCR was significantly better (P<0.05) in split bamboo ponds than control ponds. Banana midrib decayed fast and was replaced 3-4 times during experimental period. Although no oxygen deficiency was observed in the banana midrib ponds care should be taken while using banana midribs because excessive loading might cause oxygen deficiency in a pond.

Introduction

Pond aquaculture is a well-established culture system of carp species. However, it is becoming greatly dependent on external resources such as feed and fertilizers for fish production. The ratio of feed cost in total inputs is large in case of both commercial as well as small scale culture practice. For small scale farmers it is not easy to bear the cost of expensive food ingredients. Providing an alternative means to reduce the feed cost has thus become essential for sustainability of the farming system. Enhancing the growth of periphyton in pond production system has been proved to be a suitable method to increase the natural food production (Rai et al., 2008; Jha et al., 2018). Many researches in periphyton based aquaculture was carried out using different parts of bamboo as substrate in Bangladesh and Nepal (Azim et al., 2002; Rai et al., 2008; Shirin et al., 2013; Jha et al., 2018). However, farmers have some complains about using bamboo substrates for periphyton growth. Considering their problem, present experiment was carried out to assess the performance of locally available alternative substrates in farmer's ponds stocked with carp and SIS.

Materials and Methods

The experiment was carried out for 210 days from 12th April to 10th November 2017 in 15 ponds of farmers involved in Mishrit Fish Farmer Cooperative at Seri and Nandapur of Nawalparasi district. The average area of experimental pond was 502.9±68.4 m^2 ranging from 163.0-1760.0 m^2. There were following five treatments with triplicates:

- Control/ No substrate (Tc)
- Split Bamboo (TSB)
- Whole Bamboo (TWB)
- Banana Midrib (TBM)
- Plastic Bottle (TPB)

All ponds were stocked with six carp species (silver carp, bighead carp, grass carp, common carp, rohu and mrigal in ratio of 4:1:4:4:5:2) at the rate of 15,000/ha and two SIS (Pothi, *Puntius* spp. and Dedhuwa, *Esomus danricus*). Feeding with freshly made dough of mustard oil cake and rice bran (1:1) was done daily at rate of 1.5% of BW. Fertilization with Urea (9.4 g/m^2) and DAP (7.2 g/m^2) was done fortnightly in all ponds. Temperature, DO, pH and Sechhi disk visibility of ponds were monitored at 7-9 am in situ monthly. Harvesting was done by complete drying of ponds at the end of experiment.

Split Bamboo substrate

Whole Bamboo substrate

Banana midrib substrate

Plastic Bottle substrate

Harvesting fish

Substrate installed in pond

Results and Discussion

Water quality parameters, production of fish and periphyton biomass in different treatments during experiment is shown in table 1,2 and 3 respectively.

Table 1 shows the water quality parameters during experiment.

	T_C	T_{SB}	T_{WB}	T_{BM}	T_{PB}
Temperature (°C)	29.3±0.3^a	29.8±0.7^a	30.0±0.8^a	30.1±0.5^a	30.1±0.5^a
Transparency (cm)	24±3^a	25±4^a	25±3^a	22±3^a	23±3^a
DO (mg/L)	3.9±0.7^a	4.6±0.8^a	4.3±0.8^a	4.5±0.5^a	4.3±0.6^a
pH	8.0	8.2	8.0	7.3	8.1

Table 2 shows the production of fish in different treatments

Parameters	T_C	T_{SB}	T_{WB}	T_{BM}	T_{PB}
NFY carp only (t/ha/yr)	3.63±0.49^a	3.87±2.78^a	4.05±0.74^a	4.28±0.97^a	4.34±3.75^a
NFY of SIS only (t/ha/yr)	0.07±0.47^a	0.07±2.78^a	0.1±0.02^a	0.1±0.97^{ab}	0.08±3.75^a
Combined GFY (t/ha/yr)	3.70±0.4^a	3.93±0.28^a	4.15±0.74^a	4.38±0.10^a	4.41±0.37^a
Combined NFY (t/ha/yr)	3.59±0.49^a	3.82±0.28^a	4.03±0.74^a	4.27±0.10^a	4.30±0.37^a
Feed conversion ratio (FCR)	2.0±0.0^b	1.5±0.1^a	1.7±0.2^{ab}	1.8±0.1^{ab}	1.9±0.2^{ab}

Table 3 shows the periphyton biomass in different substrates

	T_{SB}	T_{WB}	T_{BM}	T_{PB}
Dry matter	0.0292±0.0068^a	0.0271±0.0099^a	0.0432±0.0123^a	0.0409±0.0056^a
Ash content	0.0205±0.0061^a	0.0157±0.0071^a	0.0337±0.0107^a	0.0313±0.0044^a
Ash free dry matter	0.0087±0.0010^a	0.0114±0.0031^a	0.0095±0.0025^a	0.0095±0.0012^a

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Determinants of Seafood Accessibility in Tanzania

Akua Akuffo and Kwamena Quagrainie*

*Department of Agricultural Economics
Purdue University
West Lafayette, IN, USA 47907

Tanzania is endowed with marine and inland water resources abundant in a range of seafood. The production of fish has ranged from 325,000 to 380,000 mt/yr between 2004 and 2014. However, consumption of fish is low, 7.0 kg/yr, compared to the global per capita fish consumption of 19 kg. The low consumption of fish in Tanzania stems from constraints to accessibility. According to the World Food Programme (WFP), lack of infrastructure, education and provision of health care, in addition to inappropriate economic and agricultural policies and governance, heighten food insecurity. In Tanzania, high post-harvest losses, inefficient distribution systems, low-income and high dependence on rain-fed agriculture contributes to a high food insecurity problem. A researchable question is "how does access to roads, electricity and telecommunication network impact the accessibility and consumption of fish in communities in Tanzania?"

This paper evaluates the association between select community development features and access to seafood by Tanzanian households using a sample of 1,730 from the 2011/12 Household Budget Survey (HBS). We hypothesize that transportation (a proxy for access to markets), electricity (a proxy for post-harvest services) and mobile networks (a proxy for market information) are significant determinants of seafood accessibility and consumption in Tanzania.

Analyses from Ordinary Least Squares, Poisson and Negative Binomial Regressions suggest that on average, growth in communication expenditure is associated with increased access to seafood among households in rural locations. That suggests that these households can have greater access with good communication networks, which enable them to obtain timely market information that includes prices and variety. It also suggests that increasing access to information services for rural households, the higher the likelihood of reducing the their food insecurity, which includes access to fish. Households in peri-urban areas are usually distant from commercial shopping districts, which imply increased cost of transportation, an increase in search time for lower prices, and variety. The results suggest that a 1% increase in the cost of transportation is associated with a 0.05% reduction in the household access to fish for peri-urban households. Improving access to seafood by improving roads and the cost of transportation seems to be relevant for households located in the suburbs. The Tanzania government is addressing the transportation challenges with the introduction of the Dar es Salaam Rapid Transit, which serves the capital, Dar es Salaam, suburbs, and surrounding communities.

A 1% rise in the average price of fish is associated with a 0.26% decline in access to fish. The decline is even higher in rural areas, 0.58%. Improvement in access to food for producers and consumers is associated with reductions in food prices since the high cost of transportation translates into high food prices.

A Comparison of Monoculture and Polyculture of Nile Tilapia With Carps in Earthen Pond System in Nepal

Narayan P. Pandit*, Rahul Ranjan, Madhav K. Shrestha, James S. Diana, and Hillary Egna

Department of Aquaculture
Agriculture and Forestry University, Rampur, Chitwan, Nepal

Carp polyculture is a well-established aquaculture system in Nepal but improving productivity of this aquaculture system is a major concern. An experiment was conducted at the Agriculture and Forestry University, Chitwan, Nepal in 12 earthen ponds of 150 m^2 for 185 days to demonstrate the value of Nile tilapia and sahar in polyculture ponds, and a culture system with only monosex tilapia. The experiment was conducted in a completely random design with four treatments in triplicate: a) Existing carp polyculture (10,000/ha)+mixed-sex tilapia (3,000/ha)+sahar (1,000/ha) (T_1); b) Existing carp polyculture+monosex tilapia (3,000/ha) (T_2); c) Monosex tilapia at 10,000/ha with fertilization only (T_3); and d) Monosex tilapia at 20,000/ha with fertilization and feeding (T_4). Silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) of 2.0–5.0 g size were stocked in all ponds at the ratio of 3.5:1:2.5:0.5:1.5:1. The ponds were fertilized weekly with urea and DAP at 4 g N and 1 g P/m^2/day. Fish were fed once daily with pelleted feed (26% CP) at 2% body weight. At harvest, the combined net fish yield was significantly higher in T_4 (3.77±0.23 t/ha/crop) compared to T_3 (1.03±0.14 $t \cdot ha^{-1} \cdot crop^{-1}$); whereas, there was no significant difference ($p>0.05$) among T_1 (2.82±0.23 t/ha/crop), T_2 (3.20±0.17 t/ha/crop) and T_4 (3.77±0.23 t/ha/crop; Table 1). The mean harvest size, daily weight gain, gross fish yield (GFY), and net fish yield (NFY) of monosex Nile tilapia in T_4 were significantly higher than in T_3 ($p<0.05$). The gross profit margin was significantly higher in T_4 (4418.5±302.9 USD/ha) compared to T_3 (1666.1±341.3 USD/ha) without any significant difference between T_1 and T_2 ($p<0.05$).

TABLE 1. Production parameters (mean ± SE) of different treatments. Mean values in a row with the different superscript are significantly different (P<0.05)

	Treatments			
Parameter	T_1	T_2	T_3	T_4
GFY (t/ha/crop)				
Carps	2.42±0.20^a	2.58±0.14^a	-	-
Tilapia	0.49±0.04^a	0.72±0.09^b	1.04±0.14^c	3.79±0.12^d
Sahar	0.02±0.00	-	-	-
Combined	2.93±0.46^b	3.29±0.17^b	1.04±0.14^a	3.79±0.12^b
NFY (t/ha/crop)	2.82±0.23^{ab}	3.20±0.17^{ab}	1.03±0.14^a	3.77±0.23^b
AFCR	2.42±0.28^b	2.09±0.14^b	-	1.86±0.07^a
Gross Margin (USD/ha)	2569.1±679.9^{ab}	3491.9±449.5^{ab}	1666.1±341.3^a	4418.5±302.9^b

A Comparison of Monoculture and Polyculture of Nile Tilapia with Carps in Earthen Pond System In Nepal

Narayan P. Pandit*, Rahul Ranjan, Madhav K. Shrestha, James S. Diana, and Hillary Egna

Agriculture and Forestry University, Rampur, Chitwan, Nepal

panditnp@gmail.com

ABSTRACT

Carp polyculture is a well-established aquaculture system in Nepal but improving productivity of this aquaculture system is a major concern. An experiment was conducted at the Agriculture and Forestry University, Chitwan, Nepal in 12 earthen ponds of 150 m^2 for 185 days to demonstrate the value of Nile tilapia and sahar in polyculture ponds, and a culture system with only monosex tilapia. The experiment was conducted in a completely random design with four treatments in triplicate: a) Existing carp polyculture (10,000/ha)+mixed-sex tilapia (3,000/ha)+sahar (1,000/ha) (T_1); b) Existing carp polyculture+monosex tilapia (3,000/ha) (T_2); c) Monosex tilapia at 10,000/ha with fertilization only (T_3); and d) Monosex tilapia at 20,000/ha with fertilization and feeding (T_4). In T_1 and T_2, silver carp, bighead carp, common carp, grass carp, rohu and mrigal of 2.0–5.0 g size were stocked in all ponds at the ratio of 3.5:1:2.5:0.5:1.5:1. The ponds were fertilized weekly with urea and DAP at 4 g N and 1 g P/m^2/day. Fish were fed once daily with pellet feed (26% CP) at 2% body weight. At harvest, the combined net fish yield was significantly higher in T_4 (3.77±0.23 t/ha/crop) compared to T_3 (1.03±0.14 $t \cdot ha^{-1} \cdot crop^{-1}$); whereas, there was no significant difference ($p>0.05$) among T_1 (2.82±0.23 t/ha/crop), T_2 (3.20±0.17 t/ha/crop) and T_4 (3.77±0.23 t/ha/crop; Table 1). The mean harvest size, daily weight gain, gross fish yield (GFY), and net fish yield (NFY) of monosex Nile tilapia in T_4 were significantly higher than in T_3 ($p<0.05$). The gross profit margin was significantly higher in T_4 (4418.5±302.9 USD/ha) compared to T_3 (1666.1±341.3 USD/ha) without any significant difference between T_1 and T_2 ($p<0.05$).

INTRODUCTION

Semi-intensive carp polyculture is an established system in tropical and subtropical regions of Nepal, using fertilized ponds with supplemental feed. Six species of Chinese and Indian carps are recommended in certain ratios with a combined density of 10,000 fish/ha. Nile tilapia is a globally prominent species for all types of management intensities. Recruitment control remains a problem, as mixed-sex tilapia is most commonly used for culture. Sahar (*Tor putitora)* is a high value indigenous fish species of Nepal which is declining in its natural habitat and has been declared an endangered species. Tilapia and sahar co-culture was attempted to control excessive recruitment of tilapia and provide an additional species to increase productivity of high-valued indigenous fish (Shrestha et al., 2011). The addition of tilapia and sahar with increased stocking density into the existing carp production system could increase productivity with no added input (Shrestha et al., 2012).

The objectives of this experiment were: (1) To evaluate the culture potential of sahar and monosex tilapia to farmers; and (2) To test a carp-tilapia-sahar polyculture and monosex tilapia culture system.

MATERIALS AND METHODS

- This experiment was conducted in 12 earthen ponds of 150 m^2 for 185 days. The experiment was conducted in a completely randomized design with four treatments in triplicate. Treatments were:

- **T_1:** Existing carp polyculture (10,000/ha)+mixed-sex tilapia (3,000/ha)+sahar (1,000/ha); **T_2:** Existing carp polyculture+monosex tilapia (3,000/ha); **T_3:** Monosex tilapia at 10,000/ha with fertilization only and **T_4:** Monosex tilapia at 20,000/ha with fertilization and feeding.

- In T_1 and T_2, silver carp, bighead carp, common carp, grass carp, rohu and mrigal of 2.0–5.0 g size were stocked in all ponds at the ratio of 3.5:1:2.5:0.5:1.5:1. The ponds were fertilized weekly with urea and DAP at 4 g N and 1 g P/m^2/day. Fish were fed once daily with pellet feed (26% CP) at 2% body weight.

Fig. Experimental pond and harvested fishes.

RESULTS AND DISCUSSION

- The gross and net fish yields for monosex tilapia without feed was significantly lower than monosex tilapia with feed and carp treatments (Table 1).

- The production of all carps was not significantly different between T_1 and T_2 ($p>0.05$).

- The production of monosex tilapia in T_4 was significantly higher than in T_3 ($p<0.05$).

TABLE 1. Production parameters (mean±SE) of different treatments. Mean values in a row with the different superscript are significantly different ($P<0.05$)

Parameter	Treatments T_1	T_2	T_3	T_4
GFY (t/ha/crop)				
Carps	2.4 ± 0.2^{a}	2.6 ± 0.14^{a}	-	-
Tilapia	0.49 ± 0.04^{a}	0.72 ± 0.09^{b}	1.04 ± 0.14^{c}	3.79 ± 0.12^{d}
Sahar	0.02 ± 0.00	-	-	-
Combined	2.93 ± 0.46^{b}	3.29 ± 0.17^{b}	1.04 ± 0.14^{a}	3.79 ± 0.12^{b}
NFY (t/ha/crop)	2.8 ± 0.23^{ab}	3.2 ± 0.17^{ab}	1.03 ± 0.14^{a}	3.77 ± 0.23^{b}
AFCR	2.42 ± 0.28^{b}	2.09 ± 0.14^{b}	-	1.86 ± 0.07^{a}
Gross Margin (USD/ha)	2569 ± 678^{ab}	3492 ± 449^{ab}	1666 ± 341^{a}	4419 ± 303^{b}

- The extrapolated GFY of tilapia in T_2 was significantly higher than T_1 ($p<0.05$).
- The combined extrapolated GFY of all species excluding and including tilapia recruits was significantly lower in T_3 than other treatments ($p<0.05$).
- Similarly, the combined extrapolated NFY of all species excluding tilapia recruits was significantly lower in T_3 than T_4 ($p<0.05$).
- The apparent food conversion ratio (AFCR) was significantly lower in T_4 compared to T_1 and T_2 without any significant differences between T_1 and T_2 (Table 1).
- Each carp species showed similar production parameters in all treatments, indicating the addition of tilapia and sahar did not affect overall carp production.

SUMMARY AND CONCLUSION

The results of this study indicates that three of the culture systems (polyculture of carps with mixed sex tilapia and sahar, carps with monosex tilapia, and monosex tilapia with fertilization and feeding) performed similarly and enhanced productivity and income compared to the currently used carp polyculture system in Nepal. Tilapia either in monoculture or in polyculture proved suitable additional species in the aquaculture for Nepal.

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Effects of Varying Water Flow Rates on the Growth Performance and Welfare of Nile Tilapia (*Oreochromis niloticus*) Reared in a Recirculating Aquaculture System

Kwasi Adu Obirikorang*, Nelson Winston Agbo, Christian Obirikorang, Daniel Adjei-Boateng, Sefakor Esinam Ahiave, Peter Vilhelm Skov

*Department of Fisheries and Watershed Management, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Optimizing the design and operation of aquaculture systems is a process that requires continuous research aimed at improving fish production output and economic returns. In recirculation aquaculture systems (RAS) and other land-based systems such as flow-through systems, a vital aspect of system design is the flow rate of water through a culture tank relative to its volume. In this study, the effects of varying water exchange rates on water quality, growth and general welfare of juvenile Nile tilapia (*Oreochromis niloticus*), was investigated in an experimental recirculating aquaculture system (RAS) during an 8-week trial.

Fish with an average initial body mass of 27 g were reared at low (LE), medium (ME) or high (HE) water exchange rates, corresponding to tank replacement rates of 1.5, 3 and 6 tank volumes/h. The LE treatment resulted in significantly higher ($p<0.05$) levels of ammonia nitrogen and phosphate in the culture water relative to the higher water exchange treatments. Absolute and relative weight gains were significantly influenced by water exchange rates. The specific growth rate (SGR) of fish cultured under the HE treatment (2.74 %day-1) was significantly higher than the SGR (2.21 %day-1) of the fish under the LE treatment. Pathological evaluations revealed a general trend of higher prevalence of dermal ulcerations, oral lesions, frayed and eroded fin conditions in fish reared under the LE treatment compared to fish under the ME and HE regimes. Haematological indicators of long-term oxygen stress and disease conditions, as evidenced by erythrocyte and platelet indices were generally higher in fish under the low and medium water exchange rates. This study has shown that although the Nile tilapia is a hardy aquaculture species, long term exposure to poor culture water conditions can result in reduced somatic growth and compromised welfare.

Table 1: Growth performance, nutrient utilisation and biological indices of *Oreochromis niloticus* under varying water flow rates

Parameter	LE	ME	HE
IBW (g)	28.5±0.7	27.04±1.34	26.8±0.6
FBW (g)	97.7±8.1^{a}	110.5±22.5^{ab}	123.9±10.0^{b}
SGR	2.2±0.2^{a}	2.5±0.3^{ab}	2.7±0.1^{b}
FCR	1.4±0.1^{a}	1.31±0.1^{b}	1.31±0.1^{b}
HSI	3.2±0.6^{a}	3.1±0.4^{a}	3.9±0.4^{b}
VSI	9.54±0.51^{a}	11.27±1.81^{a}	12.45±1.71^{b}
%Survival	95.83±7.21	100±0.00	95.83±7.21

Table 2: Haematological parameters of the *Oreochromis niloticus* under varying water flow rates

Parameter	LE	ME	HE
RBC (10^6/µL)	2.77±0.25^{a}	2.66±0.13^{a}	2.45±0.05^{b}
Hb (g/dL)	10.90±1.13	10.57±0.95	10.30±0.17
Hct (%)	37.75±3.46	37.97±2.74	36.03±0.42

Effects of Lysine and Methionine Supplementation and Cost-Effectiveness in Production of Nile Tilapia Diets (*Oreochromis niloticus*) in Western Kenya

Elizabeth Obado*, Josiah Ani, Phillip O. Raburu, Julius O. Manyala, Charles Ngugi, Kevin Fitzsimmons & Hillary Egna

University of Eldoret, Kenya,
P. O. Box 1125,
Eldoret, Kenya.

The proximate composition of local feed ingredient is limited by unbalanced dietary amino acid contents, thereby increasing de-amination and ammonia levels in water. This study formulated experimental diets and balanced the Essential Amino Acids (EAA) to enhance the feed nutritive value for culture of *Oreochromis niloticus*. Four diets comprising methionine +lysine and lysine supplemented at 5.1 g kg^{-1}, 2.7 g kg-1 to non-EEAs supplemented and commercial diets at the University of Eldoret Fish Farm were tested. Growth performance was conducted in hapas suspended in earthen pond 150 m2 in a randomized design for 105 days. There were significant variations in temperature (24 to 26°C), Dissolved oxygen (4.8 to 6.2 mg L^{-1}) and pH (7.2-7.6) but within optimal range for tilapia. The diets provided about 17.17 MJ kg-1 with 22.9% digestible Crude Protein and 8.03% ash content. Lysine supplemented Diet 2 induced highest mean final weight of 156.05±1.74 g, 2.4 Specific Growth Rate, 1.42 Feed Conversion Ratio and 2.68 Protein Efficiency Ratio. A high profit index (2.286±0.07) at low incidence cost (0.437±0.05) was observed in Diet 2.The study reports reduced production cost by supplementing plant proteins with limiting amino acids hence increasing nutritive value of aquafeeds.

Development of Research and Education for Fisheries and Aquaculture in Myanmar

Kay Lwin Tun*, Kevin Fitzsimmons, Hendrik Stolz, Uwe Scholz, May Myat Noe Lwin, Soe Tun, Hillary Egna

*Laboratory of Aquatic Bioscience, Department of Zoology, University of Yangon, Yangon, Myanmar

Myanmar has considerable future aquaculture potential due to its geography and abundance of natural resources. However, traditional extensive fish farming is practiced and production is generally low. To improve the aquaculture sector in a sustainable way, one important requirement is to develop the capacity of human resources in aquaculture and fisheries. Universities and vocational training centres can play an important role in developing a sustainable aquaculture and fisheries sector. However, in most universities in Myanmar, curricula in aquaculture and fisheries science remain extremely limited and embedded in Departments of Zoology.

Through these partnerships, universities in Myanmar have begun to make progress in human and institutional capacity development (HICD) in the areas of fisheries and aquaculture. In 2017, based on a study of country needs by the Ministry of Education and Ministry of Agriculture, Livestock and Irrigation, Yangon University (UY) was selected to establish a new undergraduate degree program for a Bachelor of Science (BSc) in Fisheries and Aquaculture within Academic Year 2018. This is the first Fisheries and Aquaculture degree program in tertiary education in the country.

Based on the needs of both the Government and private sector, German International Cooperation (GIZ) launched the 'Myanmar Sustainable Aquaculture Programme (MYSAP)' in 2018. The main targets of MYSAP in education sector are the promotion of vocational and university education, and university research capacity. MYSAP will support the development and establishment of a BSc degree curriculum in Fisheries and Aquaculture and a Master of Science (MSc) degree curriculum in Aquaculture. The four-year implementation phase (2018-2021) calls for a series of workshops for selected faculty members to facilitate future fisheries and aquaculture bachelor and master degree courses. MYSAP is also setting up an Aquaculture Campus in UY that includes lecture and laboratory facilities.

In the near future, globally competent faculty and students from UY will have enhanced capacity in research, teaching, and service to develop the sustainable fisheries and aquaculture sectors in Myanmar.

DEVELOPMENT OF RESEARCH AND EDUCATION FOR FISHERIES AND AQUACULTURE IN MYANMAR (BURMA)

Kay Lwin Tun*, Kevin Fitzsimmons, Hendrik Stolz, Uwe Scholz, May Myat Noe Lwin, Soe Tun, Hillary Egna

• Laboratory of Aquatic Bioscience, Department of Zoology, University of Yangon, Yangon, Myanmar (kaylwintun@gmail.com)

Introduction

Myanmar has considerable future aquaculture potential due to its geography and abundance of natural resources. However, traditional extensive fish farming is practiced and production is generally low. To improve the aquaculture sector in a sustainable way, one important requirement is to develop the capacity of human resources in aquaculture and fisheries. Universities and vocational training centers can play an important role in developing a sustainable aquaculture and fisheries sector.

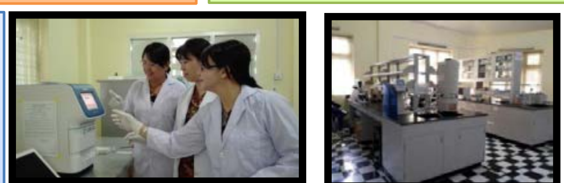
Myanmar (Burma)

Research and Education for Fisheries and Aquaculture in Universities in Myanmar (- 2013)

Up through 2013, specialization for fisheries and aquaculture had not been established in universities.

Development of Education for Fisheries and Aquaculture

- In 2014, USAID's project 'Developing a Sustainable Seafood Industry Infrastructure in Myanmar' was launched. The resulting partnership between the University of Arizona (project lead), Auburn University, University of Yangon (UY) and Pathein University was designed to support the development of an intensive marine and inland fisheries sector.
- In 2016, Oregon State University, through its USAID 'Feed The Future AquaFish Innovation Lab', joined in the effort with a specific focus of building faculty capacity in aquaculture production science.
- In 2018, German International Cooperation (GIZ) launched the 'Myanmar Sustainable Aquaculture Programme (MYSAP)' supporting the development and establishment of a Bachelor of Science (BSc) degree curriculum in Fisheries and Aquaculture and a Master of Science (MSc) degree curriculum in Aquaculture.



Seafood Safety Laboratory established by USAID's project

Internship working at processing plant

Short –term training in Bogor agricultural university, Can Tho University, Nong Lam University

Workshop for curriculum development

Notable Successes

1) The establishment of a Seafood Safety Laboratory in UY, which provides a unique facility for teaching and research
2) Fisheries and aquaculture education training of over 450 faculty members and students from 44 universities under the Ministry of Education.
3) Participation of faculty in high quality short-term trainings in universities in China, India, Indonesia, Malaysia and Vietnam
4) Introduction of internship program to universities and private sectors
5) Establishment of a BSc degree curriculum in Fisheries and Aquaculture and a MSc degree curriculum in Aquaculture.
6) Establishment of an Aquaculture Campus with teaching laboratories and lecture rooms

Series of capacity development trainings

Universities in Myanmar have begun to make progress in human and institutional capacity development (HICD) in the areas of fisheries and aquaculture. In 2017, Yangon University was selected to establish a new undergraduate degree program for a Bachelor of Science (BSc) in Fisheries and Aquaculture within Academic Year 2018.

This is the first Fisheries and Aquaculture degree program in tertiary education in the country.

Impacts of School Ponds on Human Nutrition and Health in Nepal

Dilip K. Jha[1]*, Narayan P. Pandit[1], Rahul Ranjan[1], Ishori S. Mahato[2], Madhav K. Shrestha[1], James S. Diana[3]and Hillary Egna[4]
[1]Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal
[2] National Agricultural Research Center, Parwanipur, Nepal
[3] The University of Michigan, Ann Arbor, Michigan, USA
[4]Oregon State University, Corvallis, USA

*Professor of Aquatic Resources and Director of Curriculum Development Center, Agriculture and Forestry University, Rampur, Chitwan, Nepal

Malnutrition has gained global attention and aquaculture can play a role in improving family nutrition. Establishing school ponds and a curriculum for school-age children and women's groups should be an effective approach to create awareness and to educate rural communities about the nutritional value of fish and methods of aquaculture. Two ponds of 75-105 m^2 in size were established, one each in two public schools of Chitwan and Nawalparasi districts in Nepal. A school curriculum was also developed to demonstrate methods of aquaculture and educate adolescent students on nutritional value of fish. This technology was also disseminated to women's groups to expand understanding of the value of fish production and consumption for their families. Carps and Nile tilapia fry were provided to each school from nearby fish hatcheries and were stocked in each pond at 10,000 carps and 3,000 Nile tilapia/ha respectively. The materials necessary to maintain ponds, including feed and fertilizer, were also provided to each school. Water quality test kits, weighing balance and fishing nets were given to each school. The ponds were maintained in good condition and net yield was averaged 4.3 t/ha/year. About 40 students of grade 8, 9, and 10 and 3 teachers were selected from each school to receive training on fish culture. Training of teachers and students included fish pond development, managing pond depth, pond preparation, species choice, water color, fertilizing, feeding, grow-out, and harvesting of fish, as well as nutrition education, including fish preparation and eating. Twelve sets of training were conducted in all. Tests indicated that students dramatically improved in knowledge of aquaculture and nutrition after taking this course with median scores increasing from about 60 to 80% in the schools. Overall results indicated that their knowledge about the nutritive value and production system of fish in the pre-training was quite poor. At the end of the training, the knowledge of students on fish production and nutritive value of fish were significantly increased ($p<0.05$). Number of students scoring <40 decreased while number of students scoring 61-80 and >80 increased after training ($p<0.05$). Another interesting observation was the significant increased consumption (times/year) of fish (25.5±20.0) and its frequent inclusion in the diet post training as compare to before training (14.4±19.4) ($p<0.05$) in Chandeswori School. In addition to training of students, informal education activities were also carried out for women's groups, which included forming two women's fish farming groups in the school community for each district. A training workshop was organized for each woman's group on the role of household aquaculture in family nutrition and income. This research also helped in capacity building of teachers who could spread the knowledge on the importance of fish in nutrition to parents during teacher-parent interactions.

IMPACTS OF SCHOOL PONDS ON HUMAN NUTRITION AND HEALTH IN NEPAL

Dilip K. Jha[1]*, Narayan P. Pandit[1], Rahul Ranjan[1], Ishori S. Mahato[2], Madhav K. Shrestha[1], James S. Diana[3] and Hillary Egna[4]
[1] - Agriculture and Forestry University, Chitwan, Nepal
[2] - National Agricultural Research Center, Parwanipur, Nepal
[3] - The University of Michigan, Ann Arbor, Michigan, USA
[4] - Oregon State University, Corvallis,, USA

Abstract

Malnutrition has gained global attention and aquaculture can play a role in improving family nutrition. Establishing school ponds and a curriculum for school-age children and women's groups should be an effective approach to create awareness and to educate rural communities about the nutritional value of fish and methods of aquaculture. Two ponds of 75-105 m^2 in size were established, one each in two public schools of Chitwan and Nawalparasi districts in Nepal. A school curriculum was also developed to demonstrate methods of aquaculture and educate adolescent students on nutritional value of fish. This technology was also disseminated to women's groups to expand understanding of the value of fish production and consumption for their families. Carps and Nile tilapia fry were provided to each school from nearby fish hatcheries and were stocked in each pond at 10,000 carps and 3,000 Nile tilapia/ha respectively. The materials necessary to maintain ponds, including feed and fertilizer, were also provided to each school. Water quality test kits, weighing balance and fishing nets were given to each school. The ponds were maintained in good condition and net yield was averaged 4.3 t/ha/year. About 40 students of grade 8, 9, and 10 and 3 teachers were selected from each school to receive training on fish culture. Training of teachers and students included fish pond development, managing pond depth, pond preparation, species choice, water color, fertilizing, feeding, grow-out, and harvesting of fish, as well as nutrition education, including fish preparation and eating. Twelve sets of training were conducted in all. Tests indicated that students dramatically improved in knowledge of aquaculture and nutrition after taking this course with median scores increasing from about 60 to 80% in the schools. Overall results indicated that their knowledge about the nutritive value and production system of fish in the pre-training was quite poor. At the end of the training, the knowledge of students on fish production and nutritive value of fish were significantly increased ($p<0.05$). Number of students scoring <40 decreased while number of students scoring 61-80 and >80 increased after training ($p<0.05$). Another interesting observation was the significant increased consumption (times/year) of fish (25.5±20.0) and its frequent inclusion in the diet post training as compare to before training (14.4±19.4) ($p<0.05$) in Chandeswori School. In addition to training of students, informal education activities were also carried out for women's groups, which included forming two women's fish farming groups in the school community for each district. A training workshop was organized for each woman's group on the role of household aquaculture in family nutrition and income. This research also helped in capacity building of teachers who could spread the knowledge on the importance of fish in nutrition to parents during teacher-parent interactions.

Introduction

Malnutrition has gained global attention and Nepal is not out of arena. There is a global concern that nutritious food must be supplied to women as well as their children during the first 100 days of life. Along with this, childhood and adolescence is a critical period that need high nutrients for proper growth. The fact that fishes are readily available sources of generous amounts of complete protein and of a great variety of protective vitamins and minerals make them the most valuable food for women during pregnancy and lactation, for children during their periods of growth and maturation and for our growing population of senior citizens (Jha, 2018)

Globally, there are a number of research carried out to integrate aquaculture and household nutrition. However, research alone cannot be effective in changing paradigms in aquaculture communities. Outreach of research results and social interactions to advise local communities are also important in changing aquaculture systems to become more sustainable and more profitable (Diana et al., 2013). School pond concept is found very effective to bring the multiplier effect in aquaculture development, knowledge transfer and learning as well as in improvement in family nutrition..

Materials and Methods

Two schools were selected in Chitwan and Nawalparasi districts of Nepal and pond of approximately 75-105 m^2 area was established. Ponds were stocked with six carps species and Nile tilapia at rate of 10,000 and 3,000 per ha respectively. One cycle of fish culture was demonstrated with the participation of school teachers and students. Materials necessary to maintain ponds, including feed and fertilizer, were provided to each school. A course of study was developed to educate teachers and students about fish culture and human nutrition. Twelve sets of training was conducted at each school. A pre-training and a post-training questionnaire survey was done to evaluate the effectiveness of trainings. Two women's fish farming groups in each community around school were also formed for further training activities. A training workshop was organized at each women group to discuss about the role of aquaculture in family nutrition and income.

Results and Discussion

Table 1 shows the percentage of students receiving different scores on nutrition related questions before and after training. Survey results indicated that students' initial knowledge about the nutritive value for fish prior was quite poor which increased significantly after training. Similarly, table 2 shows the percentage of students receiving different scores on aquaculture related questions before and after training. The results indicated that students' initial knowledge about the farming practices for fish prior was quite poor which increased significantly after training courses. A linkage developed between the women's fish farming group and teachers and students could ultimately work for the long-term sustainability of the school ponds.

Table 3 shows the different fish production parameters at each school during demonstration trial.

Districts with school pond program

Pond at Annapurna SS, Chitwan

Students harvesting fish in School pond

Pond at Chandeswori SS, Nawalparasi

Harvested fish from school pond

Table 1: Percentage of students obtaining scores on nutrition related questions

	Before training				After training			
Score	<40	40-60	61-80	>80	<40	40-60	60-80	>80
Annapurna	66.0	26.0	6.0	2.0	0.0	17.5	32.5	50.0
Chandeswori	36.1	38.9	25.0	0.0	0.0	13.5	48.6	37.8
Mean	51.1±21.1^a	32.5±9.1^a	15.5±13.4^b	1.0±1.4^b	0.0±0.0^b	15.5±2.8^b	40.6±11.4^a	43.9±8.6^a

Table 2: Percentage of students obtaining scores on aquaculture related questions

	Before training				After training			
Score	<40	40-60	61-80	>80	<40	40-60	60-80	>80
Annapurna	28.0	26.0	38.0	8.0	10.0	7.5	32.5	50.0
Chandeswori	8.3	27.8	61.1	2.8	0.0	5.4	43.2	51.4
Mean	18.2±13.9^a	26.9±1.3^a	49.6±16.3^a	5.4±3.7^b	5.0±7.1^b	6.5±1.5^b	37.9±7.6^b	50.7±1.0^a

Table 3: Fish production parameters during demonstration trial

School	Net yield (t/ha/yr)	Gross yield (t/ha/yr)	Tilapia survival (%)	Carp survival (%)	Overall survival (%)	FCR
Annapur-na	3.3	3.5	95.2	77.3	79.8	2.1
Chandes-wori	5.4	5.6	87.1	69.8	72.3	1.7

Refernces

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Integrated Mola Fish and Gher/Freshwater Prawn Farming with Dyke Cropping to Increase Household Nutrition and Earnings for Rural Farmers in Southwest Bangladesh

Khandaker Anisul Huq*, Shikder Saiful Islam, Joyanta Bir, Wasim Sabbir, Shahroz Mahean Haque and Russell Borski

Professor, Fisheries and Marine Resource Technology Discipline, Khulna University, Bangladesh

The fish farmers of the Southwest Bangladesh practice integrated farming of freshwater prawn (*Machrobrachium rosenbergii*) and carp (*Labeo rohita*) culture in seasonal paddy fields, known as "gher farming". In this traditional farming system farmers are unable to invest sufficient amount quality feed and seed due to higher costs, which results lower production and household earnings. The present investigation proposes to address this problem by incorporating Mola, a small indigenous fish species with high nutrient value, into current prawn-gher farming practices. In the first year of this study (July 2014 to January 2015) was focused on feasibility of Mola integration with traditional prawn-carp farming system. The results in the first year revealed that mola integration in the traditional *gher* farming does not hamper the main crop prawn. However, we found a higher total fish production from the treatment with mola integration (1291.7 kg/ha) compared to without mola (988.9kg/ha). In second experiment, sought to optimize Mola stocking densities in prawn-carp gher ponds. Three experimental were designed with 2/m^2 prawn, 0.1/m^2 carp in all three treatments, brood mola were stocked at 1, 2, and 4/m^2 respectively in T1, T2 and T3. Brood mola stocking at 2/m^2 in prawn-carp gher farming systems provides optimal production of all three species. As in the southwestern region of the country, most of the farmers do not fed the fish properly, an experiment was conducted with the aim of fertilizing the ponds to minimize supplementary feed. Here, the stocking density was same at three treatments where prawn, rohu and mola were stocked at 2, 0.1 and 2/m^2 respectively with three different fertilizer doses (monthly), T1 (Urea 25 kg/ha, TSP 12.5 kg/ha), T2 (Molasses 30kg + Yeast 0.3g/ha), T3 (50 % of T1+ 50% of T2) and T4 no fertilizer. Higher production was found mixed fertilizers compared to other groups (Table 1). The mola fish become matured within 2-3 months and spawn year round within the pond/gher. Mola fish can fulfill household nutrition by regular harvest and also provide additional benefit by sell in the market. The findings of the study were disseminated arranging several workshops and training programs with the presence of different stakeholders like farmers, Department of fisheries (DoF), Bangladesh Fisheries Research Institute (BFRI), Department of Agricultural Extension (DAE), National and International NGOs, resources person from different public university, fisheries stockholder i.e, Fish farmer, Feed producers, Fish traders. About 100 farmers were trained up throughout the research period and 5000 copies of leaflet and 75,000 copies Krishikotha (Farmers Voice) were distributed throughout Bangladesh.

Table 1. Production (kg/ha) of prawn, mola and rohu with 3 different fertilizers. Rows with different letters indicate significant differences.

Treatments	**T1** Urea + TSP	**T2** Molasses + Yeast	**T3** 50% T1 + 50% T2	**T4** No fertilizer
Prawn	459.12±14.6 *a*	471.8±15.6 *a*	508.8±13.9 *b*	396.8±17.8 *c*
Rohu	608±16.47 *ab*	589±17.3 *a*	633±15.4 *b*	547.6±16.8 *c*
Mola	401± 11.6 *a*	417 ±15.3 *ab*	440.4±18.4 *b*	348.4±23.3 *c*

Investigating the Status of Lobster Cage Culture and Environment Quality at Xuan Dai Bay, Phu Yen Province

Hoang Thi My Huong[1], Tran Thi Kim Nhung[1], Ton That Khoa[1], Lê Quang Hiep[2], Nguyen Phu Hoa[1*]

[1]Nong Lam University, Ho Chi Minh City
[2]Aquaculture Species and Technical Center of Phu Yen Province

The status of lobster cage farming was investigated basing on Participatory Rural Appraisal (PRA) to assess the status of lobster culture in Xuan Dai bay, Phu yen province. The survey shows that lobster farming has three forms: rearing in suspending cages, settling cages and combining both forms. The experience of farmers from 10 to 20 years accounts for 54%. Number of cages is increasing significantly. People use live food (such as trash fish, swimming crab, green mussel, and other bivalve mollusc) to feed lobster. Most of the leftover food is not collected ashore. When collecting and analyzing the water quality parameters at lobster farming area during 12 times lasted for 4 months, the results showed that the water quality, especially in the bottom layer, was getting worse. During the investigating, temperature, pH, salinity, DO are almost stable and within the allowable limits. But the turbidity fluctuated quite large from 1st time to 8th time comparing to another sample collecting time. Ammonia concentration (NH_3^+) exceeded the allowable standard, especially in the bottom. Nitrite concentrations tended to rise at the bottom. Nitrate levels are almost stable. Total nitrogen in the bottom layer is relatively higher than the other layers, the lowest is 0.1 mg/l and the maximum is 0.2 mg/l. The dissolved PO_4 concentration has a large variation in the surface, middle, and bottom layers, with the highest in the 4th time. Total phosphorus at most of the layers were above the allowed standard and oriented in a bad direction.

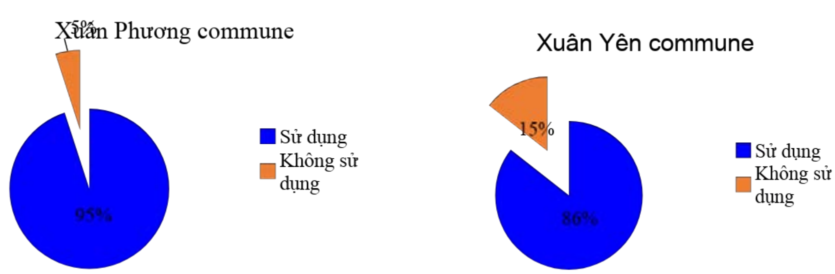


Fig: percentage of households using and non-using drug and chemical in culturing lobster

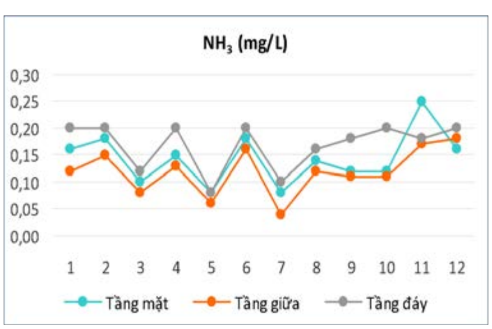


Fig 2. Fluctuation of NH_3 concentration

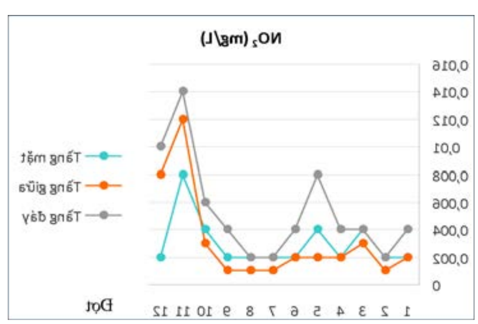


Fig 3. Fluctuation of NO_2 concentration

INVESTIGATING THE STATUS OF LOBSTER CAGE CULTURE AND ENVIRONMENT QUALITY AT XUAN DAI BAY, PHU YEN PROVINCE

Hoang Thi My Huong[1], Tran Thi Kim Nhung[1], Ton That Khoa[1], Le Quang Hiep[2], **Nguyen Phu Hoa**[1*]

[1]Nong Lam University, Ho Chi Minh City, Viet Nam

[2]Aquaculture Species and Technical Center of Phu Yen Province

[*]Email: phuhoa@hcmuaf.edu.vn

1. INTRODUCTION

Xuan Dai Bay, Phu Yen province is a place where the water quality is quite favourable, suitable for the development of aquaculture and fishing. However, with effective revenues is a worrying situation due to marine pollution caused by waste from aquaculture.

One of the causes of environmental pollution is the waste from lobster and the waste from cages and rafts used in aquaculture. This amount of waste accumulated over many years will adversely affect the quality of water here. Many farming areas are facing pollution and environmental degradation, disease outbreaks on a large scale.

The incidence of algal blooms, fish diseases more frequently in recent years is a clear indication of the overload of the aquaculture.

2. METHODOLOGY

The status of lobster cage farming was investigated basing on Participatory Rural Appraisal (PRA) at Xuan Dai bay, Phu Yen province.

Water samples were collected at lobster farming area during 12 times lasted for 4 months.

3. RESULTS

3.1 The status of lobster cage culture

The survey shows that lobster farming has three types: rearing in suspending cages, settling cages and combining both forms. The experience of farmers from 10 to 20 years accounts for 54%. Number of cages is increasing significantly. People use live food (such as trash fish, swimming crab, green mussel, and other bivalve molluscs) to feed lobster. Most of the leftover food is not collected ashore.

Fig. 1: Current status of using chemicals and drugs in lobster cage culture

Table 1. Lobster species and supply sources

No.	Investigated data	Xuân Phương commune		Xuân Yên commune		Total	
		No. of household	(%)	No. of household	(%)	No. of household	(%)
1.	Sources of seed supply:						
	- Local supply	35	58,3	20	36,4	55	47,8
	- Provicial surroundings	41	68,3	40	72,7	81	67,9
	- Foreign sources	12	20	15	27,2	25	21,7
2.	Lobster species:						
	- *Panulirus ornatus*	60	100	46	83,6	106	92,2
	- *Panulirus homarus*	17	28,3	43	8,2	60	52,2
	- *Panulirus longipes*	1	1,7	27	49,1	28	24,3

Current results :

- more than 100 tons of live food provide to lobsters every day
- 81,7% surveyed households dump waste into bay

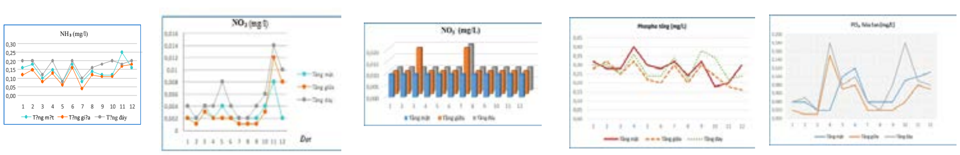
3.2. Environment quality at Lobster cage culture in Xuan Dai bay, Phu Yen province

The water quality, especially in the bottom layer, was getting worse. The amount of waste, sludge and waste from aquaculture cages of all types discharged to the Bay is about 8 tons/day,

During the investigating, temperature, pH, salinity, DO are almost stable and within the allowable limits. But the turbidity fluctuated quite large from 1st time to 8th time comparing to another sample collecting time.

Ammonia concentration **(NH_3)** exceeded the allowable standard, especially in the bottom. Nitrite **(NO_2^-)** concentrations tended to rise at the bottom. Nitrate **(NO_3^-)** levels are almost stable. Total nitrogen in the bottom layer is relatively higher than the other layers, the lowest is 0.1 mg/l and the maximum is 0.2 mg/l.

The dissolved PO_4^{3-} concentration has a large variation in the surface, middle, and bottom layers, with the highest in the 4th time. Total phosphorus at most of the layers were above the allowed standard and evolve in a bad direction



Local authorities have set up water quality monitoring stations in watershed areas to alert shrimp farmers, helping them avoid the unnecessary damage due to poor water quality.

However, this traditional warning procedure requires a long period of time, usually a few days, from the collection of water samples, the analysis of water quality to notification, to alert farmers. Sometimes it does not meet the urgent needs of farmers.

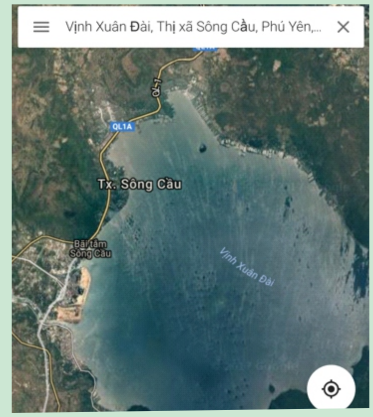
4. CONCLUSION

Lobster farming in Xuan Dai Bay has brought considerable socio-economic benefits. The survey results showed that people with 10-20 years of experience had a high rate (54%) with 3 forms of farming: suspended cages, deeper cages and a combination of both. Number of cages is increasing significantly. Lobster feed is fresh food and most of famers do not collect leftover food to shore but discharges directly into the water. Therefore, the lobster farming at the research site is facing difficulties, especially in the planning and water quality of farming areas.

5. ACKNOWLEDGEMENT

This study was part of National project funded by Vietnamese Ministry of Science and Technology ĐTĐL.CNN-60/15

Travel of author was funded by AquaFish, USA



Lobster died in 2015 & 2016

Lobster died in 2017

Lobster died in 2018

Developing Pellet Feeds for Snakehead *Channa striata* Culture in Vietnam and Cambodia

Tran Thi Thanh Hien[1],Tran Le Cam Tu[1], Tran Minh Phu[1], Pham Minh Duc[1], Bui Minh Tam[1], Huynh Van Hien[1], Chheng Phen[2], Nen Phana[2], SoNam[2], Robert Pommeroy[3], Hillary Egna[4] and David A. Bengtson[5]

[1]College of Aquaculture and Fisheries, Can Tho University, Viet Nam
[2]Inland Fisheries Research and Development Institute (IFReDI)
[3]University of Connecticut, Groton, CT, USA
[4]AquaFish Innovation Lab, Oregon State University, Corvallis, OR, USA
[5]University of Rhode Island, Kingston, RI, USA

Traditional methods for snakehead (*C. striata*) culture involve catching wild juvenile snakehead from the river and holding and feeding them on trash fish collected from the wild in Vietnam. Industry conversion from trash fish to commercial pellet feed for snakehead was necessary. We conducted a series of studies to a) optimize the weaning protocol to enable hatchery-reared fish to adapt to formulated feeds, b) determine protein, lipid, and energy requirement for grow-out stage, c) assess digestibility of different feed ingredients, d) develop formulated feeds that maximize the plant protein amount to reduce fishmeal usage, e) replace fishmeal by soybean meal, rice bran and cassava meal, or soy protein concentration (SPC) with supplementation of soluble fish attractant, alpha-galactosidase, mannan oligosaccharides (MOs) and vitamin C to enhance the immune response of snakehead. The optimal procedure for weaning snakehead in the hatchery was established, beginning weaning at 17 days post-hatch and replacing 10% of low value-fish with formulated feed per day for 10 days. Up to 40% of the fish meal could be replaced by plant proteins in snakehead grow-out diets. Formulated feed for the grow-out stage was developed and used successfully in on-farm trials in Vietnam and Cambodia.

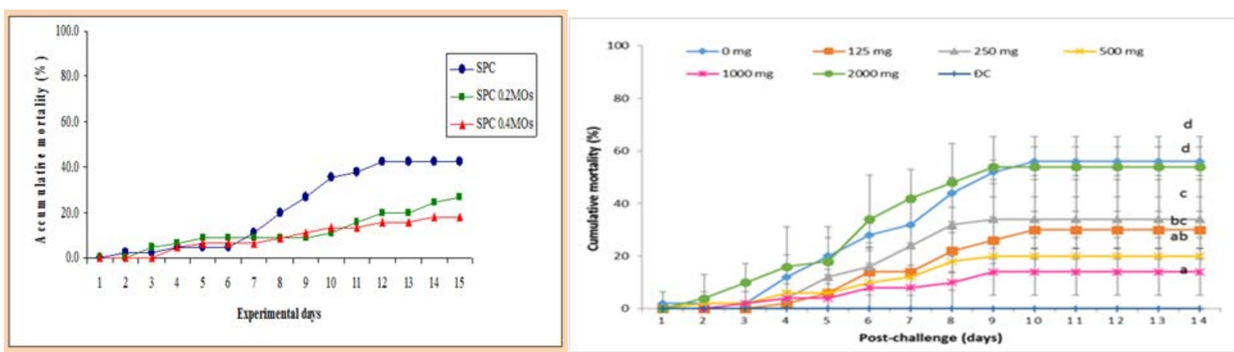


Fig. 1: Strengthening snakehead health through application to feed of added immune stimulant such as 0.2% Mannan Oligosacharide (MO) and 500mg/kg feed.

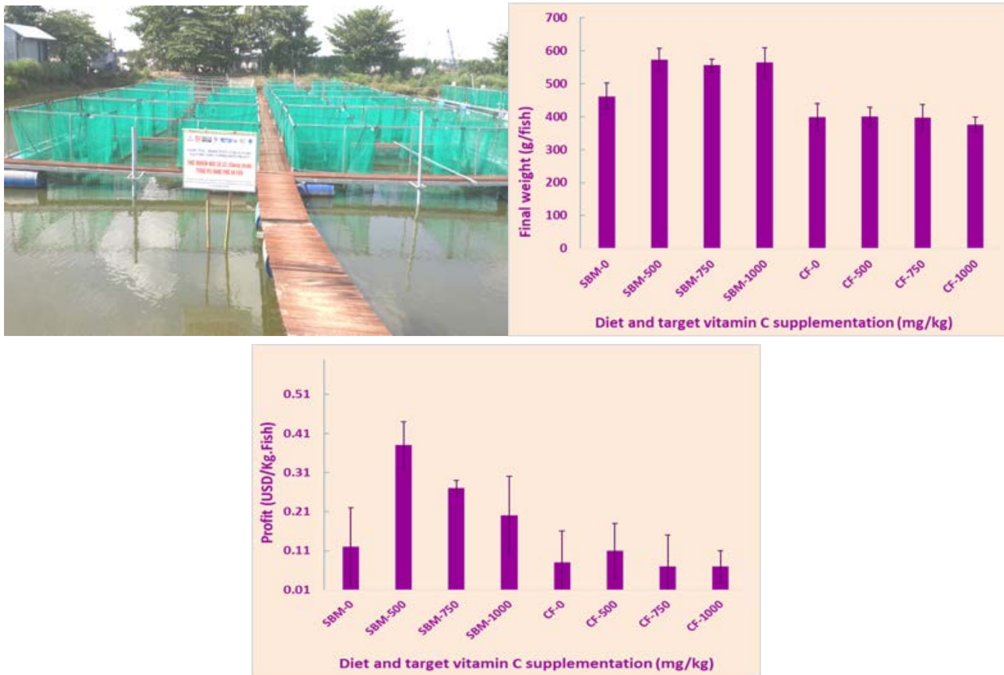


Fig. 2: Index of success in snakehead on-farm trials fed on pellet supplemented with Vitamin C cultured.

DEVELOPING FEED FORMULATION FOR SNAKEHEAD (*Channa striata*) CULTURE IN VIETNAM AND CAMBODIA

AQUA 2018

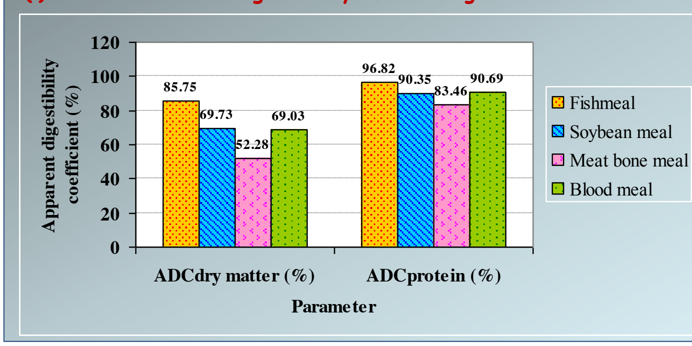
Tran Thi Thanh Hien[1*], Tran Le Cam Tu[1], Tran Minh Phu[1], Pham Minh Duc[1], Bui Minh Tam[1], Huynh Van Hien[1], Chheng Phen[2], Nen Phana[2], SoNam[2], Robert Pommeroy[3], Hillary Egna[4] and David A. Bengtson[5]
[1]College of Aquaculture and Fisheries, Can Tho University, Viet Nam; *Email: ttthien@ctu.edu.vn
[2]Inland Fisheries Research and Development Institute (IFReDI)
[3]Connecticut University, USA, [4]AquaFish Innovation Lab, Oregon State University, USA, [5]University of Rhode Island, Kingston, USA

Introduction

- Traditional methods for snakehead culture involve catching wild juvenile snakehead (*C. striata*) feeding them on wild trashfish;
- Conversion of trashfish into commercial pellet feed for snakehead become urgently;
- A series study were to *(i)* optimize the weaning protocol to enable hatchery-reared fish to adapt to formulated feeds; *(ii)* determine protein, lipid and energy requirement for grow-out stage; *(iii)* assess digestibility of different feed ingredients; *(iv)* develop formulated feeds that maximize the amount of plant proteins to reduce fish meal usage; *(v)* replacement of fishmeal by soybean meal in supplementation of soluble fish attractant and, alpha-galactosidase and Mannan oligosaccharides (MO) and Vitamin C to enhance the immune response of snakehead.

Results

(i) Determination of digestibility of feed ingredients



(ii) The weaning protocol for snakehead

Fig 1: The optimal procedure for weaning snakehead in the hatchery was begun weaning at 17 days post-hatch; daily replacing 10% of low value-fish with formulated feed for 10 days.

(iii) The replacement of fishmeal by Soy protein concentrate

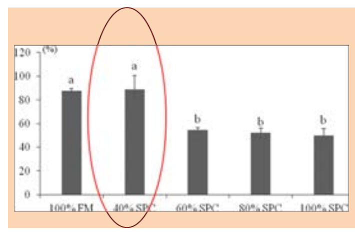


Fig 2: The replacement of fishmeal by soy protein concentrate (SPC) up to 40% in diet for snakehead.

(iv) Strengthening snakehead health through MO and Vitamn C

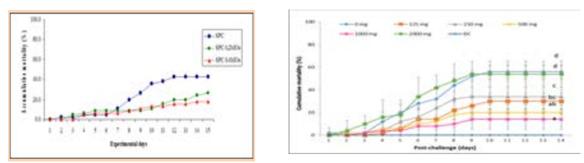


Fig 3: Strengthening snakehead health through application to feed of added immune stimulant such as 0.2% Mannan Oligosacharide (MO) and 500mg/kg feed.

(v) Success pellet feed for snakehead in grow-out stage

Fig 4: Success in snakehead on-farm trials fed on pellet supplemented with MO cultured in hapa, operated by women farmers.

Fig 5: Index of success in snakehead on-farm trials fed on pellet supplemented with Vitamin C cultured.

Conclusion

Aquaculture of snakehead fed on pellet diets in hapas and lined-tanks is suitable for small-scale farmers in Cambodia and Vietnam

Acknowledgment

Funding for this research was provided by the AquaFish Innovation Lab which is supported in part by United States Agency for International Developmen (USAID) Cooperative Agreement No. EPP-A-00-06-00012-00 and by contributions from participating institutions.

Effects of combining Shing (*Heteropneuestes fossilis*) at Different Stocking Densities on Production and Economic Benefits of Koi-carp Polyculture

Shahroz Mahean Haque , Fariha Reza, Ratumoni Rumana, Huzzatul Islam, Russell J. Borski and Hillary Egna

*Department of Fisheries Management Bangladesh Agricultural University Mymensingh, Bangladesh

The stinging catfish or shing (*Heteropneuestes fossilis*) is high value, micronutrient dense, air-breathing fish that has a strong capacity to tolerate poor oxygen environments. This fish provide a significant advantage for pond culture, as they tend to be resilient to harsh conditions, particularly during periods of low-oxygen, which can occur with high temperatures, drought or poor water quality. Because of this, the culture of shing has grown substantially over the past decade in Bangladesh. Currently, production of shing (*H. fossilis*, stinging catfish) is limited to monoculture systems with intensive use of commercial-grade feeds (30%–35% crude protein). As feed can comprise up to 60% of total production costs, the current practices for these fish limit participation by small homesteads and therefore comprise a significant impediment to further expansion of this industry. Effects of combining shing at different stocking densities in Koi-carp polyculture was observed in a study of 152-day growout period in Bangladesh Agricultural University Mymensingh. Studies were carried out to determine: 1) effects of addition of shing at different densities on growth and economic returns for koi carp poly culture by applying reducing feed by 50% from levels typically used by the industry to grow fish, and 2) to assess the best stocking density of shing for koi-carp- shing polyculture which might provide further cost savings strategy. This study consisted of four treatments (T1, T2, T3, T4) with three replications. T1 consisted of a koi-carp polyculture (catla, 0.2/m^2; rohu, 0.8/m^2; koi, 5/m^2). Shing were stocked at the densities of (1.0/m^2) (2.0/m^2) (3.0/m^2) in T2, T3 and T4 respectively. Reduced feeding 50% was applied, the amount applied was calculated based on the biomass of both koi and shing and adjusted every two weeks from fortnightly sampling of fish weights. All ponds were fertilized weekly. The treatment groups was randomly assigned to ponds (N = 12, 100 m^2, 1.5 m depth). The combined net production for the four species was obtained 4642 kg/ha for T1, 5431kg/ha for T2, 6686kg/ha for T3 and 7051kg/ha for T4 respectively. The apparent combined feed conversion ratio (FCR; feed applied to body weight gain) was lowest in T3 (1.53) relative to T2 (1.59), T1 (1.62) and T4 (1.86). Highest net return was obtained from T4 (1820920 Ta/ha) followed by T3 (1595970 Ta/ha) T2 (1210680Ta/ha)) and T1 (812810 Ta/ha). Despite of the higher net production in T4 (not significantly different from T3), the benefit-to-cost ratio (returns - investment) was better for T3 (1.70) than for T4 (1. 54), T2 (1.47) and T1 (1.23). This is due to the additional cost of feed used in T4 with high shing densities than in T3. Considering the high fish production, low FCR value and highest BCR, T3 was found as the most cost effective strategy. Thus stocking of shing (2 /m^2) in koi-carp polyculture can be recommended to the farmers which will be helpful for reducing the feed cost. This polyculture of shing-koi-carp technology may help to meet the dietary needs and improve the socio-economic status of the people of Bangladesh.

EFFECTS OF COMBINING SHING *Heteropneuestes fossilis* AT DIFFERENT STOCKING DENSITIES ON PRODUCTION AND ECONOMIC BENEFITS OF KOI-CARP POLYCULTURE

Shahroz MaheanHaque* Fariha Reza, Ratumoni Rumana. Abdul Wahab, Hillary Egna, and Russell J. Borski

Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh
Shahrozm2002@yahoo.com

Introduction

• Fish is a popular compliment to rice in the national diet and Pond fish farming is playing an important role in supplying ever-increasing fish needs of the people of Bangladesh.

• Polyculture is the practice of culturing more than one species of fish having different feeding habit in the same pond by which fish production may be maximized.

• Climbing perch (*Anabas testudineus*) locally known as koi is an important air breathing fish and and economically important group of fish in Bangladesh. Popularity of this species for cultivation is also high due to high nutritional value, extreme hardiness, fast growth, ability to survive in low oxygen level, and efficient feed utilization.

Introduction cont'd…

• Rui and Catla are indigenous fish in our country and have been used in our research. They are commercially important fishes because they have high market demand, nutritional value and delicious taste and easy to culture.

The stinging catfish or shing (*Heteropneuestes fossilis*) is another high value, micronutrient dense, air-breathing fish that has a strong capacity to tolerate poor oxygen environments.

Objectives:

The present research has been undertaken with the following objectives

➢ To evaluate the feasibility and profitability of semi-intensive polyculture of Koi - Indian carps (Rohu and Catla) with shing in ponds,

➢Assess economic and environmental benefits of combining Shing with Koi-carp pond polyculture.

➢Evaluate overall performance and economic returns of the improved management strategies

➢To evaluate the effect of reduced feed and fertilization regimes on Koi-carp-shing polyculture.

➢To find out economically feasible polyculture system and to maximize cost-benefits for local farmers.

Materials And Methods cont'd…

Table : Experimental design

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Rohu (*L. rohita*)	80 (0.8/m^2)	80 (0.8/m^2)	80 (0.8/m^2)	80 (0.8/m^2)
***Catla* (*C. catla*)**	20 (0.2/m^2)	20 (0.2/m^2)	20 (0.2/m^2)	20 (0.2/m^2)
Koi (*A. testudineus*)	500 (5.0/m^2)	500 (5.0/m^2)	500 (5.0/m^2)	500 (5.0/m^2)
Shing (*H. fossilis*)	0	100 (1.0/m^2)	200 (2.0/m^2)	300 (3.0/m^2)
Fertilization (/ha)	28 kg N, 5.6 kg P	28 kg N, 5.6 kg P	28 kg N, 5.6 kg P	28 kg N, 5.6 kg P
Daily Feeding	50% Ration	50% Ration	50% Ration	50% Ration
Replicates (*n*)	3	3	3	3
Pond number	12,13,14	8,10,11	9,16,18	7,15,17

Materials And Methods

- **Duration of the experiment :** 152 days (19th September to 18th December, 2017)
- **Location:** Fisheries Field Laboratory Complex, Faculty of Fisheries, BAU, Mymensingh
- **Number of Ponds:** 12
- **Depth:** water depth 1.5 m
- **Experimental Species:** Koi (*Anabas testudineus*), Rohu (*Labeo rohita*), Catla (*Catla catla*) and Shing *Heteropneuestes fossilis*

Materials And Methods Cont'd….

❖ Pond Preparation

- All ponds had to completely free from fishes through several times netting and after that the application of rotenone was done.
- Liming was done at a standard rate of 1 kg CaO per decimal.
- All ponds were fertilized initially.

❖ Fingerlings Stocking

- Fingerling of Koi (~2 g), Rohu (~20 g) Catla (~25 g) and Shing (~2 g) were collected from local supplier and were acclimatized and stocked in 12 experimental ponds on 19 August 2017

Materials And Methods Cont'd….

Pond Preparation

Pond drying

Excavation

Liming (1 Kg CaO per decimal)

Fertilization (Urea and TSP at 28 kg N/ha and 7 kg P/ha)

Water filling

Feeding

Utilization of feed was well considered as the treatments, where pellet feed was only used calculated based on the body weight of koi and shing. Major carps, rohu and catla were expected to feed on the natural production. The rate was showed in the research design.

- **Fingerling Collection & Stocking**
  - Koi
  - (~2g) **Shing ((~3g)**
  - Rui
  - (~20 g)
  - Catla
  - (~25 g)

Feeding Strategy

- Commercial fish feed was used twice a day (early morning and evening)

Feed was applied based on the body weight of Koi and shing . Koi and shing were fed 50% daily ration of commercial feed (CP feed) (at 50%(10% - 2.5% bw/day) 50% reduced feeding was applied .the amount applied was calculated based on the biomass of both Koi and Shing and adjusted every two weeks from
fortnightly sampling of fish weights.
Additionally, all the ponds were fertilized weekly with urea and triple super phosphate (28 kg/ha N, 5.6 Kg P/ha) to boost pond productivity.

Materials And Methods Cont'd….

❖ Study of Water Quality Parameters

Collection Water Sample Temperature and Transparency was done in the fieldf ortnightly . Water samples were collected fortnightly from each ponds in small plastic bottles . Then the collected samples were taken into Water Quality and Pond Dynamics for chemical water quality analysis

Water Quality Parameter Monitoring

- Temperature (°C)
- Transparency (cm)

- **Chemical Parameter**
  - pH (Hydrogen ion concentration)
  - Dissolved oxygen (mgl^{-1})
  - [illegible]al alkalinity
  - Nitrate-nitrogen (mgl^{-1})
  - Nitrite-nitrogen (mgl^{-1})
  - Ammonia-nitrogen (mgl^{-1})
  - Phosphate-phosphorus (mgl^{-1})
  - Chlorophyll-a (μgl^{-1})

Materials & Method...

Figure: Chollorophyll-a analysis process

Water Sample Collection and Analysis of Water Quality Parameters

Materials And Methods Cont'd….

❖ Study of Plankton

Collection and Preservation of Plankton Sample

Plankton samples were collected fortnightly from each pond. Then the collected plankton samples were preserved in 10% buffered formalin in small plastic bottles and taken into Water Quality and Pond Dynamics Laboratory, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh for subsequent studies.

Qualitative and Quantitative Study of Plankton

From each 100 ml preserved sample, 1 ml sub-sample was examined using a Sedgewick-Rafter (S-R) cell and a binocular microscope (Swift, M-4000) and then all planktonic organisms present in 10 squares of the cell chosen randomly were identified and counted.

Materials And Methods Cont'd….

Whole process of plankton collection (Pictorial View). Here, A. Plankton net by which plankton sampling was done, B. Collection of plankton sample, C. Plankton samples were taken into bottle, D. Plankton samples were preserved in 10% formalin, E. Bottle of Plankton sample was taken into laboratory, F. Sedge wick-Rafter cell by which counting of plankton sample was done, G. Plankton sample was taken into Sedge wick-Rafter cell, and H. Counting of plankton sample under microscope.

Benthos Collection

Benthic macro-invertebrate samples were collected fortnightly from three different locations of each pond by using an Ekman dredge.

The samples were flushed through a 0.2 mm net. Collected organisms were taken into vial and then preserved in 10% formalin and taken into Water Quality and Pond Dynamics Laboratory, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh for laboratory analysis.

Plankton and Benthos collection and stud

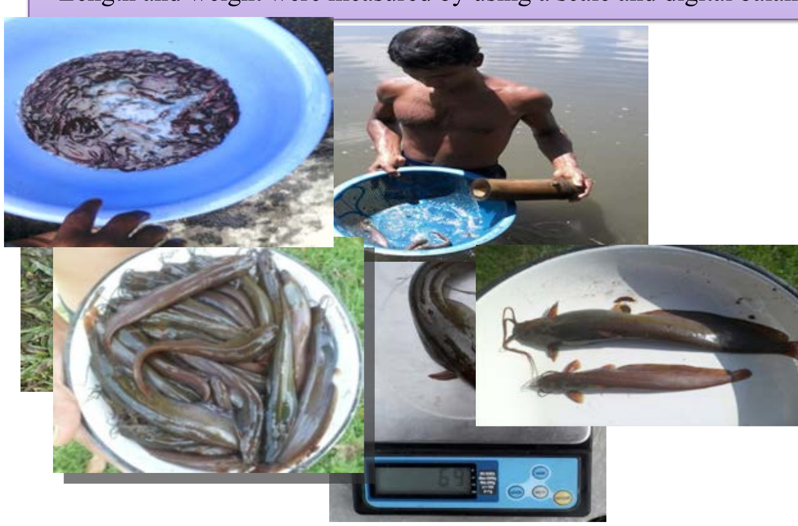
The plankton and benthic macro-invertebrate samples were collected fortnightly

Sampling and Health Monitoring (koi and Shing)

- Sampling of fishes was done at 15 day's interval for Koi
- Sampling was done by using a seine net
- Length and weight were measured by using a scale and digital balance

Sampling and Health Monitoring (koi and Shing)

- Sampling of fishes was done at 15 day's interval for Koi and shing
- Sampling was done by using a seine net and bamboo pol e
- Length and weight were measured by using a scale and digital balance



❖ **Fish Sampling:** Fortnightly sampling was done by using a seine net to monitor the growth of koi and to adjust the feeding rate. The weight of fish was measured by using an electric balance and the length of fish was measured by using a measuring scale.

❖ **Harvesting**

After 152 days of culture periods, all fishes were harvested on 18 December , 2017. Primarily, the partial harvesting of fishes was performed by repeated netting using a seine net. Final harvesting was done by pond dewatering.

Materials And Methods Cont'd….

Plankton abundance was calculated using the following formula (Azim *et al.*, 2001):

N (cells/L) = (P × C × 100) /L

Where,

N = number of plankton cells or units per liter of original water

P = number of plankton counted in 10 fields

C = volume of final concentrate of the sample (ml)

L = volume (l) of the pond water sample

Calculation of Benthic Fauna

The abundance of benthic organism was expressed as density (individual / m^2) by following the formula of Welch (1984):

N = O× 10000/ A × S

Where,

N= Number of macroscopic organisms of profundal bottom (/m^2),
O= Number of organisms actually counted,
A= Transverse area of Ekman dredge in (cm^2) and
S= Number samples taken at one sampling station

Analysis of Growth and Production Parameters

- **Weight gain (g)** = Mean final weight (g) – Mean initial weight (g)

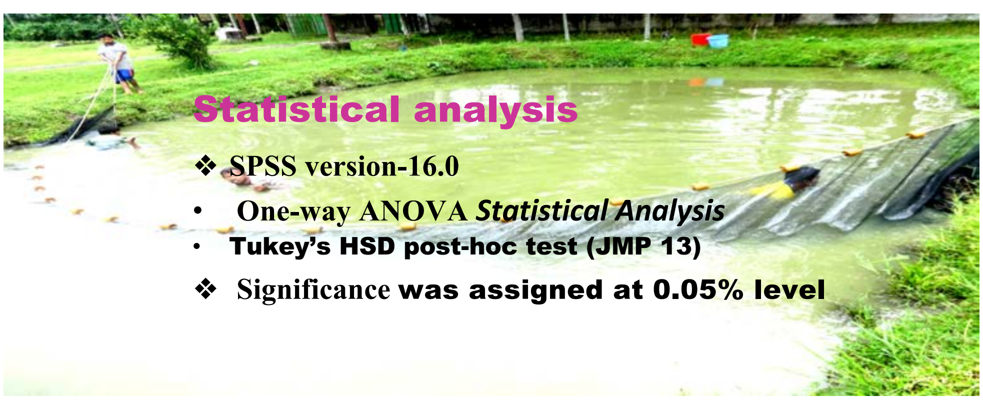
- **Survival rate (%)** = $\frac{\text{No. of fishes harvested}}{\text{No. of fishes stocked}} \times 100$

- $\text{SGR}(\%\ \text{per day}) = \frac{log_e W_2 - log_e W_1}{T_2 - T_1} \times 100$

- **FCR (Food Conversion Ratio)** = $\frac{\text{Total feed used (kg)}}{\text{Total weight gain (kg)}}$

- **BCR (Benefit Cost Ratio)** = Gross return (Tk) ÷ Total investment (Tk)

Final Fish Sampling:
Length and weight of fish were measured



Results

Table: Water Quality parameters recorded from the ponds among four treatmentsValues are mean ± SEM. Different letters indicate significant differences (Tukey's HSD; P < 0.05).

	T1 (0/m² Shing)	*T2 (1/m² Shing)*	*T3 (2/m² Shing)*	*T4 (3/m² Shing)*
Temperature (°C)	28.96±0.037[a]	29.04±0.037[a]	29.26±0.161[a]	29.31±0.046[a]
Transparency (cm)	28.71±0.66[a]	28.47±0.66[a]	24.05±1.18[b]	27.43±0.59[ab]
Alkalinity (mg l^{-1})	78.63±0.67[a]	81.11±1.00[a]	90.07±1.07[b]	87.11±1.22[b]
pH	7.38±0.01[a]	7.43±0.02[a]	7.56±0.02[b]	7.53±0.01[b]
Dissolved Oxygen (mg l^{-1})	6.95±0.05[a]	7.10±0.04[ab]	7.31±0.07[b]	6.96±0.04[a]
Nitrate (mg l^{-1})	0.12±0.002[a]	0.11±0.007[a]	0.14±0.007[b]	0.09±0.008[a]
Nitrite (mg l^{-1})	0.13±0.005[a]	0.15±0.006[b]	0.11±0.001[a]	0.16±0.005[b]
Ammonia (mg l^{-1})	0.22±0.013[a]	0.21±0.005[a]	0.17±0.003[b]	0.21±0.003[a]
Phosphate (mg l^{-1})	0.87±0.007[a]	0.91±0.013[a]	0.81±0.020[a]	0.84±0.009[a]
Chlorophyll-a (µg l^{-1})	135.07±0.36[a]	146.40±0.53[b]	155.12±0.78[c]	154.60±0.71[c]

Table: Mean abundance (±SEM) (× 10³ cells/l) of plankton populations recorded from the ponds among four treatments letters indicate significant differences

	T1 (0/m² Shing)	T2 (1/m² Shing)	T3 (2/m² Shing)	T4 (3/m² Shing)
Plankton				
Phytoplankton	480.52±38.9[a]	467.22±6.35[a]	543.67±18.6[a]	462.78±13.6[a]
Zooplankton	15.96±0.39[a]	15.85±1.24[a]	24.85±2.29[b]	19.44±0.84[ab]
Total Plankton	496.48±38.8[a]	483.07±5.14[a]	568.52±16.8[a]	482.22±13.2[a]
Benthic Organisms				
Oligochaeta	618.38±6.11[a]	530.59±9.23[b]	469.68±15.5[c]	369.82±21.1[d]
Chironomid Larvae	225.93±12.4[a]	433.33±15.8[b]	446.91±2.39[c]	586.42±6.33[d]
Mollusca	392.87±2.90[a]	370.37±13.3[a]	348.97±37.5[a]	305.62±60.3[a]
Unidentified	20.30±0.55[a]	22.50±4.88[a]	18.11±2.51[a]	19.75±3.43[a]
Total Benthos	**1562.69±8.08[a]**	1369.00±10.5[ab]	1198.35±51.9[b]	941.56±85.7[c]

Growthand production performance of *Shing (Heteropneuestes fossilis)*

	T1 (0/m² Shing)	*T2 (1/m² Shing)*	*T3 (2/m² Shing)*	*T4 (3/m² Shing)*
Harvesting Weight (g)	NA	104.38±0.13[a]	108.58±0.20[b]	106.96±0.30[c]
Harvesting Length (cm)	NA	21.94±0.04[a]	22.01±0.09[a]	21.98±0.12[a]
Survival Rate (%)	NA	68	72	67
Specific Growth Rate(% bw d^{-1})	NA	2.535±0.001[a]	2.563±0.001[b]	2.553±0.002[c]
Gross Production (kg/ha)	NA	709.75±0.85[a]	1563.60±2.92[b]	**2149.86±5.99[c]**

Results

Growth and production performance of Koi *(Anabas testudineus)*

	T1 (0/m² Shing)	*T2 (1/m² Shing)*	*T3 (2/m² Shing)*	*T4 (3/m² Shing)*
Harvesting Weight (g)	103.96±0.20[a]	103.83±0.26[a]	107.29±0.27[b]	109.17±0.36[c]
Harvesting Length (cm)	14.33±0.16[a]	14.04±0.11[a]	14.25±0.14[a]	14.54±0.18[a]
Survival Rate (%)	62	70	67	65
Specific Growth Rate(% bw d^{-1})	2.327±0.001[a]	2.326±0.002[a]	2.349±0.002[b]	2.376±0.007[b]
Gross Production (kg/ha)	3222.71±6.17[a]	**3634.17±9.22[b]**	3594.27±9.33[c]	3547.92±11.72[d]

Results

Growth and production performance of Catla (*Catla catla*)

	T1 (0/m² Shing)	*T2 (1/m² Shing)*	*T3 (2/m² Shing)*	*T4 (3/m² Shing)*
Harvesting Weight (g)	243.21±0.30[a]	246.08±0.23[b]	246.21±0.24[b]	246.5±0.20[b]
Harvesting Length (cm)	27.91±0.12[a]	28.42±0.14[a]	28.17±0.16[a]	28.44±0.19[a]
Survival Rate (%)	85	92	90	79
Specific Growth Rate(% bw d^{-1})	1.366±0.002[a]	1.376±0.002[b]	1.373±0.001[b]	1.374±0.001[b]
Gross Production (kg/ha)	413.45±0.32[ac]	**452.79±0.42[b]**	443.18±0.44[bc]	389.47±0.32[a]

Growth and production performance of *Rohu (Labeo rohita)*

	T1 (0/m² Shing)	*T2 (1/m² Shing)*	*T3 (2/m² Shing)*	*T4 (3/m² Shing)*
Harvesting Weight (g)	152.42±0.15[a]	153.17±0.19[ab]	155.88±0.16[bc]	159.04±0.53[c]
Harvesting Length (cm)	24.67±0.19[a]	25.73±0.16[b]	25.54±0.16[b]	25.58±0.15[b]
Survival Rate (%)	87	89	93.5	82
Specific Growth Rate(% bw d^{-1})	1.385±0.003[a]	1.386±0.001[ab]	1.396±0.003[bc]	1.410±0.004[c]
Gross production (kg/ha)	1060.82±1.04[ab]	1090.55±1.34[bc]	**1165.95±1.23[c]**	1043.31±3.48[a]

Results

Production performance and FCR of Koi (*Anabas testudineus*) Catla *Catla catla*) and rohu (*Labeo rohita*) and Shing (*Heteropneuestes fossilis*) polyculture

Total	*T1 (0/m^2 Shing)*	*T2 (1/m^2 Shing)*	*T3 (2/m^2 Shing)*	*T4 (3/m^2 Shing)*
Feed Conversion Ratio	1.62±0.051^{a}	1.59±0.055^{a}	1.53±0.035^{a}	1.86±0.049^{b}
Gross Production (kg/ha)	4696.98±6.85^{a}	5887.26±10.37^{b}	6766.99±9.17^{c}	7130.56±14.43^{d}

Table: Economic analysis of the production performances of Koi, Rohu Catla and shing in four different treatments

Financial Input *(BDT/ha)*	***T1 (0/m^2 Shing)***	***T2 (1/m^2 Shing)***	***T3 (2/m^2 Shing)***	***T4 (3/m^2 Shing)***
Bleaching Powder	5928	5928	5928	5928
Lime ($CaCO_3$)	10,338	10,338	10,338	10,338
Urea	7231	7231	7231	7231
Triple Super Phosphate	5530	5530	5530	5530
Koi	49,400	49,400	49,400	49,400
Rohu	55,328	55,328	55, 328	55,328
Catla	21,736	21,736	21,736	21,736
Shing	0	49,400	98,800	148,200
Feed	495,594	609,708	674,916	865,326
Labour	10,000	10,000	10,000	10,000
Total Cost (BDT/ha)	661,085	824,599	939,207	1,179,017
Total Production (kg/ha)	4696.98±6.85^{a}	5887.26±10.37^{b}	6766.99±9.17^{c}	7130.56±14.43^{d}
Gross Return (BDT/ha)	822,445±1224^{a}	1,226,849±1959^{ab}	1,615,276±1946^{bc}	1,841,847±3505^{c}
Net Return (BDT/ha)	161,360±1224^{a}	402,250±1959^{ab}	676,069±1946^{c}	662,829±3505^{bc}
Benefit Cost Ratio	1.24	1.49	**1.72**	1.56

** Values of the parameter in each row with different superscripts (a and b) differs significantly ($p<0.05$)

Garph

Feed Conversion Ratio

Figure . Feed conversion ratios for Koi-Carp (T1) and Koi-Carp-Shing (T2, 1/m^2 Shing; T3, 2/m^2 Shing; T4, 3/m^2 Shing) polyculture .Values are mean ± SEM. Different letters indicate significant differences between treatments (Tukey's HSD; P <0.05).

Cont,d

Gross Production (kg/ha)

Figure : Gross production (kg/ha) for Koi-Carp (T1) and Koi-Carp-Shing (T2, 1/m^2 Shing; T3, 2/m^2 Shing; T4, 3/m^2 Shing) polyculture in Study 2.Values are mean ± SEM. Different letters indicate significant differences between treatments (Tukey's HSD; P <0.05).

Cont,d

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Figure . Gross (black) and net (grey) profits in Bangladesh Taka (BDT) for Koi-Carp (T1) and Koi-Carp-Shing (T2, 1/m^2 Shing; T3, 2/m^2 Shing; T4, 3/m^2 Shing) polyculture in Study

Conclusion

Production and survival of Koi, Rohu, and Catla was higher in ponds containing lower stocking densities of Shing (T2 and T3)

Gross production and returns were greatest in T4 because of the increased abundance and higher market value of Shing.

However, due to the higher cost of feed and lower survival rates for all species in T4, the greatest net profit and benefit cost ratio was observed in T3

Incorporating Shing into Koi-carp polyculture at a stocking density of2.0/m^2would be the most beneficial for increasing food production and incomes for rural farmers in Bangladesh.

Take Away Message

The results of this investigation indicate that Koi and Shing are ideal candidates for polyculture with carps. further enhanced growth and production of Koi as well as both carp species.

weekly pond fertilization to support natural productivity can lower production costs without any negative impacts on fish growth or survival

Thus, adding Koi and Shing to existing carp culture systems and reducing feed application could allow an overall increase in production of both species in Bangladesh as well as enhance earnings and food availability for small-scale rural fish farmers
Treatment T3 was found
as the most cost effective strategy considering the high fish production, low FCR value and highest BCR. Stocking of shing (2 /m^2) in koi-carp polyculture can be recommended to the farmers. technology may help to meet the dietary needs and improve the socio-economic status of the people of Bangladesh.

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Zooplankton Populations in Tilapia Ponds Fed With Different Diets

Regina E. Edziyie*, Stephen Gyamfi , Kwasi Adu Obirikorang, Emmanuel Frimpong, D. Adjei-Boateng

* Department of Fisheries and Watershed Mangement, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Plankton are an important component of the diet of Nile tilapia fingerlings, even in ponds in which fish are fed manufactured diets. The goal of the study was to determine the effect of three different but iso-nitrogenous and iso-caloric nursery diets (D1- commercial control, D2 and D3) on zooplankton abundance and composition in earthen ponds.

The study was carried out in 48, 1m3 hapas mounted in six 150 m2 ponds with each stocked with 100 Nile tilapia (Oreochromis niloticus) fingerlings of average weight 3g and fed their assigned diets for 40 days. Zooplankton sampling was done every three days; preservation, identification and enumeration methods followed that described in Ludwig et al. 2010. Zooplankton was grouped into rotifers, copepod nauplii, copepods and cladocerans. Data were subjected to two-way ANOVA to determine spatio-temporal differences in zooplankton abundance among treatments.

In general, rotifers dominated the zooplankton population in all treatments. Peak rotifer abundance for D1, D2 and D3 groups were 2112, 2858 and 3358 individuals per m3 respectively. Peak rotifer abundance occurred between the 15th and 21st days after the inception of the experiment. Rotifers accounted for 51.8, 50.1 and 42.3% of total zooplankton abundance in the treatments that were fed the Control, D2 and D3 diets respectively. Cladocerans were the least represented zooplankton group accounting for between 7.7 and 8.9% of total zooplankton abundance among the treatments. Overall, there were no significant dietary effects ($p > 0.05$) on individual and total zooplankton abundance over the experimental period.

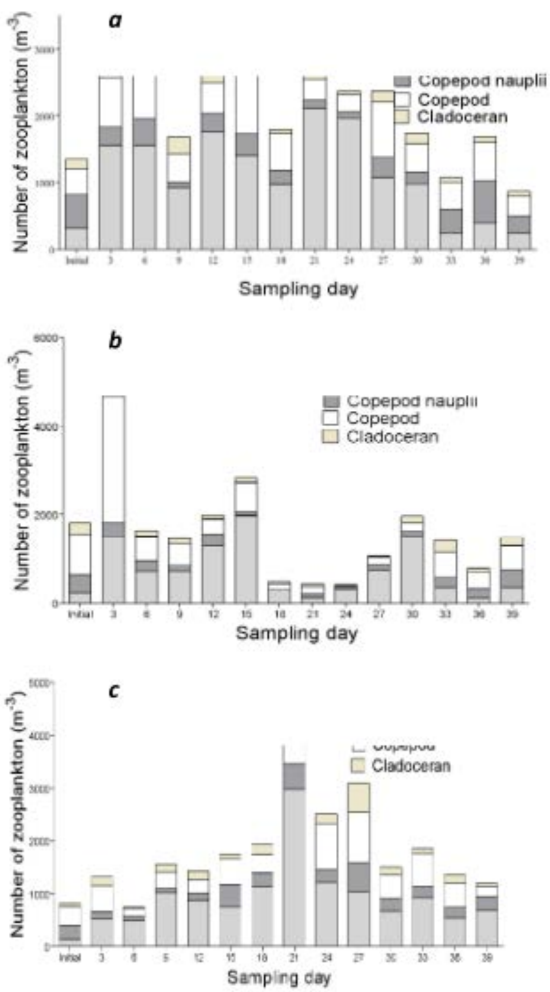

Fig. 1 Zooplankton abundance in the treatments fed the (a) control –D1, (b) D2 and (c) D3

Introduction

3

- Several studies - plankton production in ponds - highly influenced by the types of materials in the system
  - Organic fertilizers are better than inorganic fertilizers when it comes to zooplankton production
    - The type of organic material (Barkoh *et al.*, 2004)
- Plant based proteins → more faeces → high fibre content (Kaliyan and Morey, 2009)
- Higher fibre → low pellet integrity → higher levels of organic wastes in culture systems (Obirikorang, 2017)

Introduction

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- With no well established commercial nurseries (Ghana) farmers are forced to grow their own stocklings
- High cost of nursery feeds still a challenge for farmers
- Through work with the AquaFISH
  - Produced 2 practical tilapia diets
    - Higher inclusion levels of agro by products
    - Performed well in short duration studies – recirculation tanks
    - Diets ($0.77-0.81/Kg) Vs. $2.3/Kg for a commercial control
- Question: Would higher inclusion levels of the agro by products affect plankton production in ponds?

Objective

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- To determine the effect of three nursery diets (D1-commercial control, D2 and D3) on zooplankton abundance and composition in earthen ponds

Materials & Methods

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Study: KNUST research station, Ghana

Duration: 40 days

Experimental Design

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- **Expt. units:** 1m^3 hapas in 6 ponds (20m x 10m x1m)
- **Treatments:** three diets (48% CP):
  - Commercial control & 2 practical diets (D2, & D3)
- **Treatment assignment:** CRBD
- **Variables monitored:** Zooplankton production, fish growth & water quality

Diets used

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- **Proximate Composition**
  - All diets were iso-nitrogenous and iso-caloric
  - Crude Protein: 48%; Crude Lipid: 7%
  - Crude Fibre: 3-5%; Gross Energy: 17 kJg^{-1}

Diet 2

% Inclusion levels/final formulation	
Fishmeal FM	40.30
Soy SBM	42.47
Fermented Copra meal	7.45
Wheat meal WM	5.78
Maize meal MM	0.00
Herring oil	2.00
Corn oil	0.00
Binder BIN	1.00
Supplement SUP	1.00
Total	100.00

Diet 3

% Inclusion levels/final formulation	
Fishmeal FM	32.45
Soy SBM	50.98
Fermented Copra Meal	7.15
Wheat meal WM	5.42
Maize meal MM	0.00
Herring oil	2.00
Corn oil	0.00
Binder BIN	1.00
Supplement SUP	1.00
Total	100.00

Stocking & feeding

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- **Stocking**: ~4g all male *Oreochromis niloticus*
- **Stocking rate** : 100/hapa (100/m^2)
- **Feeding**: 8% body weight , three times daily

Sampling

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- **Fish**: every 10 days – 4 hapas
- **Zooplankton**: before the expt & every 3 days.
  - Water samples were filtered using a Wisconsin net
  - Preserved in 70% ethanol
  - **Identification/enumeration:** major groups – cladocerans, copepods, rotifers, copepod nauplii (Ludwig *et al.*, 2010)
- **Water quality**:
  - Chlorophyll a (APHA, 2005) & alkalinity – weekly
  - Temp., DO, pH, Cond., Secchi depth every 3rd day

Table 1: Survival, growth performance and feed utilization

Variables	Control	D2	D3
WG (g)	16.92±1.69[a]	13.20±1.94[a]	8.53±0.25[b]
FCR	**1.00±0.06**	**1.01±0.010**	**1.61±0.35**
SGR (%/day)	4.15±0.20	3.63±0.21	2.92±0.18
FI (g/fish/day)	**0.42±0.06[a]**	**0.33±0.02[b]**	**0.34±0.07[b]**
FER	1.01±0.06	0.99±0.09	0.65±0.13
PER	2.09±0.12	2.07±0.19	1.36±0.28
SR (%)	**91.75±7.66[a]**	**99.33±0.58[a]**	**87.25±11.14[a]**

Table 2: Physicochemical water quality & chlorophyll *a*

Variable	Control	D2	D3
DO (mg/L)	5.07±2.45	3.85±2.08	3.70±1.90
pH	7.19-9.28	6.75-8.63	6.86-8.97
Temperature (°C)	28.43 ± 0.73	28.40 ± 1.11	28.39 ± 0.07
Secchi depth (cm)	19.47 ± 7.96	34.13 ±6.90	24.38 ± 11.11
Conductivity (µS/cm)	**162.50 ± 26.42 [a]**	**145.8±26.26 [ab]**	**133.7 ± 23.14[b]**
Alkalinity (mg/L $CaCO_3$)	204.40 ± 80.91	194.40±111.50	213.80 ± 108.3
Chlorophyll-a (µg/L)	**3044 ± 224.10**	**3119± 307.7**	**3175 ± 428.1**

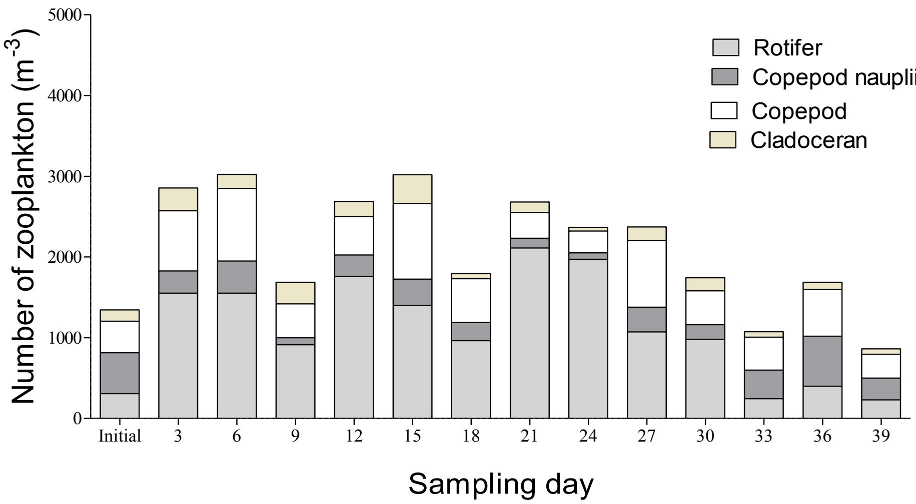

Fig. 1 Zooplankton in ponds with fish fed on control diet

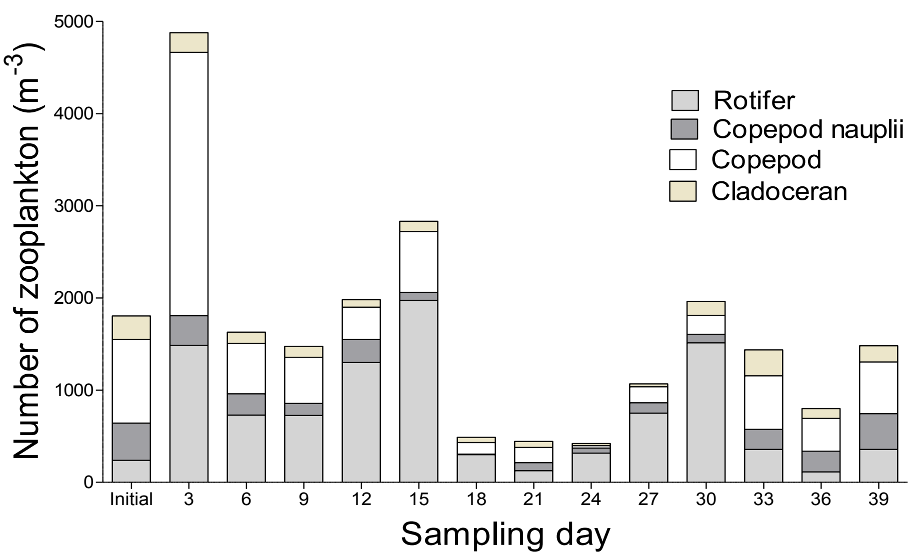

Fig. 2 Zooplankton in ponds with fish fed on diet 2

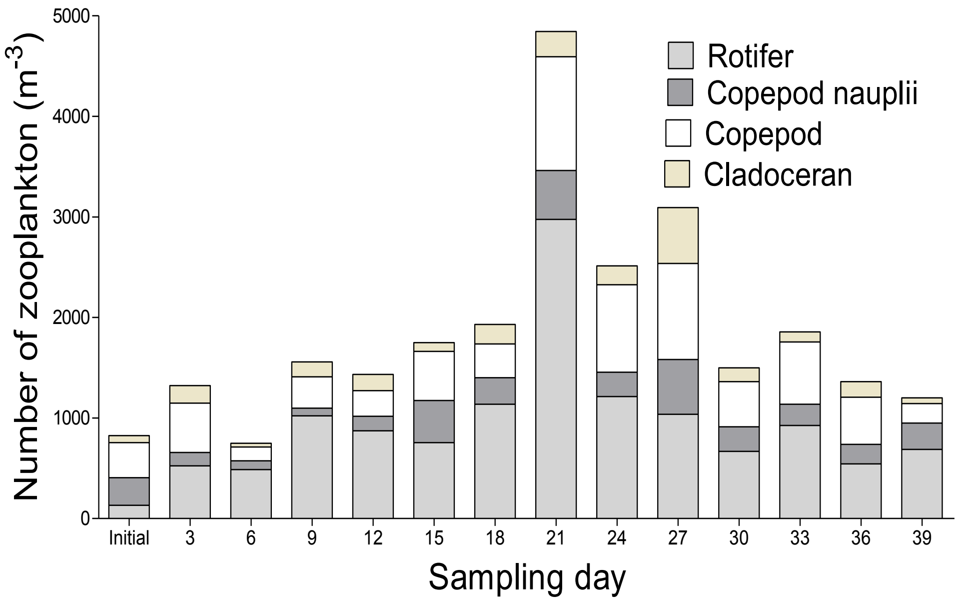

Fig. 3 Zooplankton in ponds with fish fed on diet 3

Zooplankton in gut - supplementary*

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- Zooplankton were an important part of the fish diet – 30% of encountered items
- Rotifers were the most eaten zooplankton group
- After day 20, not much of the zooplankton were consumed by the fish
- More zooplankton eaten by fish in the D2 group:

  D2 > control> Diet 3
- Phytoplankton (50%) were more than zooplankton

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Studies on Fungi and Bacteria Infection to Snakehead *Channa striata* Culture in the Mekong Delta Vietnam

Pham Minh Duc* and Tran Thi Thanh Hien

College of Aquaculture and Fisheries, Can Tho University,
Can Tho city, Vietnam

The study was investigated pathologens infection to snakehead, studied on the classification of fungus isolated from juvenile, and determine whether *A. hydrophila* is a hemorrhagic pathogen in snakehead fingerlings in the Mekong Delta, Vietnam. A total of 296 samples, showing secretion of swimming lethargic, feeding reduction, mucus mass, red spots and white spots on the body and threadfin, were colected from the culture ponds in the period of project. The result indicated that fungi were defined in the first three months of culture period, of which, *Achlya* appeared only in the first sampling time. Three genera of fungi, *Acremonium*, *Fusarium* and *Geotrichum* were firstly isolated from cultured snakehead. Bacteria including *Aeromonas*, *Edwardsiella*, *Streptococcus* and *Pseudomonas* appeared at frequency of 54.3, 17.3, 14.8 and 13.6%, respectively. The identification of fungal *Achlya* was based on the morphological characteristics, asexual reproductive process of fungi and using of expressed sequence tag and BLAST search. The result showed that *Achlya bisexualis* was isolated from infected snakehead. On the other hand, bacterial disease on fingerling stage, snakehead showed clinical signs of floating and impaired swimming, hemorrhagic and ulcerative lesions on the fish body, and protruding scales were observed among cultured snakehead fingerlings. A strain of *A. hydrophila*, designated CD1012, was isolated from these snakehead. The pathogenicity of this isolate was assessed at the College of Aquaculture and Fisheries, Can Tho University, using intraperitoneal injection in snakehead fingerlings. Inoculation with *A. hydrophila* CD1012 was associated with clinical signs similar to those seen in naturally infected snakehead. Resulting mortality indicated an LD_{50} of 1.16×10^5 CFU/fish. Molecular characterization demonstrated that the same bacterial strain was re-isolated from the artificially infected fish. Thus, *A. hydrophila* CD1012 is a demonstrated pathogen of snakehead fingerlings.

AQUA 2018

STUDIES ON FUNGI AND BACTERIA INFECTION TO SNAKEHEAD (*Channa striata*) CULTURE IN THE MEKONG DELTA VIET NAM

Pham Minh Duc* and Tran Thi Thanh Hien

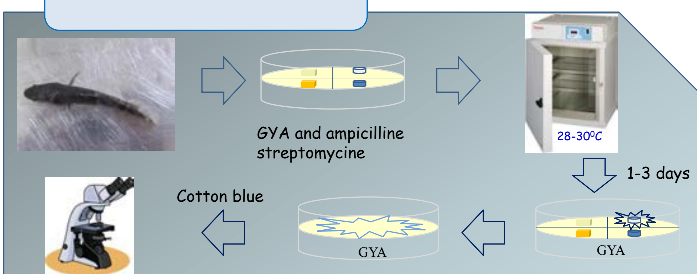
College of Aquaculture and Fisheries, Can Tho University, Viet Nam

*Email: pmduc@ctu.edu.vn

Introduction

- Snakehead fish (*C. striata*) is one of species popular cultured in Mekong Delta, Viet Nam.
- The study was investigated pathologens infection to snakehead fish, studied on the classification of fungus isolated from juvenile, and determine whether *Aeromonas hydrophila* is a hemorrhagic pathogen in snakehead fingerlings in the Mekong Delta, Vietnam.

Method



- The fungi were incubated at 28°C for 1-3 days on GYA, and identified based on the morphological characteristics, colony pigmentation, hyphae, conidiophores and conidia.
- Strain *Aeromonas hydrophila* CD1012 was isolated from liver sample of snakehead cultured in Co Do district, Can Tho City, Viet Nam and was identified by PCR technique (Bartie *et al.*, 2006; Panangala *et al.*, 2007).

Conclusion

The result showed that *Achlya bisexualis* was isolated from infected snakehead and *Aeromonas hydrophila* CD1012 is a demonstrated pathogen of snakehead fingerlings

Acknowledgment

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Results

Achlya bisexualis

Fig 1: Striped catfish disease with swollen and septate hypha in swim bladder.

Fig 2: The colonies is round, yellow in backside and the front is white smooth similar as cotton wool.

Aeromonas hydrophila CD1012

Fig 3: Clinical signs in snakehead fingerlings injection with *A. hydrophila*; A) Hemorrhage in fish body. B) Hemorrhage in abdominal cavity.

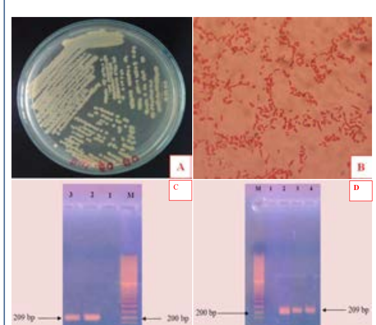


Fig 4: The morphological characteristics and molecular examination of *A. hydrophila* CD1012 re-isolated from challenged snakehead fingerlings.

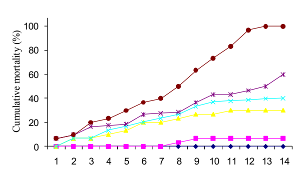


Fig 5: Cumulative mortality of snakehead fingerlings inoculated IP with *A. hydrophila* CD1012.

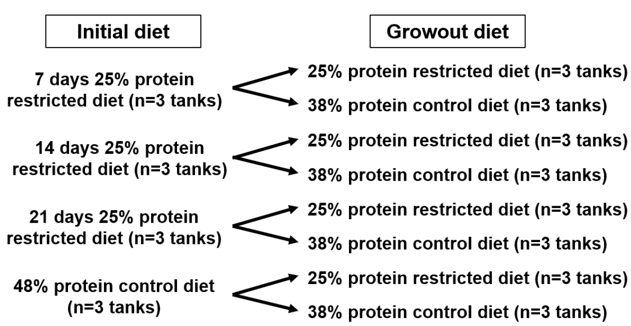
Effects of Nutritional Conditioning on Growth of Nile Tilapia Fry

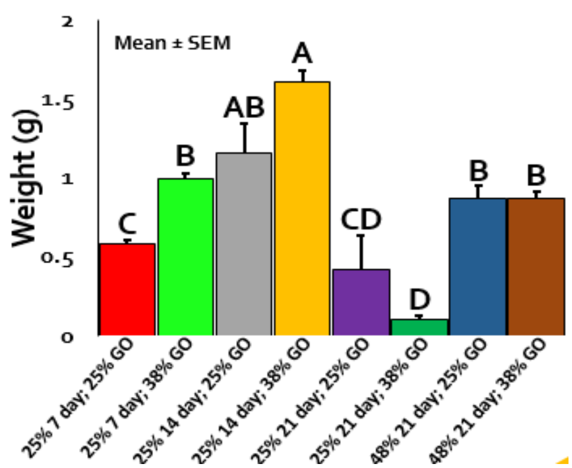
Courtney A. Deck*, Scott A. Salger, Kaniz Fatema, and Russell J. Borski

*Department of Biological Sciences, North Carolina State University, Raleigh, NC USA

Global production of farmed Nile tilapia (*Oreochromis niloticus*) has increased exponentially over the past 30 years. Feed comprises 50-70% of production costs for tilapia, with protein being the most expensive component. We have previously shown that alternate day feeding and pond fertilization improves feed efficiency and increases gut microbe diversity of tilapia grown in ponds with no detriments to the survival rate of the fish. To further these studies, experiments have been performed to determine whether larval nutritional conditioning, the concept that critical events early in life have lifelong effects on growth and health and may modify the gut transcriptome and microbial community in favour of improved food conversion efficiency.

We conditioned newly hatched fry on an initial low protein (25% crude protein) diet versus a typical 48% crude protein diet for various time intervals (7, 14, 21 days) to determine if reducing protein in the diet early in life may enhance growth or affect nutrient assimilation and gut microbe diversity later on (Fig. 1). Following this initial exposure to low protein, fry were then grown out for up to 49 days on either the 25% reduced protein or the typical 38% protein diet. We show that tilapia fry fed a 25% protein diet for 14 days had greater mean weights (Fig. 2) and lengths than fry fed the initial 48% protein diet. RNAseq analysis of the intestine revealed an upregulation of muscle-related processes in fish fed low protein initially, possibly indicating a compensatory proliferation of the intestine once dietary protein levels increase. No differences in overall microbe diversity was observed between treatments, however the low protein group did exhibit greater species richness. This study is the first indication that protein conditioning may be beneficial for production in tilapia culture.





Effects of nutritional conditioning on growth of Nile tilapia fry (*Oreochromis niloticus*)

NC STATE UNIVERSITY

Courtney A. Deck[1], Scott A. Salger[1], Hannah M. Reynolds[1], Nusrat Hossain Nushy[2], Md Mehedi Hasan[2], Jakir Hossain[2], Mst Kaniz Fatema[2], and Russell J. Borski[1]

[1]Department of Biological Sciences, North Carolina State University, Raleigh, USA

[2] Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh

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Introduction

- Production of farmed Nile tilapia is increasing exponentially worldwide
- Tilapia comprise a large portion of dietary protein in countries like Bangladesh
- 50-80% of production costs for fish come from feed, with high quality protein being the most costly component
- Farmers in underdeveloped countries may have difficulty affording commercial feeds but their use can quadruple production
- Feed management strategies to reduce production costs include:
  1) Reducing feed frequency (eg. alternate day feeding)
  2) Altering feed formulas (eg. use of less costly ingredients)
  3) Enhancing feed utilization (eg. increasing digestibility)

- Nutritional conditioning → critical events early in life have lifelong effects on growth and health
- Altering early nutrient components may enhance uptake and utilization later on in life
- Demonstrated with phosphorous in chickens, glucose in rainbow trout, and high unsaturated fatty acids in sea bass
- Nutritional programming has never been applied to tilapia culture

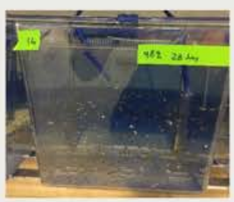
Objectives

1. **Determine if reducing the crude protein (CP) content of feed during the first 7-21 days post-yolk sac absorption will enhance growth of Nile tilapia and reduce production costs.**
2. **Investigate the effects of protein restriction on the intestinal transcriptome.**
3. **Examine whether protein restriction enhances the diversity of microbes within the gut.**

Methods

Tank study performed at North Carolina State University:

Initial diet	Growout diet
7 days 25% protein restricted diet (n=6 tanks)	25% protein restricted diet (n=3 tanks)
	38% protein control diet (n=3 tanks)
14 days 25% protein restricted diet (n=6 tanks)	25% protein restricted diet (n=3 tanks)
	38% protein control diet (n=3 tanks)
21 days 25% protein restricted diet (n=6 tanks)	25% protein restricted diet (n=3 tanks)
	38% protein control diet (n=3 tanks)
48% protein control diet (n=6 tanks)	25% protein restricted diet (n=3 tanks)
	38% protein control diet (n=3 tanks)



- Sub-sampled for lengths and weights every 7 days for 56 days
- Anterior intestine sampled after 56 days for RNAseq analysis
- Metagenomics analysis after 21 days to determine microbe diversity

Pond study performed at Bangladesh Agricultural University:

Initial diet	Growout diet
14 days 20% protein (n=6 hapas)	20% protein restricted diet (n=3 ponds)
	40% protein control diet (n=3 ponds)
14 days 40% protein (n=6 hapas)	20% protein restricted diet (n=3 ponds)
	40% protein control diet (n=3 ponds)

- Sub-sampled for lengths and weights every 14 days for 90 days
- Feed conversion ratios and net profits determined at end of study

Results

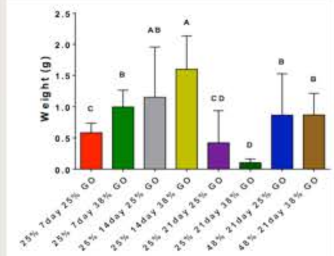


Figure 1. Final weights of Nile tilapia raised in tanks on normal or protein-restricted diets. GO, growout diet. Data are means ± SD. Values with different letters are significantly different (One-way ANOVA; p < 0.05).

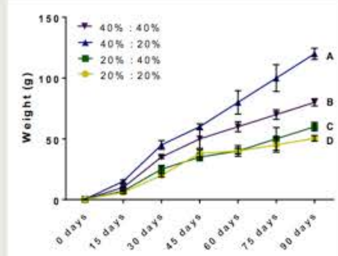


Figure 2. Weights of Nile tilapia raised in ponds on normal or protein-restricted diets over a 90-day culture period. Data are means ± SD. Values with different letters are significantly different at 90 days (One-way ANOVA; p < 0.05).

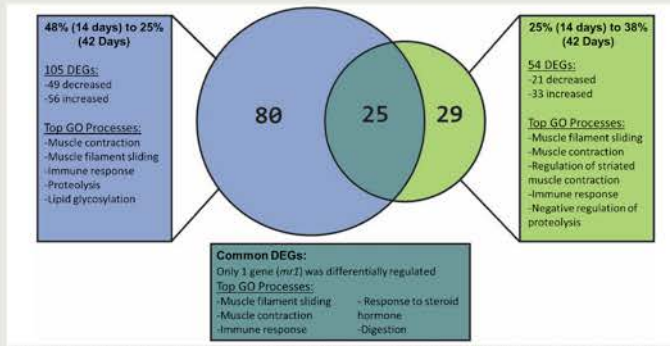


Figure 3. Number of differentially expressed genes (DEGs) and the top significantly enriched gene ontology (GO) biological processes from the anterior intestine of Nile tilapia fry reared in tanks. The GO analysis for each treatment group is relative to the control diet (48% to 38% CP).

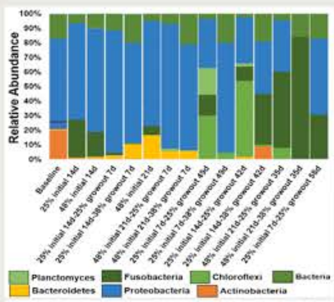


Figure 4. Relative abundance of phyla identified from Nile tilapia fry raised in tanks after feeding on restricted or normal protein diets. Bacteria = Kingdom Bacteria, OTUs could not be further identified.

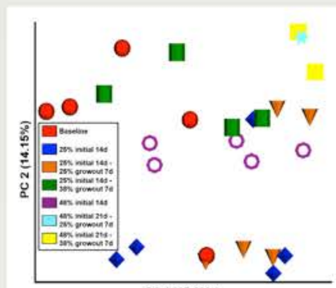


Figure 5. Principle component analysis for beta diversity of pair-wise differences in microbial communities in anterior intestine of Nile tilapia fry raised in tanks and fed varying protein level diets.

Conclusions

1. **Reducing dietary protein for 7-14 days post-yolk sac enhances growth in tilapia raised in tanks which could reduce feed-associated production costs.**
2. **Ponds provide alternate natural food sources, likely preventing protein-restriction and thus conditioning effects. Starting in clean water systems before transfer to the pond is a possibility.**
3. **Intestinal transcriptome revealed regulation of genes involved in protein metabolism and muscle function to cope with reduced dietary protein levels.**
4. **No difference in beta diversity of microbes between treatments but fish fed 25% CP had higher species richness than 48% CP.**

Funding: The AquaFish CRSP is funded in part by United States Agency for International Development (USAID) Cooperative Agreement No. EPP-A-00-06-00012-00 and by US and Host Country partners.

Comparison of Pond Fertilization and Supplementary Diet Feeding on Pond Water Quality and Growth Performance of Nile Tilapia *Oreochromis niloticus*

Sebastian W. Chenyambuga*, Renalda N. Munubi, Nazael A. Madalla, Kwamena Quagrainie, Emmanuel Frimpong and Hillary Egna

*Sokoine University of Agriculture, P.O.Box 3004, Morogoro, Tanzania.

In Tanzania aquaculture is dominated by pond culture of Nile tilapia (*Oreochromis niloticus*) under both extensive and semi-intensive farming systems. Under these systems, management practices involve irregular pond fertilization and feeding of low quality feeds. These practices result into low production. The use of good quality feeds in aquaculture is limited due to high price and unavailability of the high quality concentrate feeds. Proper pond fertilization and 50% supplementary feeding with good quality feeds can promote higher fish yield at low cost. This experiment was carried out to compare the effects of pond fertilization, concentrate feeding at 5% of fish biomass and a combination of fertilization and concentrate feeding at 2.5% of fish biomass on water quality parameters, growth performance and yield of Nile tilapia. The experiment was conducted using nine earthen ponds with average size of 188.7 m^2 at Tindiga Village, Kilosa district, Tanzania. The treatments were weekly fertilization alone with urea and Di-Ammonium Phosphate (DAP) at a rate of 3 g/m^2 and 2 g/m^2, respectively (T_1), concentrate feeding alone at 5% of fish biomass (T_2) and weekly fertilization with urea and DAP plus concentrate feeding at 2.5% of fish biomass (T_3). The concentrate diet contained 30% crude protein. The ponds were stocked with sex-reversed Nile tilapia at a stocking density of 3 fingerlings per m^2. A random sample of 50 fish per pond was measured for body weight every two weeks. Dawn pond water pH, dissolved oxygen (DO), conductivity, total dissolved solids (TDS), salinity, alkalinity, total nitrogen, nitrate, ammonium, phosphorus (P) and temperature were measured weekly. The experiment was conducted for 166 days.

Results indicate that ponds under fertilization alone (T_1) (pH = 8.23 ± 0.02, DO (mg/L) = 4.03 ± 0.11,P (mg/L) = 0.33 ± 0.08) and fertilization plus feeding (T_3) (pH = 8.20 ± 0.02, DO (mg/L) = 4.43 ± 0.11, P(mg/L) = 0.23 ± 0.04) had higher ($p \leq 0.05$) water pH, DO and phosphorus than those under concentrate feeding alone (T_2) (pH = 8.08 ± 0.02, DO(mg/L) = 3.88 ± 0.09, P(mg/L) = 0.15 ± 0.03). Furthermore, treatment significantly ($p \leq 0.05$) affected the final body weight, weight gain, growth rate, specific growth rate, feed conversion ratio (FCR) and yield of Nile tilapia, but not ($p > 0.05$) survival rate. Fish cultured in ponds under T_1 had lower weight gain (65.4 ± 1.1 g), growth rate (0.4 g/day), specific growth rate (2.5%) and yield (4,602 ± 376 kg/ha/year) than those cultured under T_2 and T_3. The weight gain (193.8 ± 4.5 g), growth rate (1.2 g/day), specific growth rate (3.3%) and yield (13,065 ± 456 kg/ha/year) of fish reared in ponds under T_3 were significantly higher than of those on T_2. It is concluded that the combination of weekly fertilization of ponds and concentrate feeding at 50% of the amount used for feeding alone treatment promotes higher growth rate and results into higher yield and profit than weekly fertilization alone or concentrate feeding alone.

COMPARISON OF POND FERTILIZATION AND SUPPLEMENTARY FEEDING ON POND WATER QUALITY AND GROWTH PERFORMANCE OF NILE TILAPIA (*Oreochromis niloticus*)

Sebastian W. Chenyambuga[1], Renalda N. Munubi[1], Nazael A. Madalla[1], Kwamena Quagrainie[2], Emmanuel Frimpong[3] and Hillary Egna[4]

[1]Sokoine University of Agriculture, Morogoro, Tanzania. [2] Purdue University, USA, [3]Virginia Polytechnic Institute and State University, USA, [4]Oregon State University, USA.

Introduction

In Tanzania aquaculture is dominated by pond culture of Nile tilapia (*Oreochromis niloticus*) under both extensive and semi-intensive farming systems. Under these systems, management practices involve irregular pond fertilization to support natural food production and supplementary feeding of low quality feeds. Weekly fertilization of fish pond has been shown to increase fish yields by increasing primary productivity (Knud-Hansen *et al*., 1991). Natural food can support fish growth, however, if used alone it may lead to slow growth rate, hence, increased production cycle and low yield. On the other hand, supplementary feed can support fast growth of the fish and high production performance. However, feed is the most expensive input in farmed fish production. Studies have shown that proper fertilization and supplementary feeding may increases fish production and reduces production cost, hence, high profit (Wahab *et al*., 2014; Phanna *et al*., 2014). In Tanzania information on the combined effects of fertilization and supplementary feeding on water quality parameters and fish growth performance in ponds is lacking**.** This study was carried out to compare the effects of pond fertilization alone, 100% feeding alone and a combination of fertilization and 50% feeding on water quality parameters, growth performance and yield of Nile tilapia.

Materials and Methods

- An experiment was conducted using nine earthen ponds, each with average size of 188.7 m^2 at Kilosa district, Tanzania.
- The ponds were stocked with sex-reversed Nile tilapia of about 1 g at a stocking density of 3 fingerlings per m^2. The fish were fed a diet containing 30 % crude protein. The feed comprised of fish meal (25%), cotton seed cake (10%), sunflower seed cake (10%), maize meal (4%), wheat bran (50%) and mineral premix (1%).

- The experiments had three treatments as follows:
  - Weekly fertilization alone with urea and Di-Ammonium Phosphate (DAP) at a rate of 3 g/m^2 and 2 g/m^2, respectively (T_1),
  - Feeding alone at 5% of fish body weight (T_2) and
  - Combination of weekly fertilization with urea and DAP plus feeding at 2.5% of fish body weight (T_3).

- The treatments were assigned to the ponds in a completely randomized design.
- Fish were fed twice per day at 10.00 am and 4.00 pm with 10% and 5% of body weight during the first two months and then the amount was reduced to 5% and 2.5% for the last four months for T_2 and T_3 respectively.
- A random sample of 30 fish per pond were sampled for body weight measurements fortnightly in order to adjust daily feed ration and monitor growth.
- Water quality parameters (pH, dissolved oxygen (DO), conductivity, total dissolved solids (TDS), salinity, alkalinity, total nitrogen, nitrate, ammonium, phosphorus (P) and temperature) were measured weekly.
- The experiment was conducted for 166 days.

Statistical Analysis

Data generated on growth parameters, yield, revenue, gross margin and water quality parameters (pH, Temperature, DO, TDS, Salinity, turbidity) were analysed using R Studio software version 3.4.4.
One way analysis of variance was done and the effect of treatment on the above parameters was tested using the F-test. Tukey's test was used to determine the significance of the differences between a pair of treatment means.

Results

- Ponds under fertilization alone (T_1) and fertilization plus feeding (T_3) had higher ($p \leq 0.001$) water pH and DO than those under the treatment of feeding alone (T_2) (Table 1).
- Concentrations of nitrate, ammonium and phosphorus did not differ ($p > 0.5$) among the three treatments.
- Fish cultured in ponds under T_1 had significantly lower weight gain, growth rate and specific growth rate than those cultured under T_2 and T_3 (Fig. 1 and Table 2).
- The weight gain, growth rate and specific growth rate of fish reared in ponds under T_3 were significantly higher than of those on T_2 (Table 2).
- Treatment influenced significantly labour and feed costs, fish yield, revenue and gross margin. Fish reared in ponds under T_3 resulted into higher yield and gross margin (Table 2).

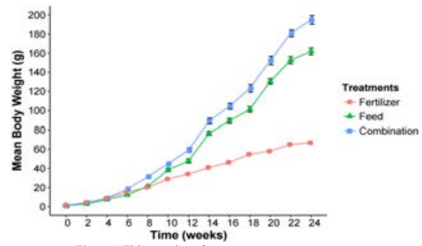


Figure 1. Fish growth performance

Table 1: Comparison of water quality parameters in pond under three different treatments

Water variable	Treatment			p-Value
	Fertilization alone	Feeding alone	Fertilization and Feeding	
pH	8.23±0.02^{a}	8.08±0.02^{b}	8.20±0.02^{a}	0.0001
DO (mg/L)	4.43±0.11^{a}	3.88±0.09^{b}	4.03±0.11^{b}	0.0007
Conductivity (µS/cm)	1324±9^{b}	1363±8^{a}	1343±9^{ab}	0.0051
TDS	662±4^{b}	681±4^{a}	672±4^{ab}	0.0052
Salinity (PSU)	0.66±0.0^{c}	0.68±0.0^{a}	0.67±0.0^{b}	0.0072
Temp (^{O}C)	25.20±0.09^{a}	25.24±0.09^{a}	25.30±0.08^{a}	0.6918
Water depth (cm)	31.5±0.2^{c}	34.8±0.3^{a}	33.5±0.2^{b}	0.000
Secchi disk (cm)	25.7±0.7^{a}	25.7±0.7^{a}	24.3±0.7^{a}	0.2848
Alkalinity (mg/L)	191.83±13.4a	194.46±13.4	187.60±14.5	0.8256
Total nitrogen (mg/L)	20.82±1.3	20.28±2.40	18.67±1.5	0.4828
Nitrate (mg/L)	11.85±0.7	11.19±0.5	11.44±0.5	0.8209
Ammonium (mg/L)	8.46±0.9	9.87±1.01	8.34±0.8	0.3553
Phosphorus (mg/L)	0.33±0.08a	0.15±0.03b	0.23±0.04ab	0.0369

Note: Means with the same superscript letter in the same row do not differ while those with different superscript differ significantly at $P \leq 0.001$.

Table 2: Comparison of growth performance of Nile tilapia (*O. niloticus*) cultured in ponds under three different treatments

Growth variable	Treatment			
	Fertilization (T_1)	Feeding (T_2)	Combination (T_3)	p- Value
Initial body weight (g)	1.3 ± 0.1^{a}	1.0 ± 0.1^{b}	0.9 ± 0.0^{b}	0.003
Final body weight (g)	66.7 ± 1.1^{c}	161.8 ± 3.6^{b}	194.8 ± 4.5^{a}	0.000
Weight gain (g)	65.4 ± 1.1^{e}	160.8 ± 3.6^{b}	193.8 ± 4.5^{a}	0.000
Growth rate (g/day)	0.4 ± 0.0^{e}	1.0 ± 0.0^{b}	1.2 ± 0.0^{a}	0.000
Specific growth rate (%)	2.5 ± 0.0^{c}	3.1 ± 0.0^{b}	3.3 ± 0.0^{a}	0.000
Survival (%)	90.0 ± 0.0^{a}	89.6 ± 0.2^{a}	89.7 ± 0.4^{a}	0.4672
FCR	-	4.1 ± 0.3^{a}	2.0±0.1^{b}	0.0085
Yield (kg/ha/year)	4,602±376^{b}	10,720±962^{a}	13,065±458^{a}	0.001
Total revenue (TZS/ha/year)*1000	36,820±3,008^{b}	85,763±7,696^{a}	104,514±3,659^{a}	0.001
Total var. cost *1000	24,821±560^{b}	91,275±12,580^{a}	78,913±652^{b}	0.0046
Gross margin *1000	11,999±2,588^{ab}	5,511±8,013^{b}	25,600±3,007^{a}	0.0373

Note: Means with the same superscript letter in the same row do not differ while those with different superscript differ significantly at $P \leq 0.001$.

Conclusions

- Combination of weekly fertilization of ponds and feeding at 2.5% of fish body weight promotes higher growth rate and results into higher profit than either weekly fertilization alone or feeding alone at 5% of fish biomass.
- Combination of weekly fertilization of ponds and feeding at 2.5% of fish body weight does not affect water quality parameters beyond the range recommend for tilapia growth.

Acknowledgements

This research was funded by AquaFish Innovation Lab program. The program is supported in part by United States Agency for International Development (USAID) and by contributions from participating institutions.

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Successful Propagation of Sahar *Tor putitora* Using Synthetic Hormone in Nepal

Jay D. Bista*, Narayan P. Pandit, Rahul Ranjan, Madhav K. Shrestha, James S. Diana. and Hillary Egna

Department of Aquaculture
Agriculture and Forestry University, Rampur, Chitwan, Nepal

Sahar (*Tor putitora)* is a high value indigenous fish species of Nepal which is declining in its natural habitat and has been declared an endangered species. Limited seed production of this species in the temperate region has restricted its expansion in culture and rehabilitation in natural waters. Experiments were conducted at the Center for Aquaculture Research and Production (CARP) and Agriculture and Forestry University (AFU), Chitwan, Nepal during 2017 to explore and assess spawning performance of sahar in a subtropical climate. Sixty males (0.5-1.5 kg) and 50 females (0.9-1.8 kg) broods at CARP and 25 females (0.35-2.2 kg) and 40 males (0.3-1.0 kg) at AFU were reared in ponds at the rate of 1000 kg/ha and provided 32% protein feed at the rate of 3% body weight per day. Maturity was observed by sampling fish and testing softness of abdomen by weekly during off season; this frequency was increased to every third day as breeding season approached. During maturity testing, 6 females were found ready to spawn and were directly stripped without injecting synthetic hormone. Females with a soft and extended abdomen but not ready to spawn were injected with synthetic hormone (Ovulin) at 0.5 mL/kg body weight. Males did not receive any hormone injection. After 24-26 hours of injection, ova from injected females were obtained by simple hand stripping and fertilized with milt collected from males. The fertilized eggs were incubated in Atkin hatching trays. Out of 22 females injected, 16 females released eggs and 6 females did not responded. Egg per kg body weight from spawned females was 2030.8±184.3. Mean hatching and larval survival rates were 78.4±1.9 and 74.7±1.1%, respectively. This study demonstrated that mass seed production of sahar is possible in the subtropical region of Nepal using inducing hormone. Induced spawning reduces the number of over-matured females within short maturation period by synchronizing the stripping time of injected broods.

Increasing Farmers' Access to aquaculture Extension Services: Lessons from Central and Northern Regions of Uganda

Gertrude Atukunda*, Peter Atekyereza, Hillary Egna, John Walakira and Andrew State

National Agricultural Research Organisation
Aquaculture Research and Development Centre
P.O Box 530, Kampala

In Uganda, aquaculture largely involves freshwater fish farming, and is increasingly viewed as a reliable alternative source of fish to dwindling wild stocks. Provision of aquaculture extension services is a fundamental intervention for increasing fish production, income generation and improving food security. While literature exists on agricultural extension in Uganda, few studies have focused on the relevance and effectiveness of services provided to local fish farmers.

A study on the effectiveness of aquaculture extension services was carried out in central and northern Uganda in 2016. A survey of 246 households undertaking fish farming was used to collect quantitative data. Qualitative data were collected during in-depth structured interviews with extension workers as Key Informants and Focus Group Discussions with selected fish farmers.

The predominant method of providing extension services was visits to individual farms by government fisheries staff based in the respective districts. The main inefficiency in service provision was low farmer coverage (27%) due to staff shortfalls, limited transport and low budgets. The various services provided were in line with farmers' needs though not to the satisfaction of fish farmers. The respondents perceived service provision ineffective due to poorly planned and erratic farm visits. Size of land owned, income earned from fish, and membership to fish farmer groups significantly influenced frequency of visits to fish farmers. Usage of ICTs was limited despite farmers' ownership of devices such as radio and mobile phones.

Recommendations are: 1) Fish farmers and extension staff need a socially negotiated approach and a reliable schedule of extension activities; and 2) Government fisheries extension staff need to access novel aquaculture information through refresher training courses.

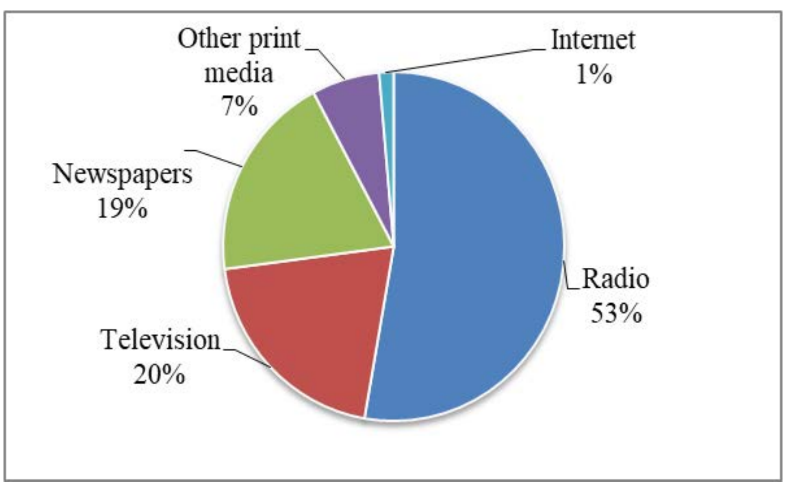

FIGURE 1. Percentage of respondents obtaining information from ICT sources

TABLE 1. Ranking of sources of information used by extension staff

Information sources	Rank
Accumulated work experience	1st
Notes from higher institution	2nd
Documents from the Ministry	3rd
Workshops attended	4th
Print materials on research results	5th
Consultations with researchers	6th
Tours to successful farms	7th
Internet	8th

Increasing Farmers' Access to Aquaculture Extension Services: Lessons from Central and Northern Regions of Uganda

Gertrude Atukunda[1,2], Peter Atekyereza[2], Hillary Egna[3], John Walakira[1] and Andrew State[2]

[1] National Agricultural Research Organisation , National Fisheries Resources Research Institute.
[2]School of Sociology and Social Anthropology, Makerere University, Kampala Uganda.
[3]AquaFish Innovation Lab, Oregon State University USA.

1. Introduction

In Uganda, aquaculture largely involves fresh water fish farming, and is increasingly viewed as a reliable alternative source of fish to dwindling wild stocks. Provision of aquaculture extension services is a fundamental intervention for increasing fish production, income generation and improving food security. While literature exists on agricultural extension in Uganda, few studies have focussed on the relevance and effectiveness of services provided to local fish farmers.

2. Methodology

A study on the effectiveness of aquaculture extension services was carried out in central and northern Uganda in 2016. A survey of 246 households undertaking fish farming was used to collect quantitative data. Qualitative data were collected during in-depth structured interviews with extension workers as Key Informants, and Focus Group Discussions with selected fish farmers.

Figure 1: Map of Uganda showing study area

3. Results

The predominant method of providing extension services was visits to farms by the fisheries staff based in the respective districts. The main inefficiency in service provision was low farmer coverage (27%) due to staff shortfalls, limited transport and low budgets.

Various services provided were in line with farmers' needs though not to the satisfaction of fish farmers. The respondents perceived service provision ineffective due to poorly planned and erratic farm visits.

Extension staff frequently visited farmers that had big size of land, earned regular income from fish, and were members of farmer groups.

Usage of Information, Communication Technologies (ICTs) was limited despite farmers' ownership of devices such as radio and mobile phones.

Table 1. Ranking of sources of information for extension staff

Information sources	Rank
Work experience	1st
Notes from previous higher institution attended	2nd
Ministry documents	3rd
Workshops attended	4th

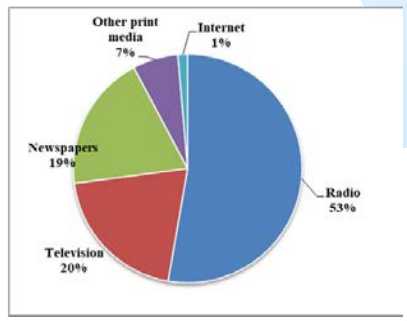

Figure 2: Percentage of respondents obtaining information from ICT sources

4. Recommendations

1. Fish farmers and extension staff need a socially negotiated approach and a reliable schedule of extension activities.
2. Government fisheries extension staff need to access novel aquaculture information through refresher training courses.

Acknowledgement of funding for the study

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Contact:
gertrude.atukunda@gmail.com

Assessing Women's Participation in Aquaculture Post Economic Stimulus Program in Kenya

Judith M. Amadiva*, Victoria Boit Tarus, Hillary Egna.

Ministry of Agriculture, Livestock, Fisheries & Irrigation
State Department for Fisheries, Aquaculture and the Blue Economy
P.O. Box 58187 - 00200 Nairobi, Kenya

Women are at the forefront of the rapid growth of the aquaculture sector, especially in activities such as farming, processing, and marketing. Women's participation along the aquaculture value chain is higher than in capture fisheries. From 2009 through 2014, the Kenyan government -- in seeking to alleviate poverty among the poor and ease fishing effort on wild fish stocks -- targeted Kenyan youth and women who constitute a large proportion of the rural poor in establishing aquaculture as an income generating activity through a national *Economic Stimulus Program (ESP)*. Of the 48,000 ponds constructed under the ESP, 22% were strictly owned by women. Visible outcomes of the ESP after it ended in 2014 have ranged from the development of new aquaculture businesses on one hand, to abandoned ponds on the other. The effect of ESP on women, however, has not been evaluated. This study therefore seeks to assess the current status of women's participation in aquaculture post ESP in Kenya. Study parameters included: a census of the number of women remaining in the aquaculture sector, including their position in the value chain (e.g., farming, marketing, processing, retail), and challenges faced by women in aquaculture. A cross sectional survey design was used for a target population of 25 women in 5 counties. Data were collected through unstructured interviews with women farmers and stakeholders in the aquaculture value chain, field visits, and desk reviews of relevant documents. Preliminary results show a positive correlation between ESP and women's participation in aquaculture. Major challenges identified are: water shortage, inadequate capital, unreliable sources of fingerlings, and lack of proper marketing systems.

AN ASSESSMENT OF WOMEN'S PARTICIPATION IN AQUACULTURE FOLLOWING KENYA'S ECONOMIC STIMULUS PROGRAM

Judith M. Amadiva[1], Victoria Tarus[2], Hillary Egna[3].

1 State Department for Fisheries, Aquaculture and the Blue Economy, Kenya
2 Chief Officer Livestock and Fisheries Uasin Gishu County, Kenya
3 AquaFish Innovation Lab Oregon State University Corvallis, Oregon, 97331 USA

OVERVIEW

Women are at the forefront of the rapid growth of the aquaculture sector, especially in activities such as farming, processing and marketing. The Role of Women along aquaculture Value chain is higher than in capture fisheries.

Between the year 2009 and 2014 the Kenyan government, in seeking to alleviate poverty and ease fishing effort on wild stocks targeted youth and women who constitute a large proportion of the rural poor in establishing aquaculture as an income generating activity through a national Economic Stimulus Program (ESP).

Through the program a total of 48,000 ponds were constructed and farm inputs i.e. fertilizer, fingerlings and feed were purchased for the farmers.


Mrs. Mary Oda Kibisu's Pond Constructed during the ESP Currently, she has 5 more Ponds in Vihiga County

Summary of findings from the 25 women interviewed in 5 counties

Indicator	Percent representation
Ownership of ponds (by women)	100
ESP funded	81.2
Improved livelihoods as a result of ESP	78.5
Tilapia farmers	81.8
Post ESP farmers	65.6
Farmers with more than one pond	63.6
Trained	85
Farmers with fish hatcheries	12
No. of ponds that collapsed after ESP	30
Self-employed farmers	90

METHODOLOGY

A pilot survey was used for a target population of 25 women farmers and stakeholders in aquaculture from 5 counties (Busia, Kakamega, Vihiga, Bungoma and Uasin Gishu.)

CASE STUDIES

1 ROBERTINA IN UASIN GISHU

Robertina co-owns two liner ponds with her mother in which they rear catfish. She has integrated her fish farming with strawberry in a recirculating system. Although she was not part of ESP beneficiaries she was motivated by the experience of farmers who were selected for the program. In order to reduce cost of production she formulates her own fish feeds. The biggest catfish from her farm weighed 1.8 kilograms. Fish farming has become their major source of income since they started in the year 2016.

2 THE MWANZO'S IN KAKAMEGA

Mwanzo's farm began in 2009 but was not part of ESP. The couple has a total of 28 ponds and they rear tilapia and catfish in different ponds. The farm has a hatchery which earns them more income (KES 300,000) than sale of table size fish (KES 80,000 annually). The farm is also a training centre for fish farmers, school children. College students get attached to the farm for internship.

3 MRS. ZINATH DEEN IN VIHIGA

Tigoi Fish Farm is located in Tambua ward,Hamisi Sub-County and has a total of 10 fish ponds.This consists of 5 grow-out ponds,3 are brood-stock ponds, one catfish rearing pond, and one breeding pond. She also has an indoor hatchery and a training facility that can accommodate upto 40 participants.This farm was started during the ESP program. Tigoi Fish Farm offers a range of products and services including production of monosex Tilapia fingerlings, catfish fingerlings, fish feeds, and offering of aqua culture training and demonstration facilities. Other services include farmer - farmer extension advice to fish farmers, value addition on fish and fisheries products, and pond construction. She also hosts aquaculture students on attachment from Universities, including Maseno, Egerton, and University of Eldoret.

4 MRS. AWUOR IN VIHIGA

Mrs. Awuor also operates a fish outlet shop ('Samaki Shop') at Esibuye Market (Emuhaya Sub-County), which specializes in buying farmed fish from farmers within the locality. Fish harvested from her ponds are marketed through this outlet. Her products include fresh fish and various value added fish products.
The Samaki shop was renovated by Vihiga County Government and equipped with one freezer. The State Department of Fisheries provided her with a freezer, display unit and sausage making machine. Mrs Awuor, therefore, acts as an important link between the fish farmer and the customers.

CONCLUSION

There is a positive correlation between ESP and women's participation in aquaculture. However, women in aquaculture still face a number of gender related challenges including access to friendly technologies, land, credit and insurance services that affect their quest towards commercial aquaculture. These challenges call for interventions in the form of capacity building and effective implementation of gender responsive policies to support women participation in aquaculture.

RECOMMENDATIONS

1. Women farmers should register their aquaculture ventures through membership in fish farming clusters so as to benefit from the economics of scale in their production.
2. The government (National and County Levels) should facilitate access to financial services(credit and insurance) for women by formulating and implementing appropriate policies.
3. Targeted capacity building (training and resources allocation) through extension service support should be enhanced.The effort of the County Government of Vihiga in supporting Mrs. Awuor with a freezer, a display unit and a sausage making machine should be up-scaled through- out the country.
4. More sensitization / awareness creation amongst women on how to access and benefit from government and other stakeholder initiatives including; Women Enterprise Fund (WEF) and the Kenya Women Finance Trust (KWFT)

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Effects of Dietary Protein Levels on Growth, Feed Utilization and Body Composition of Juvenile African Bonytongue, *Heterotis niloticus*

Nelson Agbo*, Steve Amisah, Peter Akpaglo, Emmanuel Frimpong and Hillary Egna

*Department of Fisheries and Watershed Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; nelagbo@gmail.com

The African Bony-tongue, *Heterotis niloticus* (Cuvier, 1829) is exploited by fisheries in Ghana and even cultured by some fish farmers. In captivity, remarkable growth have been reported with mean body weights up to 3 to 4 kg in 12 months. However, due to lack of knowledge on the ecological, behavioural and nutritional factors its contribution to African aquaculture has not been realised. Considering the Bony tongue's great economic importance in Ghana, more information is needed on its culture conditions particularly its nutritional requirements, in order to development it as an aquaculture candidate. This study, therefore evaluated the effect of varying dietary protein levels on growth, feed utilization and whole body composition of *H. niloticus* juveniles.

African Bony-tongue juveniles (initial weight 32.65±0.03g) were stocked in 12 hapas (2x1m^2) mounted in a concrete tank (5x20 m^2) at 5 fish per hapa. Four isoenergetic diets were formulated to contain varying crude protein levels ranging from 25%, 30%, 35%, and 40% using fish meal and soybean meal as protein sources in a ratio of 2:1 (TABLE 1). Each diet was assigned to triplicate groups of fish in a completely randomized design and hand-fed to satiation twice daily at 0700h and 1600h.

Parameter	**Crude protein levels in the diet (%)**			
	25	**30**	**35**	**40**
Initial body weight, g	32.30±0.40	32.73±0.03	32.80±0.06	32.77±0.03
Final body weight, g	65.56±4.57[a]	76.12±9.07[ab]	90.40±7.19[ab]	99.07±6.50[b]
Weight gain, %	102.80±12.42[a]	132.60±27.77[ab]	175.6±21.85[ab]	202.30±19.56[b]
Feed conversion ratio	1.85±0.17[a]	1.77±0.13[ab]	1.69±0.07[ab]	1.20±0.15[b]
Specific growth rate, (%day^{-1}	0.90±0.08[a]	1.06±0.15[ab]	1.29±0.11[ab]	1.41±0.08[b]
Survival, %	93.33±6.67	91.67±8.33	73.33±13.33	71.67±17.40
Protein efficiency ratio	1.27±0.16	1.44±0.30	1.65±0.21	1.66±0.16
Feed intake, g	60.49±3.45	74.33±10.14	76.53±8.69	77.45±3.0630
Condition factor	2.46±0.16	2.48±0.29	2.19±0.14	2.06±0.24

TABLE 1. Composition of diets fed to *Heterotis niloticus* with varying protein levels used in this study

An increasing growth trend and better feed utilization was observed as dietary protein levels increased from 25% to 40% dietary protein. Fish fed 40% protein diet had the best growth performance and nutrient utilization, with a mean weight gain of 202.30±19.6%, feed conversion ratio of 1.20±0.15 and protein efficiency ratio of 1.66±0.2, however this was not significantly different from values of fish fed 30% and 35% dietary protein. Significant lower values were recorded for fish fed 25% dietary protein. Whole body nutrient composition was not affected by the diets. The result of this study suggest that *H. niloticus* juveniles would grow best when fed diets containing at least 30% protein (TABLE 2).

Ingredients	Protein levels (g/100g)			
	25	30	35	40
Fish meal	18.0	23.7	29.8	35.0
Soy bean Meal	13.9	18.8	22.2	27.5
Rice Bran	38.0	30.5	23.0	15.0
Wheat Bran	18.6	15.5	13.5	11.0
Salt	1.0	1.0	1.0	1.0
Palm oil	2.0	2.0	2.0	2.0
Di Calcium Phosphate	2.0	2.0	2.0	2.0
Cassava Flour	2.5	2.5	2.5	2.5
Vit. & min. premix	4.0	4.0	4.0	4.0
Proximate composition				
Crude protein	26.2	32.1	34.6	42.8
Crude lipid	9.8	9.1	8.8	10.7
Crude fibre	8.56	7.3	4.9	4.3
Ash	13.6	15.9	15.9	15.9
Gross energy, (kJg^{-1})	16.9	17.4	17.9	18.4

TABLE 2. Growth and feed utilization of *Heterotis niloticus* fed at varying inclusion levels of dietary protein for 70 days. Values are presented as means ± SE (n=3) and values within the same row with different letters are significantly different (P< 0.05)

Effects of dietary protein levels on growth, feed utilization and body composition of juvenile African Bony-tongue, *Heterotis niloticus*

Nelson W. Agbo[a], Steve Amisah[a], Peter K. Akpaglo[a], Emmanuel A. Frimpong[b], Hillary Egna[c]

[a]Kwame Nkrumah University of Science and Technology, Kumasi; Ghana; [b]Virginia Polytechnic Institute and State University, Blacksburg, USA; [c]AquaFish Innovation Lab, Oregon State University, USA .

Introduction

Among the most highly valued species in West African inland fisheries is the African bony-tongue, *Heterotis niloticus* (Cuvier, 1829), a species widely distributed in tropical rivers, freshwater lakes of Western and Central Africa (Moreau 1982). The African bony tongue is exploited by fisheries in Ghana and even cultured by some fish farmers (Agbo *et al.*, 2014). The species is classified within the opportunistic omnivorous fish category and consume a variety of food resources, ranging from aquatic invertebrates to small seeds, including small benthic organisms, shrimps, plant remains and terrestrial insects. In captivity, remarkable growth have been reported with mean body weights up to 3 to 4 kg in 12 months. However, due to lack of knowledge on the ecological, behavioural and nutritional factors its contribution to African aquaculture has not been realised (Monentcham, 2009). Considering the Bony tongue's great economic importance in Ghana, more information is needed on its culture conditions particularly its nutritional requirements, in order to develop it as an aquaculture candidate.

Objectives

- Evaluate the effects of varying dietary protein levels on growth performance and feed utilization of *H. niloticus.*
- Determine the whole body composition of *H. niloticus* fed diets of varying dietary protein.

Methodology

In this study a total of 60 fingerlings of *H. niloticus* (initial weight of 32.7g were used. The fish were randomly stocked 5 fish per hapa in triplicates per treatment. Twelve hapas (2x1m^2) mounted in a concrete tank (5x20 m^2) were used for the feed trial. The concrete tank was fitted with an air blower for water aeration and ultra violet clarifier for water disinfection. Four isoenergetic diets were formulated to contain varying crude protein levels ranging from 25%, 30%, 35%, and 40% using fish meal and soybean meal as protein sources in a ratio of 2:1 (Table 1). The fish were hand-fed to satiation twice daily at 0700h and 1600h. Feeding rates were adjusted every week and the growth experiment lasted ten weeks.

Ingredients, diets and carcass were analyzed for proximate composition (AOAC, 1990). Gross energy was calculated as 23.6, 39.5 and 17.2 Kj.g^{-1} for protein, lipid and carbohydrate respectively (Table 2). Growth and feed utilization parameters determined were; weight gain (WG), specific growth rate (SGR), feed intake (FI), food conversion ratio (FCR). condition factor (K) and protein efficiency ratio (PER).

Plate 1. The cultured fish *H. niloticus,* feed preparation and culture facility

Table 1 Composition of diets (g/100 g as-fed) fed to *H. niloticus* with varying protein levels

Ingredients	25	30	35	40
Fish meal	18.0	23.7	29.8	35.0
Soybean meal	13.9	18.8	22.2	27.5
Rice bran	38.0	30.5	23.0	15.0
Wheat bran	18.6	15.5	13.5	11.0
Palm oil	2.0	2.0	2.0	2.0
Cassava flour (binder)	2.5	2.5	2.5	2.5
Vitamin & mineral premix	4.0	4.0	4.0	4.0
Common salt	1.0	1.0	1.0	1.0
Di-calcium Phosphate	2.0	2.0	2.0	2.0

Table 2 Proximate composition (g/100 g as-fed) and gross energy (kJ.g^{-1}) of diets fed to *H. niloticus* with varying protein levels

Components	25	30	35	40
Dry matter	97.0	95.2	95.5	96.7
Crude protein	26.2	32.1	34.6	42.8
Crude lipid	9.8	9.1	8.8	10.7
Crude fibre	8.6	7.3	4.9	4.3
Ash	7.9	8.5	8.6	8.6
NFE	38.8	30.4	30.1	25.7
Gross energy (kJ g^{-1})	16.9	17.4	17.9	18.4

Results

Growth and feed utilization of *H. niloticus*

In this study, varying inclusion levels of dietary protein had effect on the growth performance and feed utilisation of *H. niloticus* (Table 2). Results indicated that WG and SGR increased with increasing dietary protein levels with 42.8% protein diet obtaining the maximum values, although these were not significantly different from the 32.1% and 34.6% protein diets. Values for 26.2% protein diet were significantly lower than the other diets. The condition factor (K) was not affected by the varying levels of protein inclusion in the diets. The K values range from 2.06 to 2.46 (Table 2).

Table 3 Growth responses and feed utilization of juvenile *Heterotis niloticus* fed *diets* with varying protein levels for 70 days

Parameter	Crude protein levels in the diets (%)			
	25	30	35	40
Initial weight, g	32.30±0.40	32.73±0.03	32.80±0.06	32.77±0.03
Final weight, g	65.56±4.57$_a$	6.12±9.07$_{ab}$	90.40±7.19$_{ab}$	99.07±6.50$_b$
Weight gain, %	102.80±12.42$_a$	132.60±27.77$_{ab}$	175.60±21.85$_{ab}$	202.30±19.56$_b$
Specific growth rate, %.day^{-1}	0.90±0.08$_a$	1.06±0.15$_{ab}$	1.30±0.11$_{ab}$	1.41±0.08$_b$
Feed intake, g	60.49±3.45	74.33±10.14	76.53±8.69	77.45±3.06
Feed conversion ratio	1.85±0.17$_a$	1.77±0.13$_{ab}$	1.69±0.07$_{ab}$	1.20±0.15$_b$
Protein efficiency ratio	2.10±0.16	1.82±0.30	2.18±0.21	2.00±0.16
Condition factor	2.46±0.16	2.48±0.29	2.19±0.14	2.06±0.24
Survival, %	93.33±6.67	91.67±8.33	73.33±13.33	71.67±17.40

Values are means ± SE (n=3) and values within the same row with different letters are significantly different P< 0.05 (SPSS version 16).

Optimum dietary protein level

Although 42.8% dietary protein gave the best growth, the optimum protein requirement for *H. niloticus* was not established because no growth plateau was reached (Fig 1 and 2). Generally, fish reach a plateau and subsequently show decreased FCR or SGR when dietary protein levels reach and exceed their requirements.

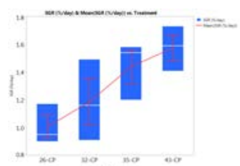

Fig.1 The relationship between Specific growth rate (%/day) and dietary protein levels (%) in juvenile *Heterotis niloticus*

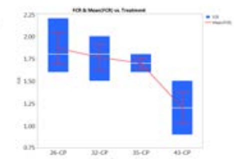

Fig 2 The relationship between FCR and dietary protein levels (%) in juvenile *Heterotis niloticus*

Whole body composition

The whole body protein, lipid, moisture and ash contents were not significantly affected by dietary protein levels (Table 4).

Table 4 Whole body composition (% wet weight) and energy of juvenile *Heterotis niloticus* fed varying levels of protein for 70 days

Components	Crude protein levels in the diets (%)			
	25	30	35	40
Moisture content	74.25 ± 0.26	76.02 ±0.71	75.22 ±0.72	76.35 ±0.50
Crude protein	18.66 ± 0.21	17.77 ±0.42	18.40 ±0.56	18.43 ±0.38
Crude lipid	1.66 ± 0.03	1.65 ±0.12	1.57 ±0.05	1.69 ±0.03
Crude fibre	0.13 ±0.01	0.14 ±0.01	0.15 ±0.11	0.15 ±0.01
Ash	1.59 ±0.04	1.51 ±0.14	1.51 ±0.04	1.44 ±0.04

Values are means ± SE (n=3) and values within the same row with different letters are significantly different P< 0.05 (SPSS version 16).

Conclusion

- Results from this study indicated that the maximum growth and feed utilization of *H. niloticus* were achieved when dietary protein was about 42.8% using practical diets with fish and soybean meals as the major sources of protein, however no definite optimum protein requirement was established.
- The results also showed that a practical diet containing at least 32.1% protein would be appropriate for growth and nutrient utilization of *H. niloticus* fingerlings under the conditions of this study

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Economic Optimization and Technical Performance for Estimating catfish (*Clarias gariepinus*) production function in Nigeria

Adeogun, O. A., A. Oresegun, B. Edah, O.T. Olajide, F.A. Bakare

Nigerian Institute for Oceanography and Marine Research
3 Wilmot Point Road, Victoria Island, Lagos Nigeria

The Nigeria aquaculture sector is presently confronting near-record high feed costs driven by the convergence of both current tight supply prospects and long-run market forces. The aquaculture sector, where feed costs account for 60% to 80% of cash operating expenses, has seen its profit margins steadily squeezed and its share of cash receipts decline. Since 2000 feed cost increases, squeezing the profitability of fish producers. When profit margins turn unfavourable, producers are more likely to retain fewer stock or to liquidate stock. Persistent upward feed price movements could result in substantial and long-lasting consequences for fish product prices throughout the marketing chain. The primary objectives of the study are to demonstrate the following: how to generate aquaculture input-output data from feeding experimentations; how to derive production functions from the data; and how to apply economic principles to the derived functional relationship. This study is largely more integrative than innovative. It is an attempt to fit the economic problem of feeding and growing commercial aquaculture into a consistent picture via integrating the production function concept with some methodological estimation problems and then by integrating the estimated production function with different price situations in order to specify optimal fish rations.