AquaFish Innovation Lab Technical Session at
Aquaculture America 2018
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19-22 February 2018

Proceedings
Sessions organized by Dr. Hillary Egna
Assembled by Briana Goodwin
Edited by Stephanie Ichien

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AquaFish Innovation Lab Management Office
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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.

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PREAMBLE

Aquaculture America 2018
Las Vegas, Nevada, USA
19 – 22 February 2018
Sessions organized by Dr. Hillary Egna

From 19-22 February 2018 AquaFish Innovation Lab partners gathered at Aquaculture America in Las Vegas, Nevada, USA. On 22 February, AquaFish held a technical session called "AquaFish Innovations for International Aquaculture" which featured 20 presentations about AquaFish-supported work. The session was organized and chaired by AquaFish Innovation Lab Director, Hillary Egna. Sunila Rai and Theodora Hyuha jointly co-chaired the session. Throughout the conference, AquaFish partners and Management Team staff gave an additional 14 presentations and presented several posters.

AQUAFISH TECHNICAL SESSION AGENDA

AQUAFISH INNOVATIONS FOR INTERNATIONAL AQUACULTURE

Thursday, February 22, 2018, 08:30 - 17:00

08:30 **Effect of different feeding strategies on growth performance and economic returns of Nile tilapia (*O. niloticus*) production in semi-intensive system**
Daniel Adjei-Boateng

08:45 **Effect on iron-amino acid chelate supplemented fish feeds on growth performance of Nile Tilapia *Oreochromis niloticus* in an aquaponic system in Kenya**
Kenneth Rono

09:00 **Effects on nutritional conditioning on growth of Nile tilapia fry**
Courtney A. Deck

09:15 **Digestibility and ammonia excretion rates of low-cost nursery diets for Nile tilapia *Oreochromis niloticus* fry**
Kwasi Obirikorang

09:30 **Pellet feed improvements through vitamin C supplementation for snakehead fish *Channa striata* culture in Vietnam**
Minh Duc Pham

09:45 **Development of technique for mass production of housefly *Musca domestica* maggots**
Nazael Madalla

10:00 Break

11:00 **Effects of stocking density on fry survival and growth of sahar *Tor putitora***
Narayan P. Pandit

11:15 **Performance of domesticated (Vietnamese) vs. non-domesticated (Cambodian) snakehead *Channa striata* during weaning and growout**
Panna Nen

11:30 **Aquaculture of African lungfish *Protopterus aethiopicus* in Uganda: Captive breeding and larval rearing**
John Walakira

11:45 **Potential for polyculture of tilapia *Oreochromis niloticus* and freshwater perch *Anabas testudineus* with pangasius catfish *Pangasius hypopthalamus* in the hyposaline waters of southern Bangladesh**
Zahid Parvez Sukhan

12:00 **Induced spawning of sahar *Tor putitora* in Terai region of Nepal**
Jay D. Bista

12:15 **Consumer preferences and consumption patterns for fish in Uganda**
Zech Halasi

12:30 Lunch

14:00 **Do household fish ponds improve family nutrition? A study in Nepal**
James Diana

14:15 **Involving women in field-testing of a periphyton enhanced aquaculture system for nutrition security**
Sunila Rai

14:30 **A school pond education program for creating awareness on aquaculture in Nepal**
Dilip Kumar Jha

14:45 **Economic benefits of reduced inputs and polyculture of tilapia with major Indian carps**
Mst. Kaniz Fatema

15:00 **Sustainable pearl farming using new techniques of spat collectors in Zanzibar**
Narriman Jiddawi

15:15 **Growth and production performance of air-breathing climbing perch *Anabas testudenius* and major carps in polyculture**
Shahroz Mahean Haque

15:30 **Integration of mola *Amblypharyngodon mola* in prawn-carp gher farming systems to increase household nutrition and earnings for rural farmers in southwest Bangladesh**
Khandaker Anisul Huq

AquaFish Innovation Lab Technical Session
Abstracts and Presentations

Effect of different feeding strategies on growth performance and economic returns of Nile tilapia (*O. niloticus*) production in semi-intensive system

Daniel Adjei-Boateng*, Anthony Aliebe, Nelson W. Agbo, Emmanuel A. Frimpong

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The production of Nile tilapia in semi-intensive system has been practiced for many years especially in Africa due to Nile Tilapia's ability to utilize natural food produced through pond fertilization. The objective was to find out if tilapia fed at half ration and on alternate days had comparable performance, feed utilization and economic returns to those fed at full ration over 15-week period in fertilized ponds. . Sex-reversed all-male O. niloticus (~35g) were cultured in fertilized ponds at Tano-Odumasi of the Ashanti Region, Ghana. Seven hundred fish were stocked into each pond (350 m2) with each treatment replicated three times. The fish were fed with commercial feed (30% crude protein) at 5% body weight initially and 2% towards the end of the experiment. Fish growth, feed conversion efficiency and economic returns were considered under the three strategies. Pond water quality variables measured were found to be within suitable range for optimum growth of Nile tilapia.

Results of the study showed no significant differences ($P<0.05$) in growth performance variables in terms of weight gain (WG), specific growth rate (SGR), daily growth rate (DGR) among the treatments. Higher growth of fish observed in the control group were not significantly different ($P<0.05$) compared to the other treatments. Feed given varied significantly among the feeding strategy and feed conversion ratio was significantly better ($P<0.05$) in fish group fed on alternate day (0.86) and half ration (0.94) compared to the control group (1.25). Economic analysis showed that profit returns were highest for the alternate day feeding strategy (GH₵ 2,269.41) and least for the full ration feeding strategy (GH₵ 995.88). It is possible to achieve similar fish yield in Nile tilapia semi-intensive production with the reduced feeding strategies and full ration feeding. Alternate day full ration feeding strategy is recommended to tilapia farmers since it proved to be the most profitable strategy.

Effect of Different Feeding Strategies on Growth Performance and Economic Returns of Nile Tilapia Production in Semi-intensive System.

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AQUAFISH INNOVATION LAB

INTRODUCTION

- Nile tilapia:
  - ➢ second most cultured fish with global production of 5.6 MMT in 2015 (Fitzsimmons *et al.,* 2013; FAO, 2017).
  - ➢ major protein source in developing countries (Jegede, 2013).
- Feed (40-70%) production cost in intensive tilapia farming (Tacon and De Silva, 1997; Agbo, 2008).
- Semi-intensive system
  - ➢ natural food produced through fertilization to reduce feed input thus increasing yield and profit.

INTRODUCTION

Feeding strategies in fertilized ponds:

- **Delayed supplemental feeding:** 42, 75, 80 and 91 days after stocking (Lin *et al.,* 1997; Brown *et al.,* 2000; Abdelghany *et al.,* 2002).
- **Reduced Feeding:** 50%, 67% and 75% (Brown *et al.,* 2000; Lin and Yi, 2003; Duodo-Prah, 2014).
- **Mixed-Feeding Schedules:** 33% CP alternated with 22% CP (Patel and Yakupitiyage, 2003).
- **Alternated Feeding:** Daily alternation of commercial feed (~33% CP) (Bolivar *et al.,* 2006).

SPECIFIC OBJECTIVES

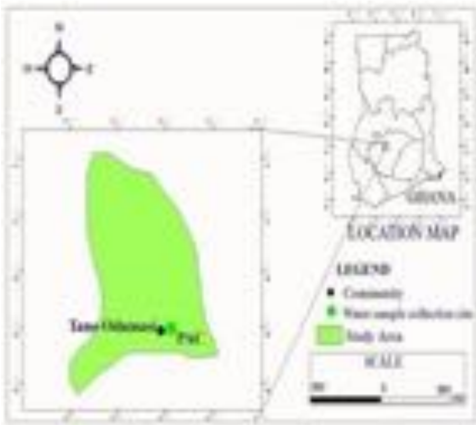
- To assess the effect of three feeding strategies on the performance and feed utilization of Nile tilapia production in fertilized ponds.

- H_0: There is no difference in growth performance among the three feeding strategies.

- To determine the economic returns of Nile tilapia (*O. niloticus*) grown under the three feeding strategies in fertilized earthen ponds

- H_0 : There is no difference in economic returns among the treatments.

MATERIALS AND METHODS



- Study Area: Pilot Aquaculture Centre (PAC), Fisheries Commission located at Tano - Odumasi.
- Experimental Design:
  - **Expt. units**: 9, 350m^2 ponds; depth,1.3 m
  - **Treatments**: 3 feeding strategies each triplicated
    - Full ration
    - Half Ration
    - Alternate Day Full Ration
  - **Treatment Assignment**: - Completely randomized design

MATERIALS AND METHODS

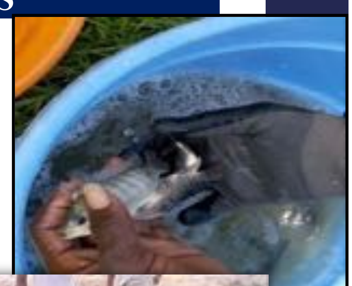
Fish: All male Nile tilapia mean weight 35.0 ± 14.8g.

Stocking Density: 2fish/m^2; 700 fish per pond
Commercial tilapia feed (Raanan) was used for the trial.

Fish fed at 5% bw followed by 2%.

Fish were fed twice daily at 10am and 4pm

Feeding was adjusted fortnightly after sampling.



Fish were hand-sexed before stocking

MATERIALS AND METHODS

Determination of Growth performance and feed utilization

- 30 fish randomly sampled fortnightly to determine growth.
- **Growth performance variables**: Final Weight (g), Weight Gain (%), Daily Growth Rate (DGR, g/day), Specific Growth Rate (SGR, %.day-1), Survival (%), Fish Yield (kg).
- **Feed utilization variables:** Feed conversion ratio (FCR) and feed intake (FI, g/fish).

MATERIALS AND METHODS

Water quality

- Temperature, dissolved oxygen and pH were collected weekly.
- Secchi depth was measured every two weeks
- Chlorophyll-a was used as a proxy for primary productivity following the standard procedure HMSO (1983).
- The Wagtech photometer used to determine ammonia, nitrite and total phosphate

MATERIALS AND METHODS

Economic Analysis

- A partial enterprise budget used to assess the economic performance of fish production under the 3 strategies.
- On-farm fixed and variable cost, and revenue from sales of fish at farm gate.
- Labour was GH₵10($2.3)/day and feed price GH₵ 3.25 ($0.74)

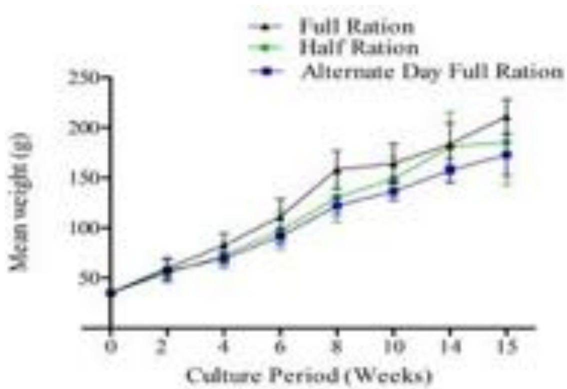
Statistical Analysis

- All data were subjected to one-way analysis of variance (ANOVA) and differences between the treatment means compared by the Tukey multiple comparison test.
- Significant differences were considered at alpha level of 0.05.

Effects of feeding strategies on Growth Performance and feed utilization of *O. niloticus*

RESULTS AND DISCUSSION

Effects varying feeding strategies on Growth Performance of *O. niloticus* in fertilized ponds



- Generally, reducing the ration did not have negative effect on fish growth.

RESULTS AND DISCUSSION

Growth performance and feed utilization of Oreochromis niloticus fed different feeding strategies culture period of 15 weeks.

Variable	Full Ration	Half Ration	Alternate Day Full Ration
Initial mean weight (g)	35.01 ± 14.81	35.01 ± 14.81	35.01 ± 14.81
Final mean weight (g)	211.29 ± 17.09	185.62 ± 42.53	173.31 ± 20.43
Weight Gain (%)	503.55 ± 48.83	416.37 ± 128.70	380.18 ± 68.12
DGR (g $fish^{-1}$ day^{-1})	2.05 ± 0.20	1.75 ± 0.49	1.61 ± 0.24
SGR (%.day^{-1})	2.09 ± 0.09	1.89 ± 0.27	1.85 ± 0.14
Survival (%)	91.48 ± 6.99	90.71 ± 5.02	91.62 ± 6.76
FCR	1.25 ± 0.23	0.94 ± 0.20	0.86 ± 0.21
FI (g/fish)	219.11 ± 28.98^a	134.32 ± 7.38^b	116.64 ± 20.69^b
Fish yield (kg)	406.43 ± 17.60	350.75 ± 20.55	334.35 ± 18.88

RESULTS AND DISCUSSION

- Feed reduction strategies (half ration or alternate day) resulted in minor changes in growth.
- No difference ($p > 0.05$) in growth indices (SGR, DGR, WG) among the treatments although the control group had slightly better growth response.
- Feed given was significantly higher ($p < 0.05$) in control group.
- Growth performance of Nile tilapia in semi-intensive systems increases with increasing supplemental feeding

(Diana *et al.,* 1994; Brown *et al.,* 2000; Bolivar *et al.,* 2006; Duodo-Prah, 2014).

RESULTS AND DISCUSSION

Mean values of water quality Variables in the different treatments over the culture period.

Variable	Full Ration	Half Ration	Alternate Day
Temperature (°C)	27.5 ± 1.03	27.71 ± 1.23	27.52 ± 0.96
DO (mg/L)	2.91 ± 2.04	2.45 ± 1.63	2.65 ± 1.73
pH (range)	6.8 ± 0.34	6.72 ± 0.34	6.77 ± 0.33
NH_3 (mg/L)	0 ± 0.00	0 ± 0.00	0 ± 0.00
Secchi Depth (cm)	15.5 ± 1.91	16.40 ± 2.22	16.61 ± 4.10
Chlorophyll-a (μg/L)	806.40 ± 489.50	817.32 ± 547.46	897.54 ± 604.17
Nitrite (mg/L)	0.03 ± 0.07	0.04 ± 0.07	0.02 ± 0.04
Phosphate (mg/L)	12.48 ± 16.69	13.19 ± 10.46	23.24 ± 22.04
Water depth (m)	0.97 ± 0.11	0.82 ± 0.08	1.01 ± 0.18

Each value is the mean ± SD of data from three replicates. Mean values with different superscripts in the same row are significantly different at $P < 0.05$. Absence of letters indicates no significant difference between all the treatments. DO – Dissolved Oxygen, N =7.

Effect of different feeding strategies on economic returns of Nile tilapia (*O. niloticus*) production in fertilized earthen ponds.

RESULTS AND DISCUSSION

Table 3: Economic analyses of *O. niloticus* fed at different feeding strategies.

Parameters	Unit	Full Ration	Half Ration	Alternate Day Full Ration
Yield	kg	548.63 ± 19.40	535.63 ± 25.62	529.89 ± 24.42
Gross revenue	GH₵	5,486 **(1,247)**	5,356 **(1,217**)	5,298 **(1204)**
Total costs (TC)	GH₵	4,490 **(1021)**	3,774 **(858)**	3,029 **(689)**
Breakeven				
Yield above TC	GH₵	449.04	377.42	302.95
price above TC	GH₵	8.18	7.05	5.72
Net return				
above TC	GH₵	995 **(226)**	1,582 **(360)**	2,269 **(516)**
Economic Efficiency	**%**	**22.18**	**41.92**	**74.91**

RESULTS AND DISCUSSION

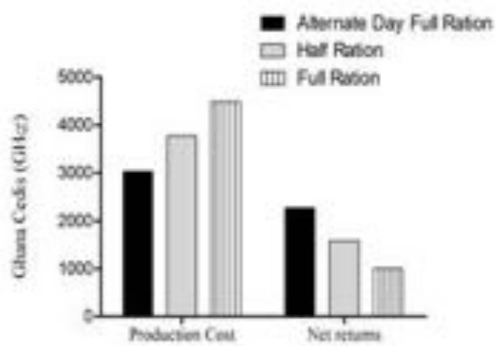


Figure 4: Comparative profit return in Nile tilapia culture under different feeding strategies

- All the feeding strategies were profitable (Figure 4).
- Half ration and alternate day were more profitable because production cost was lower 16% and 33% respectively.
- Diana *et al.,* (1996) and Brown *et al.,* (2000) similarly, reported higher profits for reduced feeding strategies.
- The alternate day recording the highest profit proving the most economic efficient (75%) feeding strategy; Bolivar *et al.,* (2006).

CONCLUSIONS

- No difference performance between tilapia fed at full ration and at the reduced rations.
- Half ration and alternate day feeding strategy reduced feed by 39 and 47%.
- Tilapia pond farmers encouraged to boost natural food production to reduce quantity of feed used and adopt the alternative day feeding approach to increase profitability.

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AQUAFISH INNOVATION LAB

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Effect on iron-amino acid chelate supplemented fish feeds on growth performance of Nile Tilapia *Oreochromis niloticus* in an aquaponic system in Kenya

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Aquaponics is an environmentally friendly production system involving reuse of waste and nutrients in production of fish and vegetables. This study investigated the effect of iron bis-glycine supplement in fish feeds on growth performance of mono-sex Nile tilapia (Oreochromis niloticus) and spinach (Spinacia oleracea) in a small aquaponic system. The study was conducted at the University of Eldoret for 119 days. Complete randomized design was used. Supplementation rates in fish diets constituted 30g Fe kg-1, 20g Fe kg-1, 10g Fe kg-1 and 0g Fe kg-1 respectively. Nile tilapia fry with a mean weight of 0.475 ± 0.025g 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, an SGR of 2.516 ± 0.01 and a good FCR of 1.10 ± 0.107 compared to the 0g Fe kg-1 treatment that exhibited the lowest mean weight of 4.354 ± 0.295g, an SGR of 1.744 ± 0.02 and a higher FCR of 2.081 ± 0.797. In the carcass composition analysis, 30g Fe kg-1 treatment exhibited a significant difference ($p < 0.05$) for higher ash content, crude protein and lower crude lipids (16.350 ± 0.03%, 65.607 ± 0.74% and 12.20 ± 0.256%, respectively) while treatment 0g Fe kg-1 showed lowest ash content, crude protein and crude lipids (10.59 ± 2.12%, 59.671 ± 0.676% and 18.20 ± 0.465% respectively). The hemoglobin and hematocrit levels were higher at 30g Fe kg-1 (45.090 ± 0.704 % and 15.630 ± 0.935g dL-1) and lower at 0g Fe kg-1 treatment (29.773 ± 0.213% and 9.9244 ± 0.071g dL-1). We recorded a decrease in glucose levels with increased supplementation of iron amino acids chelates. The 0g Fe kg-1 demonstrated higher glucose levels (26.8 ± 0.0289mg dL-l) and lower levels at 30g Fe kg-1 (13.433 ± 0.169 mg dL-1). 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. Iron amino acid chelate supplementation at appropriate levels of concentration may be desirable in complete diet formulations for enhancement of physiological efficiency and accumulation of body proteins for growth efficiency. 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.

EFFECT OF IRON AMINO ACID CHELATE SUPPLEMENT IN FISH FEEDS ON GROWTH PERFOMANCE OF NILE TILAPIA (*Oreochromis niloticus*) AND SPINACH (*Spinacia oleracea)* IN AN AQUAPONIC SYSTEM

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INTRODUCTION - 1

- Aquaponics is the combination of aquaculture and hydroponics (Connolly and Trebic, 2010).
- Chelated minerals are minerals that have been combined chemically with amino acids to form complexes.
- Minerals, like magnesium and iron, are metal ions which attach to other compounds
- Specific chelated amino acids:
  - Iron bis glycine,
  - Magnesium diglycinate,
  - Zinc bis-glycinate, and
  - Selenomethionine (Saurabh *et al.*, 2015)

INTRODUCTION - 2

- One unique challenge – is maintaining micronutrients specifically iron, magnesium and potassium that are suitable for the plant growth and also the pH balance for both plants and fish.
- Deficiency of some micronutrients in plants
- Application of micronutrient directly interferes with water quality.
- Direct application of iron affect fish growth performance and health

JUSTIFICATION OF THE STUDY

- Emerging use of iron bis-glycine is thought to be suitable to solve deficiency of micronutrients
- Its important for chlorophyl formation which is responsible for photosynthesis and gives plants their green color
- Improves the function of enzymes in protein metabolism and enhances the functions of calcium
- Plays an important role in the production of haemoglobin with protein and copper as well as oxygenation of red blood cells and lymphocytes in fish
- Improve growth and health of the fish

OBJECTIVES - 1

General objective:

Assess micro- nutrients supplementation in fish feeds on the growth of Nile tilapia (*Oreochromis niloticus*) and spinach (*Spinacia oleracea*) in small aquaponic system production using iron amino acid chelate.

Specific objectives:

1) **To determine growth rate of monosex male *O. niloticus* at different levels of iron amino acid chelate in aquaponic system.**
2) **To evaluate the growth of *Spinacia oleracea* at different levels iron amino acid chelate intake in an aquaponic system**

OBJECTIVES - 2

Specific objectives (Contd):

3) **To determine iron amino acid chelate composition in the carcass of monosex male *O. niloticus* at different levels of supplementation in an aquaponic system**
4) **To determine chlorophyll of *Spanacia oleracea* at different levels of iron amino acid chelate intake in an aquaponic system.**
5) **To determine different micro and macro- nutrient at different levels of iron amino acid chelate intake in an aquaponic system**
6) **To determine different water quality parameters at different levels of iron amino acid chelate intake in an aquaponic system.**

MATERIALS AND METHODS - 1

A	0fe/kg	10fe/kg	20fe/kg	30fe/kg	0fe/kg	10fe/kg
B	20fe/kg	30fe/kg	0fe/kg	10fe/kg	20fe/kg	30fe/kg

Was conducted at University of Eldoret (UoE) hatchery at the Department of Fisheries and Aquatic Sciences for a period of 180 days.

Plate 1: Experimental design and start of experiment

MATERIALS AND METHODS - 2

Experiment conducted at University of Eldoret (UoE) hatchery at the Department of Fisheries and Aquatic Sciences for a period of 180 days.

Plate 2: Successful plant growth in the aquaponic system

MATERIALS AND METHODS - 3

- **Fry with** 0.4753±0.0252**g wet weight were stocked with the same stocking densities (27) in each aquaponic system.**
- **9 pieces (**3±0.131cm**) were planted in each aquaponic system**
- **All the treatments were replicated three times in a completely randomized design layout.**
- **Each treatment diets with supplement 10fe/kg , 20fe/kg and 30fe/kg iron bis-glycine and control (0fe/kg) were administered respectively for the experiment.**

FISH FEED FORMULATION

- **Ingredients were locally purchased and formulated at the same crude protein (32% CP) supplemented with difference level of iron bis-glycine (10%, 20% and 30%) respectively.**
- **Experimental diets were formulated based on Winfeed (version 2.8) computer program.**

Determination of Proximate Composition:

- **Dried diets and carcass of the experimental fish on each diet were subjected to the analysis using the AOAC (2000) methods before and after experiment.**
- **For the composition analysis of mixture content, fat, crude protein and ash**

FISH & PLANT SAMPLING

Fish sampling:

- ❖ All the fish from each tank were individually weighed and their total length measured every two weeks.

Plants sampling:

- ❖ All the plants were individually measured for height, and leaves number counts every two weeks while wet and dry weights were only measured at initial stage and the final stage.
- ❖ Chlorophyll a and b were measured after every 3 weeks
- ❖ Elements K, Na were determined using flame photometer
- ❖ Fe, Mn and Zn were determined using an atomic absorption Perkin-Elmer 4000 spectrophotometer.
- ❖ P and N were measured by automated colorimetry after a Kjeldahl digestion.

WATER SAMPLING

- ❖ Dissolved oxygen, temperature, pH and conductivity were measured three times a week in fish and plants component while
- ❖ Ammonia, nitrate and iron were measured weekly using YSI photometer 9500

Data analysis:

- ❖ The statistical differences in water, fish and plants growth data were subjected to normality test.
- ❖ One way analysis of variance (ANOVA) were applied to determine differences on fish growth, spinach heights, minerals, chlorophyll levels, proximate composition and physiological response among all treatment.
- ❖ Kruskal Wallis was applied to determine differences on spinach leaves number.

Table 2: Fish data from an aquaponics experiment comparing the growth of (*O. niloticus*) at four difference iron amino acid chelate treatments

Parameters	Treatments			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Initial length	3.1267 ± 0.0626[a]	3.1267 ± 0.0627[a]	3.1267 ± 0.0628[a]	3.1267 ± 0.0626[a]
Final length	6.062 ± 0.143[a]	7.102 ± 0.128[b]	7.4578 ± 0.0966[c]	**8.949 ± 0.16[d]**
Initial weight	0.4753 ± 0.0252[a]	0.4753 ± 0.0252[a]	0.4753 ± 0.0252[a]	0.4753 ± 0.0252[a]
Final weight	4.354 ± 0.295[a]	6.207 ± 0.318[b]	7.406 ± 0.306[c]	**11.606 ± 0.55[d]**
Weight gain	3.8787 ± 0.2698[a]	5.7317 ± 0.2928[b]	6.9307 ± 0.2808[c]	**11.1307 ± 0.5248[d]**
Daily weight gain	0.0305 ± 0.0021[a]	0.045 ± 0.0023[b]	0.0546 ± 0.0022[c]	**0.0876 ± 0.0041[d]**
%Daily weight gain	3.054 ± 0.212[a]	4.513 ± 0.235[b]	5.457 ± 0.221[c]	**8.764 ± 0.413[d]**
SGR	1.744 ± 0.02[a]	2.023 ± 0.012[b]	2.162 ± 0.02[c]	**2.516 ± 0.01[d]**
% SGR	174.401[a]	202.322[b]	216.228[c]	**251.601[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 3: Plant growth data for Spinach (*Spinacia oleracea*) in an aquaponics system at four difference iron amino acid chelate treatments over the experimental period of 17 weeks

Parameters	Treatments			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Initial leaves no	2 ± 0.131[a]	2 ± 0.131[a]	2 ± 0.131[a]	2 ± 0.131[a]
Final leaves no	9.704 ± 0.225[a]	12.85 ± 0.16[b]	15.70 ± 0.509[c]	**19.33 ± 0.392[d]**
Initial heights	3 ± 0.131[a]	3 ± 0.131[a]	3 ± 0.131[a]	3 ± 0.131[a]
Final heights	25.36 ± 0.723[a]	33.33 ± 1.37[b]	41.52 ± 0.633[c]	**52.44 ± 0.798[d]**
Initial wet weights	0.592 ± 0.523[a]	0.592 ± 0.523[a]	0.592 ± 0.523[a]	0.592 ± 0.523[a]
Final wet weights	30.65 ± 2.15[a]	59.75 ± 2.8[b]	**107.39 ± 9.48[c]**	**113.6 ± 9.46[c]**
Initial dry weights	0.197 ± 0.0174[a]	0.197 ± 0.0174[a]	0.197 ± 0.0174[a]	0.197 ± 0.0174[a]
Final dry weights	4.1704 ± 0.0816[a]	6.7422 ± 0.0445[b]	23.796 ± 0.215[c]	**32.973 ± 0.253[d]**
Weight gain	30.058 ± 1.627[a]	59.16 ± 2.277[b]	**106.80 ± 8.957[c]**	**113.01 ± 8.937[c]**

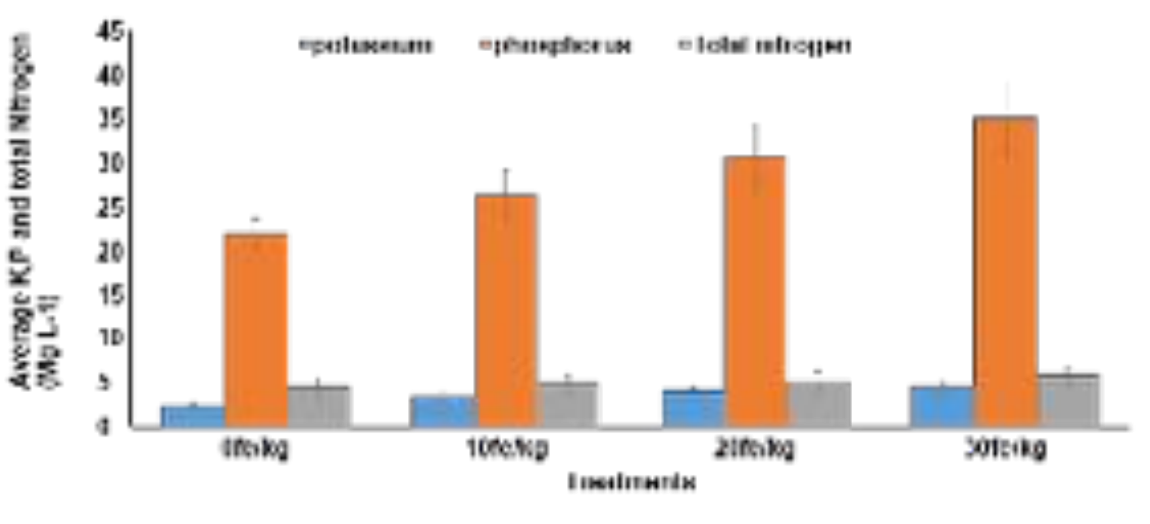

Figure 8: **Means P, K and N concentration (mg L^{-1} ± SE) of *Spinacia oleracea* performance in an aquaponic system fed from difference iron amino acid chelate supplementation over the experimental period of 17 weeks**

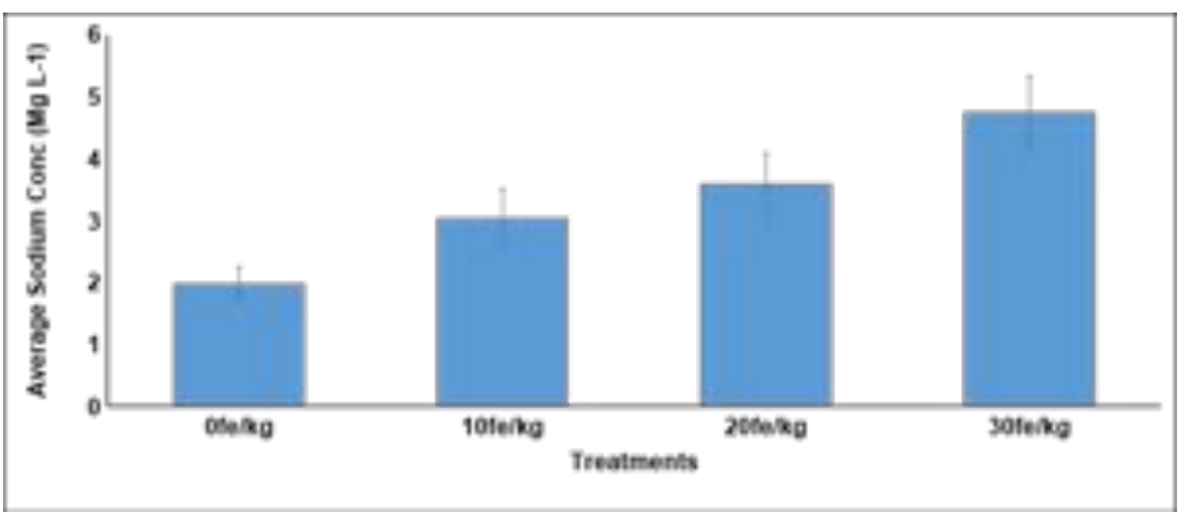

Figure 9: Means Na concentration (mg L^{-1} ± SE) of *Spinacia oleracea* performance in an aquaponic system fed with difference iron amino acid chelate supplementation

Table 6: Carcass composition of *O. niloticus* fed on different four treatments (0, 10, 20 and 30 fe/kg) (iron amino acid chelate) in aquaponic system.

Composition (%)	Treatments			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Ash content	10.590±2.12[a]	12.110±1.04[a]	**15.850±0.230[b]**	**16.350±0.03[b]**
Crude lipids	12.200±0.256[a]	14.492±0.114[b]	16.567±0.353[c]	**18.200±0.465[d]**
Crude protein	59.671±0.676[a]	63.794±0.211[b]	**64.89±0.08[c]**	**65.607±0.740[c]**
Moisture content	8.245±1.025[a]	7.681±0.541[a]	8.214±0.984[a]	7.874±0.241[a]

Table 7: Mean water chemistry parameters for the four treatments (0, 10, 20 and 30fe/kg) (iron amino acid chelate) in aquaponic system.

Parameter	Fish Component			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Ammonia	0.2248±0.0397[a]	0.2944±0.0477[b]	0.3952±0.0593[c]	**0.724±0.127[d]**
Nitrate	0.4085±0.0419[a]	0.6864±0.0937[b]	1.230±0.145[c]	**1.568±0.157[d]**
Iron	0.03907±0.00633[a]	0.5296±0.0454[c]	0.5763±0.0471[c]	**1.029±0.122[d]**
pH	7.8249±0.0434[a]	7.7549±0.0307[b]	7.2782±0.0384[b]	**7.1227±0.0478[d]**
DO	3.6820±0.0955[a]	3.5069±0.0884[a]	3.8576±0.0862[a]	3.7406±0.0925[a]
Temperature	22.949±0.217[a]	23.065±0.194[a]	23.057±0.201[a]	23.016±0.194[a]
Conductivity	421.7±26.1[a]	795.6±53.6[b]	1118.1±71.9[c]	976.1±53.9[c]
plants component				
Ammonia	0.2067±0.0361[a]	0.1889±0.0342[b]	0.2970±0.0512[c]	**0.5522±0.0889[d]**
Nitrate	1.397±0.154[a]	1.677±0.182[b]	2.373±0.220[c]	**2.949±0.259[d]**
Iron	0.03907±0.00633[a]	1.083±0.118[b]	2.237±0.206[c]	**2.890±0.153[d]**
pH	7.8618±0.0348a	7.7537±0.0287b	7.2924±0.0374c	**7.1363±0.0454[d]**
Conductivity	427.3±25.7[a]	794.6±53.5[b]	1108.0±70.4[c]	972.4±53.2[c]
Temperature	22.650±0.240[a]	23.014±0.198[a]	22.903±0.213[a]	22.858±0.204[a]

Table 8: Mean hematological level *O.niloticus* from difference (0, 10, 20 and 30fe/kg) treatments (*iron amino acid chelate*) in aquaponic system

Haematological parameter	Treatment			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Glucose (mg dL^{-1})	13.433±0.169[a]	21.8000±0.0289[b]	23.7667±0.0167[c]	26.8000±0.0289[d]
Hemoglobin (g dL^{-1})	9.9244±0.0712[a]	10.830±0.0869[b]	14.717±0.0583[d]	15.630±0.935[d]
Haematocrits (%)	29.773±0.213[a]	32.490±0.261[b]	44.150±0.475[c]	45.090±0.704[d]

Table 9: Mean spinach chlorophyll a, and b, for the four treatment iron amino acid chelate supplement (0, 10, 20, and 30fe/kg) in aquaponic system.

Chlorophyll levels	Treatments			
	0fe/kg	10fe/kg	20fe/kg	30fe/kg
Chlorophyll-a (mg Chl-a mL^{-1})	3.758 ± 0.27[a]	7.236 ± 0.326[b]	9.7624 ± 0.074[c]	10.283 ± 0.22[d]
Chlorophyll-b (mg Chl-b mL^{-1})	5.252 ± 0.28[a]	7.104 ± 0.27[b]	8.606 ± 0.297[c]	11.665 ± 0.250[d]

CONCLUSION - 1

- Iron chelate amino acid with 30fe/kg gave the highest fish growth and percentage survival followed by 20, 10 and 0fe/kg treatments respectively.
- Fish proximate composition with Supplementation of iron amino acids chelate at 30fe/kg gave higher crude protein and ash content in the fish flesh as compared with 20fe/kg, 10fe/kg and 0fe/kg.
- 0fe/kg gave the higher levels of crude lipids followed by 10fe/kg, 20fe/kg and 0fe/kg respectively
- 30fe/kg improved haematocrits, glucose and hemoglobin as compared to 20fe/kg, 10fe/kg and 0fe/kg respectively.
- Macro and micro- nutrients concentrations of Mn, Na, Fe, K, and Zn were higher in the leaves of aquaponic-grown plants with iron chelate amino acids supplementation of 30fe/kg as compared to 20fe/kg, 10fe/kg and 0fe/kg treatments

CONCLUSION - 2

- Best result of all chlorophyll a and b parameters was obtained from 30fe/kg treatments and poor in 0fe/kg treatment
- Water quality parameters in treatments 30fe/kg resulted in high nitrate, conductivity, iron concentration, low pH and ammonia as compared with 20fe/kg, 10fe/kg and 0fe/kg respectively.
- It is clear that different iron amino acids supplementation in fish diets affect *O. niloticus* growth, fish physiological response, fish composition, *S. oleracea* growth, minerals content, chlorophyll, percentage survival and water quality.

RECOMMENDATION

- The results suggest recommendation of 30fe/kg iron amino acid supplementation for both *O. niloticus* and spinach growth because finding indicated that supplementation at 30fe/kg of iron amino acid chelate result to better water quality creating favorable condition for fish growth and survival.
- Favorable water quality for the essential macro and micro nutrient for spinach was reflected in 30fe/kg
- Future studies should include power consumption rate, mineralization in fish, water evaporation and organic source of iron amino acid chelate effect on the growth of fish and spinach in aquaponic system.

Funding for this research was provided by the

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THANK YOU


END

Effects on nutritional conditioning on growth of Nile tilapia fry

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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 subsequently enhance growth or affect protein processing, uptake, and utilization later in life (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, followed by either the reduced 25% or 38% protein growout diet, had greater mean weights (Fig. 2) and lengths than fry fed the initial 48% protein diet. There were also no differences in survival rates for fry offered the 25% protein diet when compared to fry offered the 48% protein diet. This study suggests for the first time that tilapia may better utilize dietary nutrients following an early period of low protein exposure. The effects of the reduced protein diet on gut gene expression and microbial content following nutritional conditioning will also be discussed.

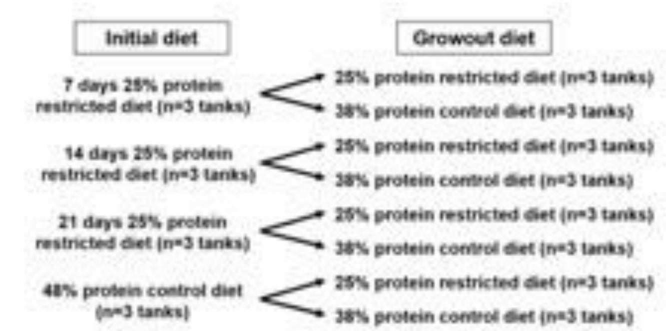

Fig 1. Experimental design indicating protein content of each diet.

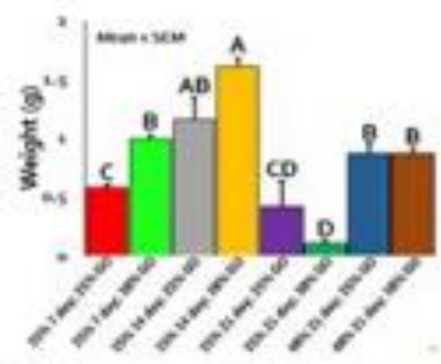

Fig 2. Mean weights of tilapia fry fed protein restricted diets. Control diet is represented by the brown bar.

Effects of Nutritional Programming on Growth of Nile Tilapia Fry

Courtney A. Deck[1], Scott A. Salger[1], Kaniz Fatema[2], Michael Tada[1], Shahroz Mahean Haque[2], and Russell J. Borski[1]

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[2]Department of Fisheries Management, Bangladesh Agricultural University

Background

- 50-80% of the production costs for fish come from feed
- Farmers in underdeveloped countries often rely on pond fertilization without providing prepared feeds

- The use of feeds can quadruple production, leading to increased incomes and sustainability
- Feed management to reduce costs would greatly benefit impoverished farmers, enhancing both earnings and food security

Belton *et al.*, 2011; Dey *et al.*, 2008

Feed Management Strategies

Feed management strategies to reduce production costs can include:

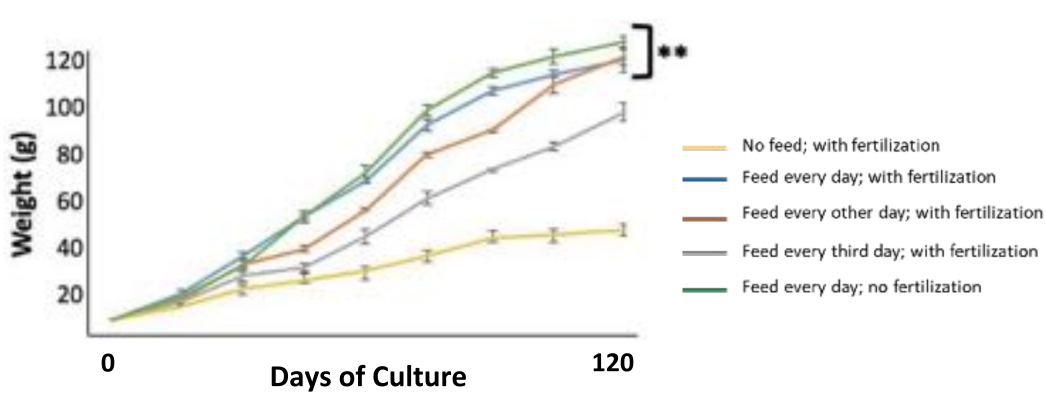
1. Reductions in feeding frequency
   -daily feeding regimens typically lead to fish being overfed

2. Altering feed formulas
   -introduce less costly ingredients, alter nutrient concentrations

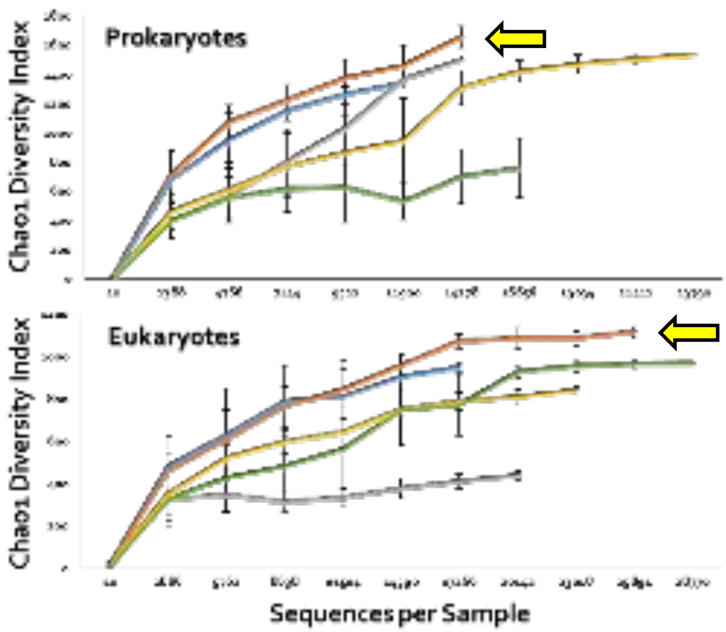
3. Enhancing feed utilization
   -increase digestibility, food conversion rates

Alternate day feeding increases production of tilapia while reducing feed and labour costs

- Supplementing pond fertilization with feeds enhances growth and feed conversion rates
- Alternate day feeding is equally effective as daily feeding on growth and production → 100% increase in feed efficiency, increase net earnings



Alternate day feeding increases diversity of gut microbes



Microbes can produce vitamins, antioxidants, or have antimicrobial effects

Greater diversity may allow better food assimilation

Nutritional Programming

Nutritional programming is the concept that critical events early in life have lifelong effects on growth and health

- Nutrient contributions early in development can influence growth and immune function in mammals (Lucas, 1998)
- Altering early nutrient components can enhance the uptake and utilization of nutrients later in life

Eg. broiler chickens fed a phosphorous-deficient diet had greater retention later in life

(Ashwell and Angel, 2010)

Nutritional Programming In Fish

- Rainbow trout (*O. mykiss*) fed high glucose diets for the first 3 days of development had greater amylase and maltase expression as juveniles (Geurden et al., 2007)
- Sea bass (*D. labrax*) fed a HUFA-deficient diet initially were able to metabolize lipids more efficiently as juveniles than those fed a high HUFA diet (Vagner et al., 2007)

Nothing is known about the effectiveness of nutritional conditioning in tilapia culture

*HUFA- High unsaturated fatty acids

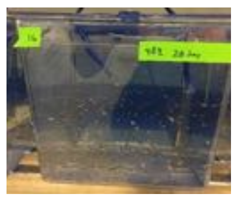
Study Objective

- Protein is required for optimal growth and health, most costly component of feed (>50%)
- The present study investigated the effects of early protein-restriction on growth and microbe diversity of Nile tilapia (*O. niloticus*)

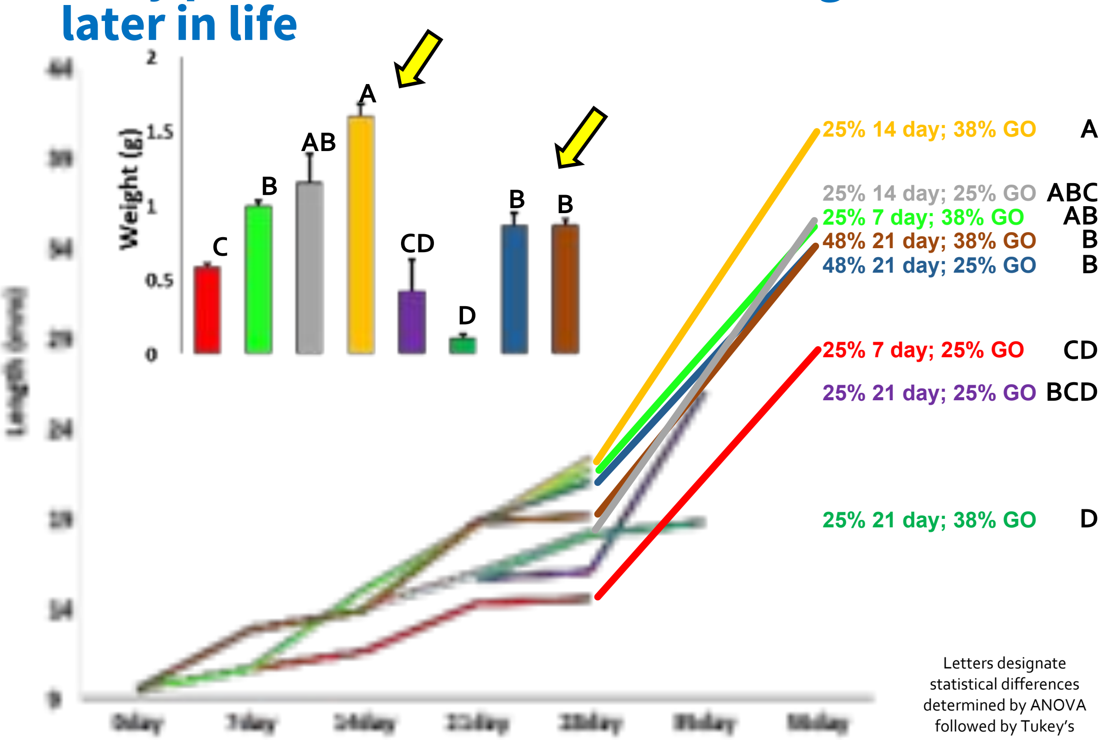
- Evidence suggests nutrient restriction followed by refeeding can enhance feed efficiency in fish (Ali et al., 2003; Picha et al., 2006; 2014)
- We hypothesized that limiting protein early in life (following yolk sac absorption) would increase uptake and utilization, leading to better growth later in life

Experimental design for tank study 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)

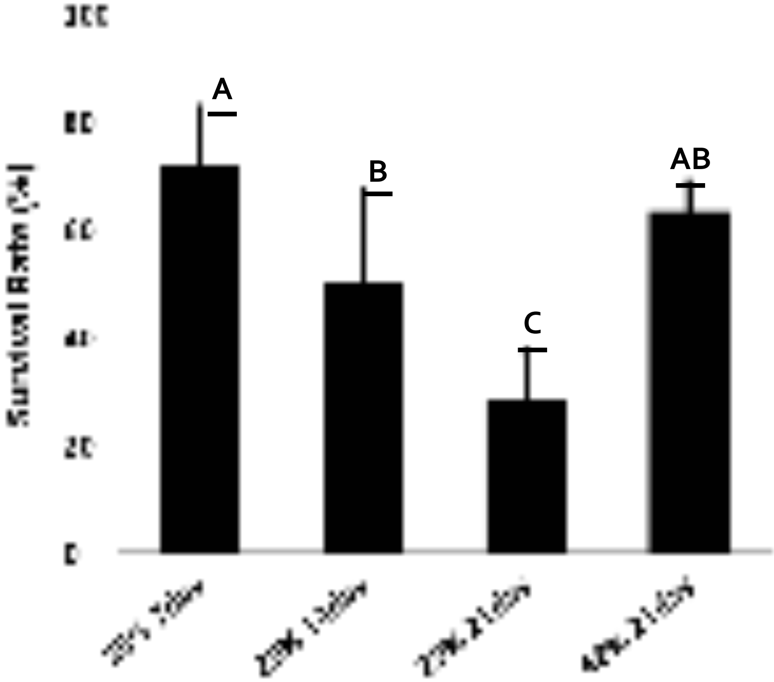


Early protein restriction enhances growth later in life



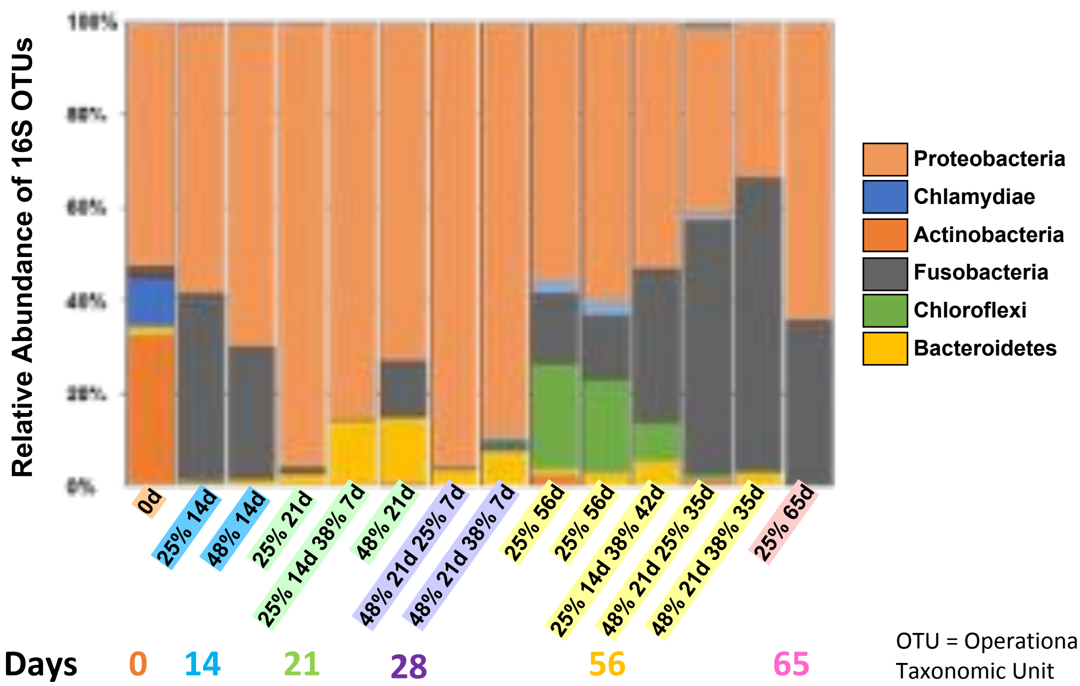
Letters designate statistical differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

Protein restriction should be limited to 14 days



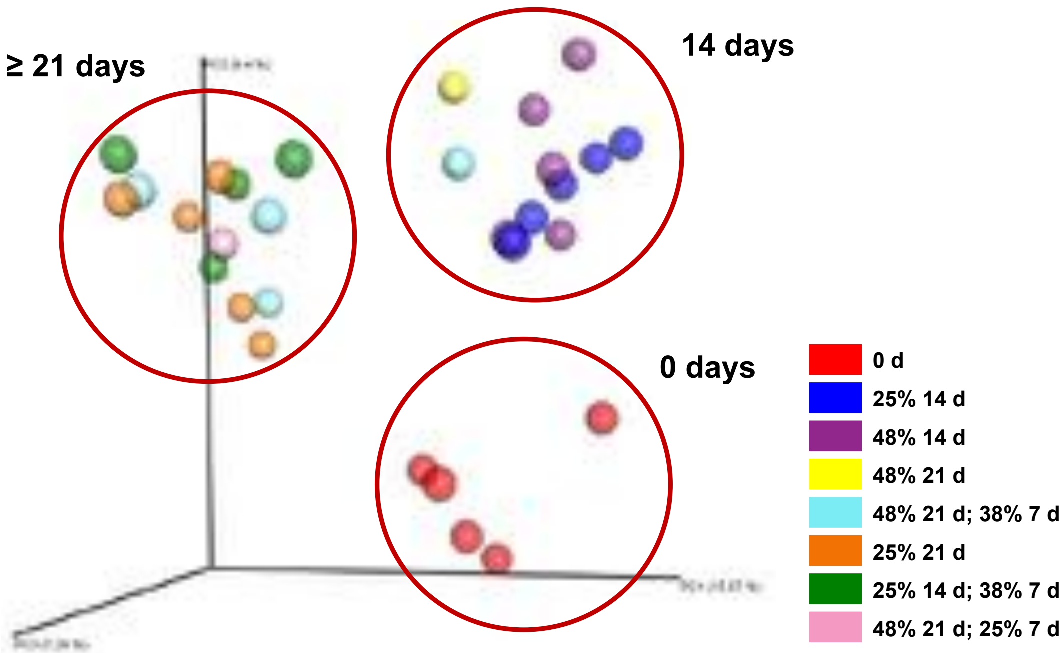
Letters designate statistical differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

Proportions of gut microbe phyla change with time



OTU = Operational Taxonomic Unit

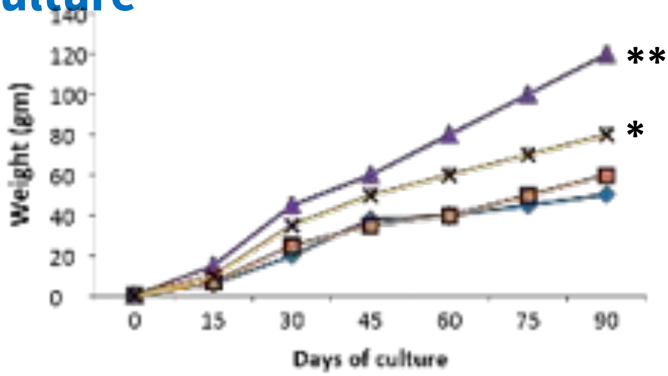
Microbe diversity between treatments varies with time on diet, not protein percentage



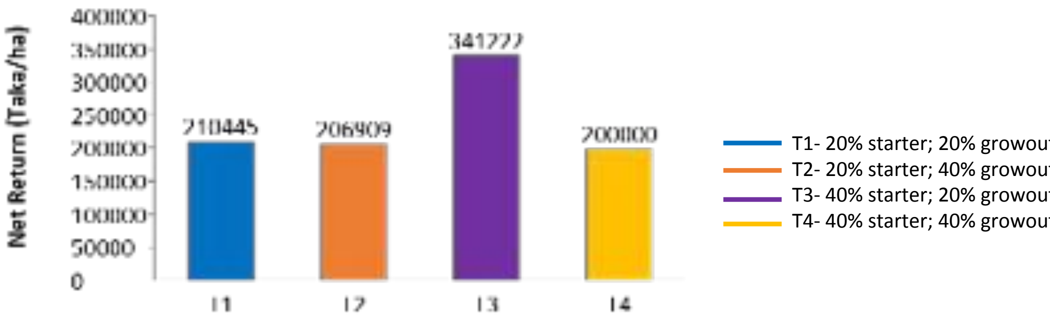
Experimental design for pond study at Bangladesh Agricultural University

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)

Early protein restriction enhanced feed conversion but not growth or net return in pond culture



Natural food sources in ponds likely negate protein restriction from supplemental feeds



Summary

- Early protein restriction for 14 days in tank cultures causes better growth of Nile tilapia fry
- Little apparent effect of limiting protein on gut microbiome, however diversity of microbes is dynamic and changes over time
- Application of nutritional programming to pond culture is less effective, likely due to natural food sources in the ponds

Limiting protein early in life could reduce feeding costs and enhance production if performed in clean tank systems

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Feed formulas (produced by Integral Fish Foods)

Nutrient	25% Starter	48% Starter	25% Grower	38% Grower
Protein	25.00%	48.00%	25.00%	38.00%
Fat	12.13%	8.58%	9.59%	8.00%
Carbohydrates	36.72%	15.88%	36.59%	23.80%
Fibre	3.64%	2.04%	4.78%	3.96%
Ash	4.47%	6.38%	5.17%	6.15%
Lysine	1.96%	3.80%	1.45%	2.19%
Methionine	0.45%	1.08%	0.44%	0.66%
Tryptophan	0.30%	0.50%	0.31%	0.48%
ME- Catfish	2583.78 kcal/kg	1986.14 kcal/kg	2352.58 kcal/kg	2350.22 kcal/kg
Fishmeal	10.08%	24.67%	9.85%	8.47%
Poultry products	0%	19.74%	0%	14.05%
Wheat grain	25.19%	14.80%	14.77%	15.06%
Soybean seeds	1.68%	9.87%	9.85%	25.10%
Wheat flour	33.59%	9.87%	49.24%	23.42%

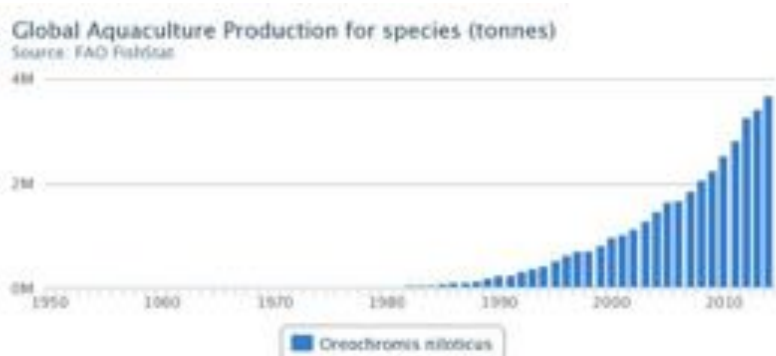
ME- Metabolizable Energy

Feed Components

- Protein requirements vary depending on fish age and size
- Juveniles may require up to 40% protein while growout diets typically contain 30% (El-Sayed, 2006)
- Tilapia can tolerate higher carbohydrate and lower protein levels than other carnivorous fish (FAO, 2015)

Background

- Tilapia are the second most important farmed fish and the mostly widely produced
- Global production of tilapia has increased exponentially in the past 30 years



Food and Agriculture Organization of the United Nations, 2015

- can also rely on manures or agricultural byproducts

Proximate composition (%)					
	Crude protein	40	30	25	20
	Crude lipid	[illegible]	[illegible]	4	[illegible]
	Crude fibre	[illegible]	[illegible]	[illegible]	[illegible]
	Cost (US$/tonne) in 2005	300	[illegible]	[illegible]	[illegible]

Creswell, 2005

Digestibility and ammonia excretion rates of low-cost nursery diets for Nile tilapia *Oreochromis niloticus* fry

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In Ghana nursery facilities are generally missing from the aquaculture production chain and this compels fish farmers to purchase fish directly from the hatcheries at very small sizes to stock in grow-out ponds which sometimes results in high mortalities. Some farmers have adopted the practice of nursing fish before stocking in grow-out ponds in Ghana but formulated commercial feeds are prohibitively expensive. This research is thus a preliminary study to evaluate the potential for using mixtures of soybean and copra meals as partial replacements of fishmeal in feeds for Nile tilapia (*Oreochromis niloticus*) fry/fingerlings.

Nutrient digestibility and postprandial ammonia excretion rates were examined. Three iso-nitrogenous (48%), and isolipidic (7%) diets (Diet 1, 2 and 3) were formulated with the oilseed mixtures as partial replacements to fishmeal (Table 1) and with a fishmeal-based commercial diet serving a as control. Diets were randomly assigned to triplicate groups of fish (Initial mean weight 0.89g±0.14 g) for the digestibility trials which spanned a total of nine (9), days. The partial inclusion of oilseed meals did not significantly affect apparent protein and lipid digestibilities although ash and dry matter digestibilities were significantly reduced ($p<0.05$). The inclusions of the plant proteins caused an increase in ammonia excretion (Fig 1). Overall, the oilseed diets showed some potential although further refinements of ingredient might be required to improve somatic growth, dry matter digestibility and reduce ammonia excretion rates.

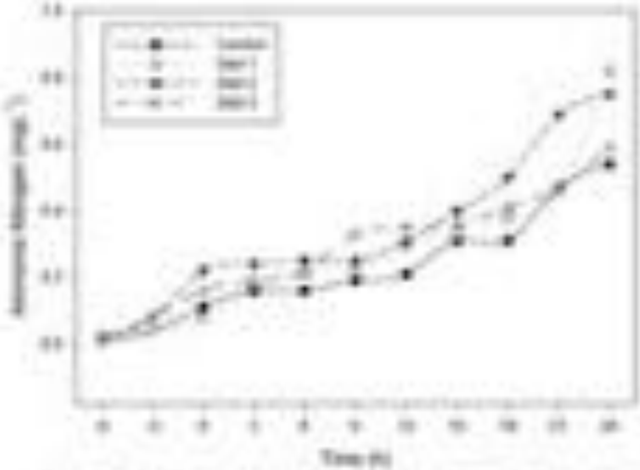

Fig. 1: Ammonia excretion rates of the fish fed the different diets

Table 1: Formulations of the experimental diets

	D1	D2	D3
FM	48.60	40.30	32.45
SBM	32.50	42.47	50.98
FCM	8.10	7.45	7.15
WB	6.80	5.78	5.42
PO	2.00	2.00	2.00
BIN	1.00	1.00	1.00
VM	1.00	1.00	1.00

FM: Fishmeal; SBM: Soybean meal; FCM: Fermented copra meal; WB: Wheat bran; PO: Palm oil; BIN: Binder; VM: Vitamin mix

DIGESTIBILITY AND AMMONIA EXCRETION RATES OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FRY FED PLANT-BASED NURSERY DIETS

Kwasi A. Obirikorang, Maame E. Goode, Stephen Gyamfi, Regina E. Edziyie, Steve Amisah

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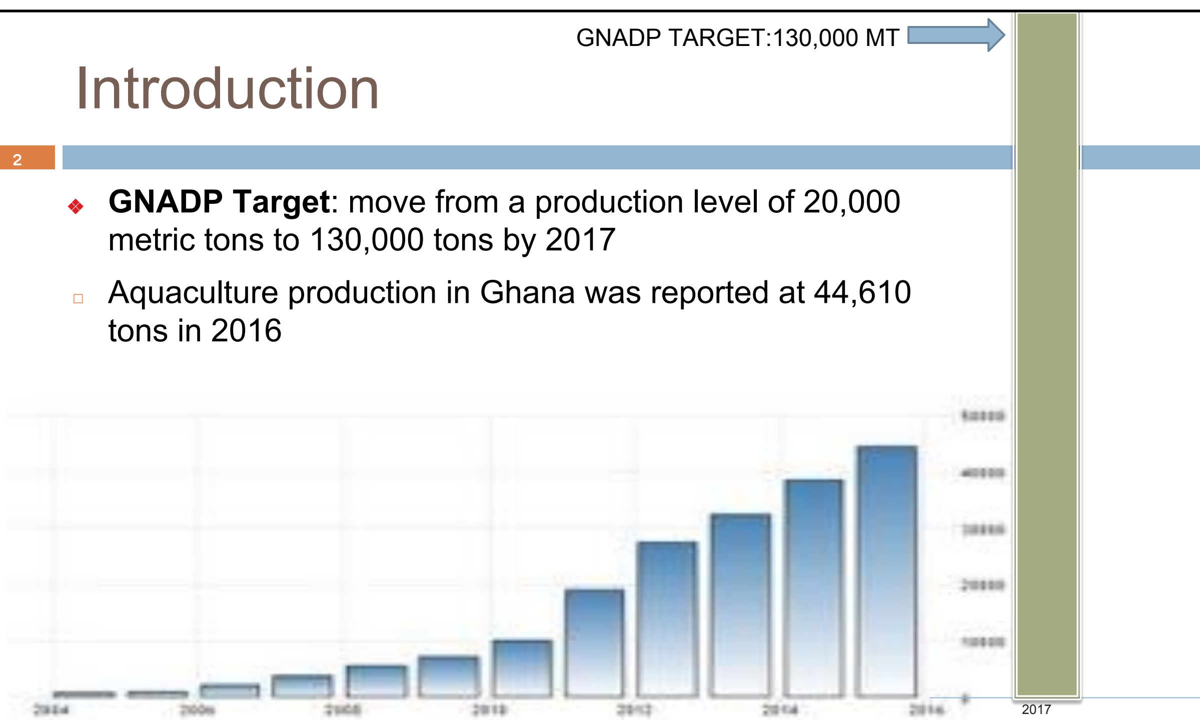
KNUST, Kumasi, Ghana

Introduction

2

- **GNADP Target**: move from a production level of 20,000 metric tons to 130,000 tons by 2017
- Aquaculture production in Ghana was reported at 44,610 tons in 2016

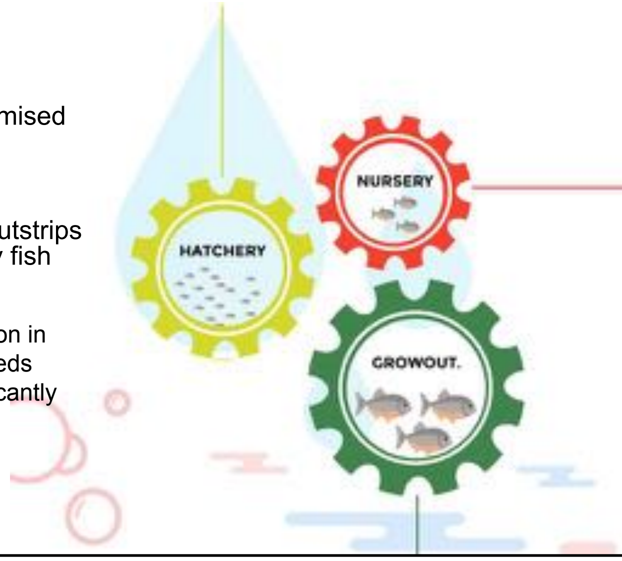


Introduction

3

- Attributed to several factors
  - High cost of feed: >US$1 per kg
  - Production systems – have not been optimised
    - Low technology e.g. 2 fish /m^2
  - Missing links in the value chain: Nursery
  - Demand for tilapia fingerlings in Ghana outstrips supply, forcing some hatcheries to supply fish farmers with 2g fingerlings or less

- Nursing tilapia to sizes >10 g can be a profitable operation in Ghana but the high cost of commercially-available fry feeds (48% crude protein) in Ghana (~$2.3 per kg) can significantly affect the profitability of the operation (Tarchie et al. unpublished data)



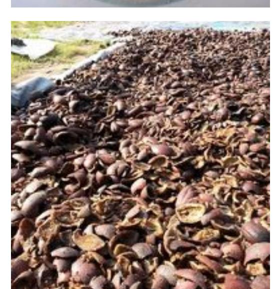
Objectives

4

1. Investigate the effects of plant based diets on nutrient digestibility and postprandial ammonia excretion rates in *O. niloticus* fry.

2. Evaluate the effects of plant-based diets on short-term growth performance, feed utilisation and gut histology of *O. niloticus* fry

- The series of lab-based trials in this presentation are the preliminary efforts to develop less expensive but efficient aquafeeds with healthy nutritional profiles for the Nile tilapia fry (*Oreochromis niloticus*) using soybean and copra meals as partial replacements to fishmeal.



Methodology

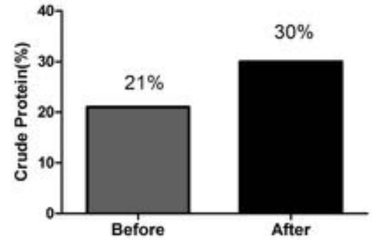
5

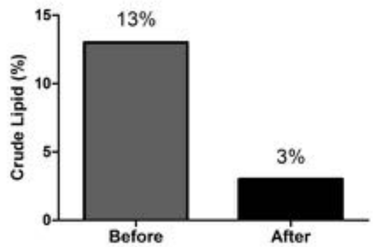
Improvement of copra meal nutritional value through SSF

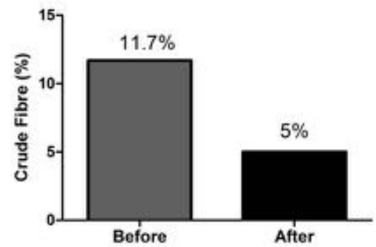
Protein

Lipid

Fibre







The Feed Formulations

6

Proximate Composition
Crude Protein: 48%
Crude Lipid: 7%
Crude Fibre: 3-5%
Gross Energy: 17 kJg^{-1}

Cost of Test Diets based on ingredients cost
$0.77-$0.81 per kg

Control:
A
commercially-available fry diet

Diet 1

% Inclusion levels/final formulation	
Fishmeal FM	48.60
Soy SBM	32.50
Fermented Copra Meal	8.10
Wheat meal WM	6.80
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 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

Experimental Fish

7

- All male Nile tilapia fry
- Average Initial Weight: ~ 2 g
- Source: A commercial hatchery in Ashanti Region
- Stocking Density: 200 fry per tank
- Feeding Rate: 8% of total fish biomass daily

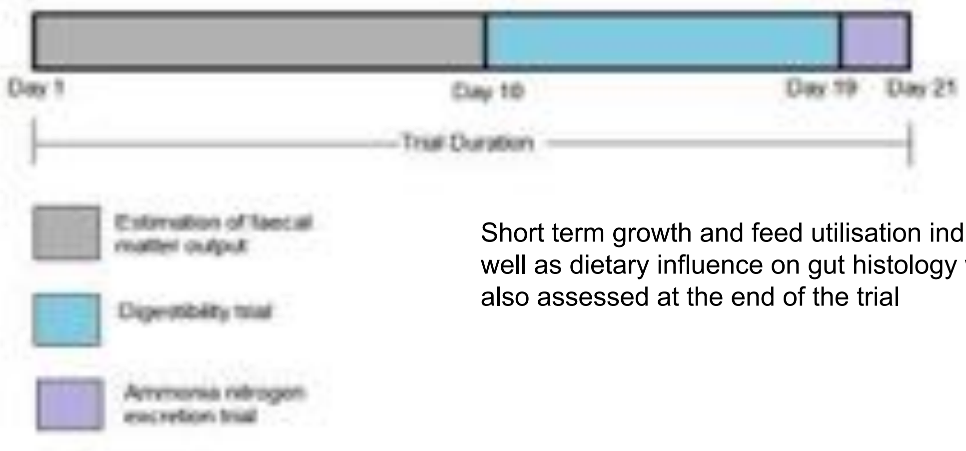
Experimental Conditions

8

- Culture tanks: Twelve 120 L cylindro-conical thermoplastic tanks
- Temperature: 25°C
- Water exchange: 100 L h^{-1}
- Oxygen concentration: >70%
- Light: Darkness regime: 12h:12h

Experimental Timelines

9

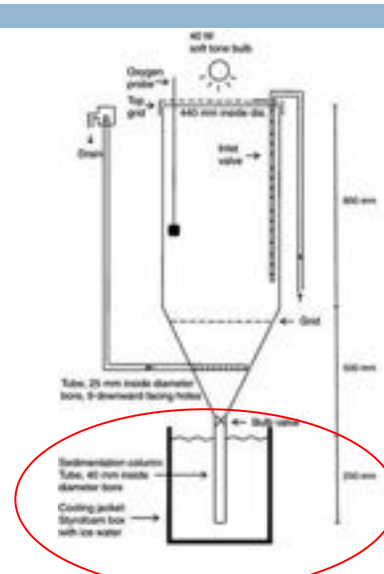


Short term growth and feed utilisation indices as well as dietary influence on gut histology were also assessed at the end of the trial

Assessment of Digestibility and Faecal Output

10

- Faecal matter for the estimation of diet digestibility and faecal output relative to feed intake were collected in sedimentation columns surrounded by ice.



Assessment of Ammonia Nitrogen Excretion

11

- An indirect assessment of protein utilisation
- Fish groups were fed at 4% of total biomass in a single meal
- 15ml of water samples were taken from each tank every 3 h over a 24-hour period for TAN measurements

Growth Performance and Feed Utilisation

12

- Specific growth rate (SGR) $= \frac{(\ln \text{Final weight (g)} - \ln \text{Initial weight (g)})}{\text{Experimental days}} \times 100$
- Feed conversion ratio (FCR) $= \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}} \times 100$
- Protein efficiency ratio (PER) $= \frac{\text{Weight gain (g)}}{\text{Crude protein fed (g)}}$
- Viscerosomatic index (VSI) $= \frac{\text{Viscera weight (g)}}{\text{Body weight (g)}} \times 100$
- Hepatosomatic index (HSI) $= \frac{\text{Liver weight (g)}}{\text{Body weight (g)}} \times 100$

Statistical Analyses

13

- Results are presented as means ± standard deviations (SD) in this study.
- Statistical analyses were performed using one-way analysis of variance (ANOVA) and differences between the dietary treatment means compared by the Tukey multiple comparison test.
- Differences were considered significant at $p<0.05$.
- All graphs and statistical analyses were executed using SigmaPlot ver. 12.0 (Systat Software, Inc).

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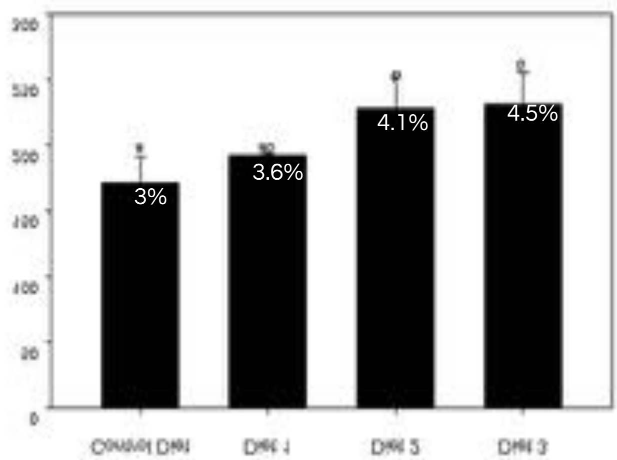
Results

Faecal Matter Output

15

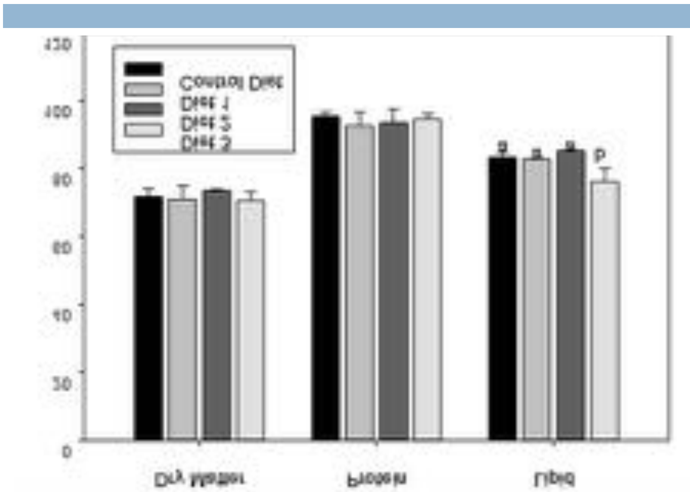


Faecal matter output of fish fed Diet 2 (228.45 g DM kg-1 feed) and Diet 3 (231.78± g DM kg-1) feed were significantly higher than the control group (171.33±20.17 g DM kg-1 feed)

The faecal matter productions appear to be directly linked to the levels of fibre in the diets.

Diet Digestibility

16

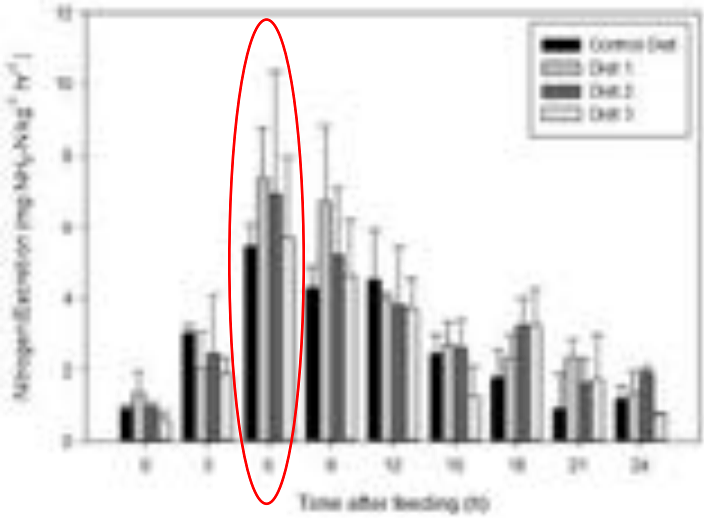


- There were no significant differences ($p>0.05$) in dry matter and protein digestibilities among dietary groups.

- Lipid digestibility in the fish fed Diet 3 was significantly lower ($p<0.05$) than the other dietary groups.

Ammonia Nitrogen Excretion

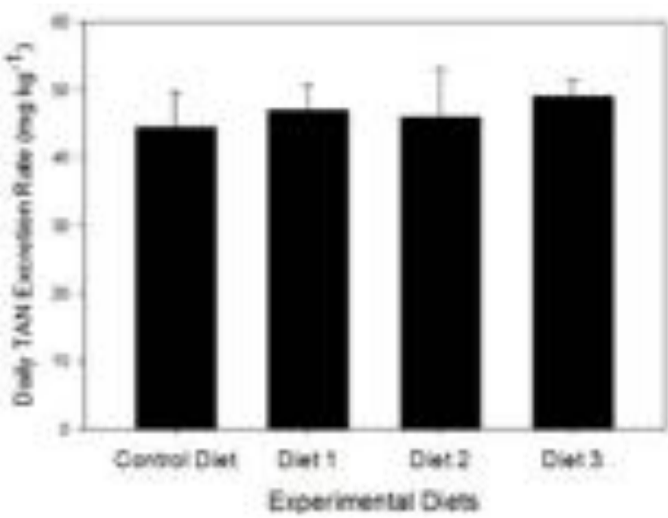
17



- TAN excretion patterns were similar among all dietary treatments
- Peak TAN excretion rates occurred 6 hours after meal ingestion similar to what was observed in juvenile Nile tilapia by Obirikorang (2015).

Ammonia Nitrogen Excretion

18

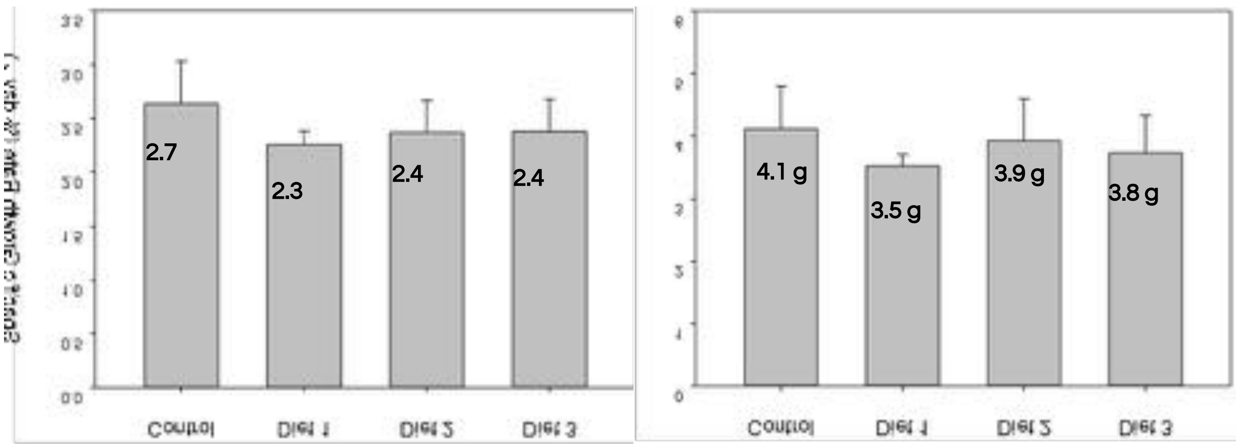


There were no significant differences ($p>0.05$) in cumulative TAN excretion among the different dietary groups over 24 h

Control: 44.50±5.27 mg kg^{-1}
Diet 1: 47.00±3.77 mg kg^{-1}
Diet 2: 46.00±6.93 mg kg^{-1}
Diet 3: 49.00±2.29 mg kg^{-1}

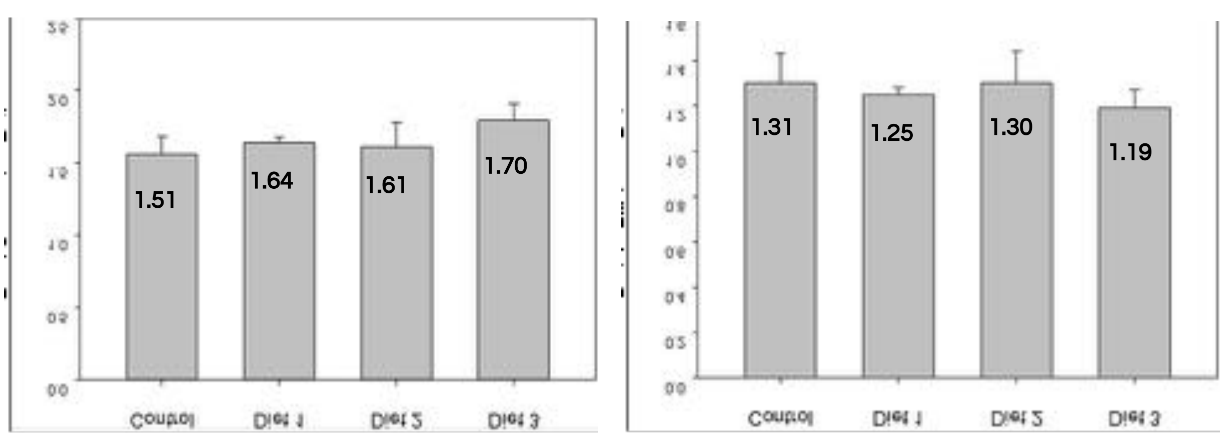
Short Term Growth Performance

19



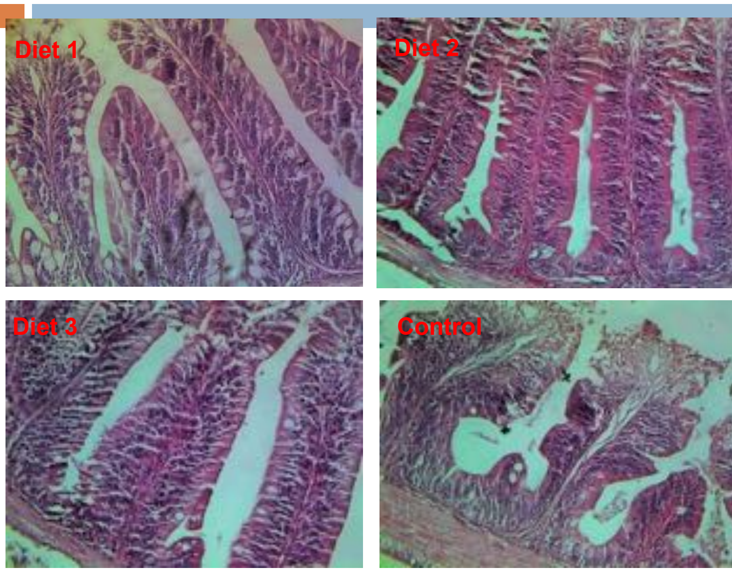
Feed Utilisation Efficiency

20



Gut Histology

21



No significant differences in villi height and goblets cell population between the test and control groups.

The control group was, however, characterized by wider villi width associated with mild inflammations.

Conclusions

22

- The dietary inclusions of soybean and copra meals do not elicit unusually higher postprandial ammonia nitrogen excretion responses in Nile tilapia fry.
- With the exception of the significantly lower lipid digestibility for Diet 3, there were no significant differences in the dry matter and protein digestibilities between the test and control diets
- There were no significant differences in cumulative TAN excretion among the different dietary groups over 24 h
- Although growth and feed utilisation parameters were slightly more improved in the control diet fish, there were no significant differences in any of the measured and calculated parameters
- From an economic perspective, the test diets could represent significant savings in terms of feed costs in nursery operations without significantly reducing somatic growth

Recommendation

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- Longer term trials should be conducted using the diet formulations in this research in real-life culture environments (This is already underway).

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Pellet feed improvements through vitamin C supplementation for snakehead fish *Channa striata* culture in Vietnam

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In Vietnam, snakehead fish is considered as one of the most valuable cultured fish. However, enhancement of fish health is an important issue for snakehead culture, because bacterial disease is a serious problem and vertebral anomalies have also been observed. Our objective was to determine optimal vitamin C levels in feed for snakehead fish culture. Several benefits have been attributed to ascorbic acid (AA) supplementation in fish such as growth, survival, reduction of skeletal deformities, disease resistance and stress response.

Laboratory feeding trial: The study was conducted to find out the optimal dietary vitamin C levels in terms of the growth performance of snakehead fish and economic aspects. The 8-week growth trial included six treatments with five replications each: 0, 125, 250, 500, 1000 and 2000 mg vitamin C (L-ascorbate-2-monophosphate) equivalent kg-1 diet. The diet, based primarily on soybean meal (SBM) and fish meal, contained 45% protein, 9% lipid and 4.2 Kcal.g1. Eighty snakehead fingerlings (6.24±0.17 g.fish1) were assigned randomly in 0.5 m3composite tanks with continuous aeration. Fish were fed twice daily. Growth rates and protein efficiency ratio were significantly greater in treatments with vitamin C supplementation compared with control treatment and optimal growth was obtained at 500 mg.kg-1. Red blood cell counts and lysozyme in treatments with vitamin C supplementation tended to rise significantly proportional to the concentration of vitamin C. White blood cell counts in treatments with vitamin C supplementation were 2.1-3.6 times higher than those in the treatment without vitamin C supplementation. A bacterial challenge following the feeding trial showed best survival for fish fed AA levels of 250 mg.kg-1 or more.

On-farm pond trial: Based on our laboratory results, effects of AA on snakehead in ponds to simulate farm conditions was tested using the following treatments: (*i*) commercial feed; (*ii*) commercial feed plus hand mixed AA at 500 mg.kg-1; (*iii*) commercial feed plus hand mixed AA at 750 mg AA.kg-1; (*iv*) commercial feed plus hand mixed AA at 1000 mg AA.kg-1; (*v*) SBM diet without AA; (*vi*) SBM diet plus 500 mg AA.kg-1; (*vii*) SBM diet plus 750 mg AA.kg-1; (*viii*) SBM diet plus 1000 mg AA.kg-1.The experiment was conducted in two experimental ponds (only SBM diet without AA placed in one pond and the rest in the other pond) with three replicate hapas each. Stocking density was 150 fish.m2 and culture period was 5 months until market size was attained. Growth rates and protein efficiency ratio were greater in treatments with vitamin C supplementation compared with control treatment. Production cost was lowest for fish fed AA levels of 500 mg.kg-1

Acknowledgment
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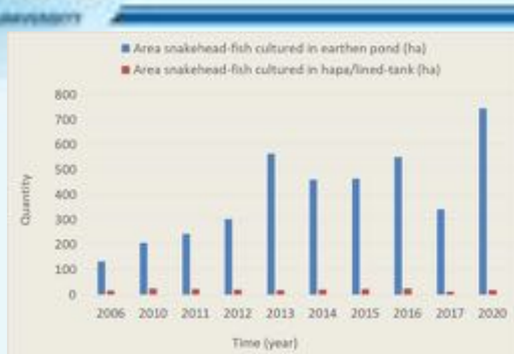
AQUAFISH FISH INNOVATION LAB

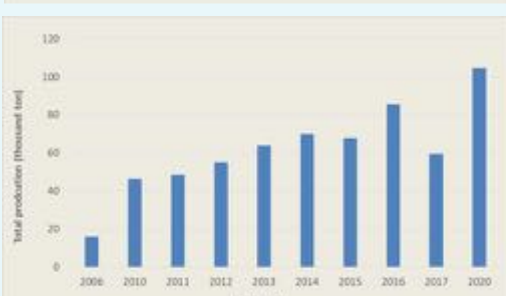
PELLET FEED IMPROVEMENTS THROUGH VITAMIN C SUPPLEMENTATION FOR SNAKEHEAD, *Channa striata* CULTURE IN VIETNAM AND CAMBODIA

Tran Thi Thanh Hien, Pham Minh Duc, Nguyen Van Khanh, Tran Thi Tuyet Hoa, Tran Minh Phu and David A. Bengtson

Las Vegas, Nevada USA 19-22 February 2018

The development of sustainable snakehead farming in Viet Nam 2006-2017





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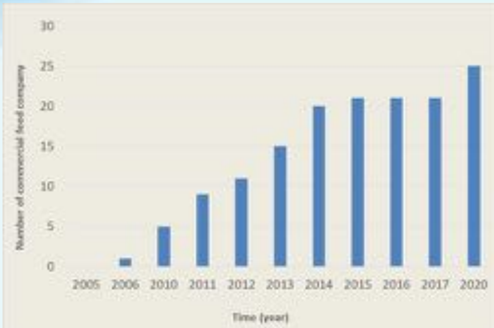
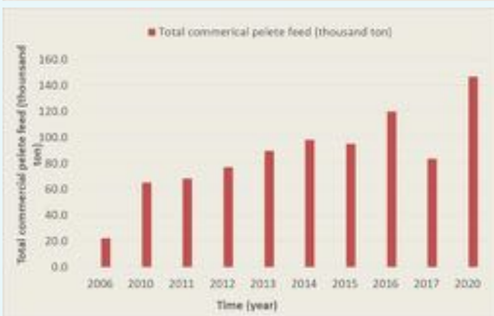




Asia Project: Cambodia and Viet Nam

Improving food security, household nutrition and trade through sustainable aquaculture in Cambodia and Viet Nam

- Inv#1: Genetic diversity of snakehead in Cambodia and Viet Nam
- Inv#2: Guidance and policy recommendations for sustainable snakehead aquaculture and aquatic resource management in Cambodia and Viet Nam
- Inv#3: Sustainable snakehead aquaculture in Cambodia
- **Inv#4: Pellet feed improvements through vitamin C supplementation for snakehead culture**
- Inv#5: Enhancing food security and household nutrition vulnerability of women and children with a focus on nutrient dense commonly consumed fish from capture fish and aquaculture in the dry season in Cambodia.

Content of the presentation

- Soybean meal diet (SBM diet) for snakehead and role of vitamin C
- Laboratory feeding trial
- Farm feeding trial

I. Soybean meal diet for snakehead

SBM Diet:
- 45% protein
- 9% lipid
- 4.2 Kcal/g

(Hien *et al.*, 2016)

Ingredients	Content (%)
Kien Giang fish meal (60%)	35.8
Soybean meal (47%)	33.4
Cassava meal	8.26
Rice bran	15.0
Mineral premix	2.00
Oil	3.08
Carboxymethyl cellulose	0.4
Lysine	0.4
Methionine	0.28
Fish solution	1.5
Phytase	0.02
Total	**100**

I. Role of vitamin C

➢ **Growth rate** of large yellow croaker **higher 8%** when supplemented 500 mg vitamin C (Ai *et al*., 2006).

➢ **Survival rate** of Japanese sea bass **higher 12.5%** when supplemented 500 mg vitamin C in feed (Ai *et al*., 2004).

➢ **Lysozyme** of Nile tilapia **increased 3%** when supplemented 500 mg vitamin C (Ibrahem *et al*., 2010).

II. Laboratory feeding trial

2.1 Effects of vitamin C in dietary on grow performance of snakehead

Experimental design:

- SBM diet + 0 mg AA/kg feed
- SBM diet + 125 mg AA/kg feed
- SBM diet + 250 mg AA/kg feed
- SBM diet + 500 mg AA/kg feed
- SBM diet + 1000 mg AA/kg feed
- SBM diet + 2000 mg AA/kg feed

↓

Evaluation data: after 8 weeks culture in tanks

- Grow performance: Wf; SR; FCR
- Feed efficiency: PER
- Requirement of dietary vitamin C on growth responses of snakehead

II. Laboratory feeding trial (cont.)

2.2 Bacterial challenge experiment

Experimental design:

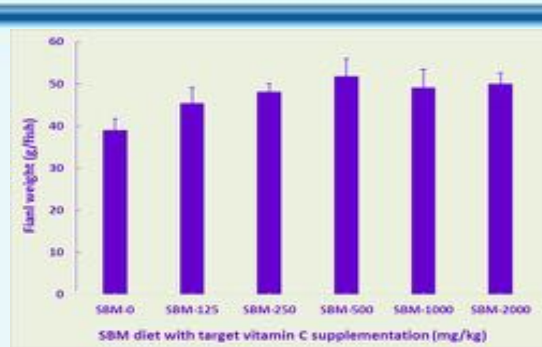
- SBM diet + 0 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 0 mg AA/kgfeed (*A. hydrophila* injection)
- SBM diet + 125 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 125 mg AA/kg feed (*A. hydrophila* injection)
- SBM diet + 250 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 250 mg AA/kg feed (*A. hydrophila* injection)
- SBM diet + 500 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 500 mg AA/kg feed (*A. hydrophila* injection)
- SBM diet + 1000 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 1000 mg AA/kg feed (*A. hydrophila* injection)
- SBM diet + 2000 mg AA/kg feed (saline 0.85% injection)
- SBM diet + 2000 mg AA/kg feed (*A. hydrophila* injection)

Evaluation data: after 2 weeks

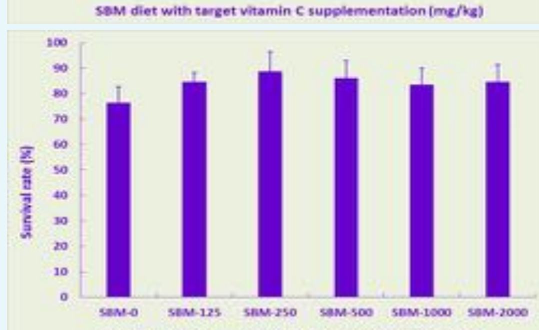
- Immune response: Total erythrocytes and leukocytes cell; lysozyme
- Bacterial pathogen injection: mortality rate

II. Laboratory feeding trial (cont.)

Growth rate

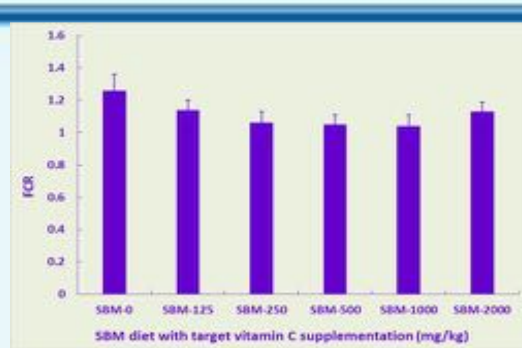


Survival rate

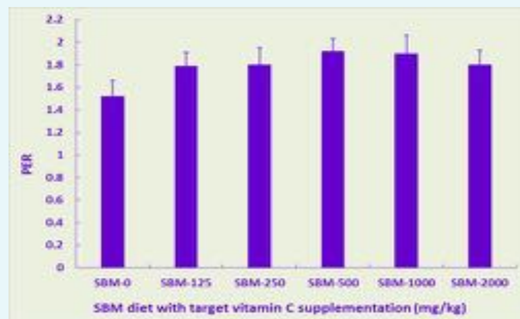


II. Laboratory feeding trial (cont.)

Feed conversion ratio



Protein efficiency ratio



II. Laboratory feeding trial (cont.)

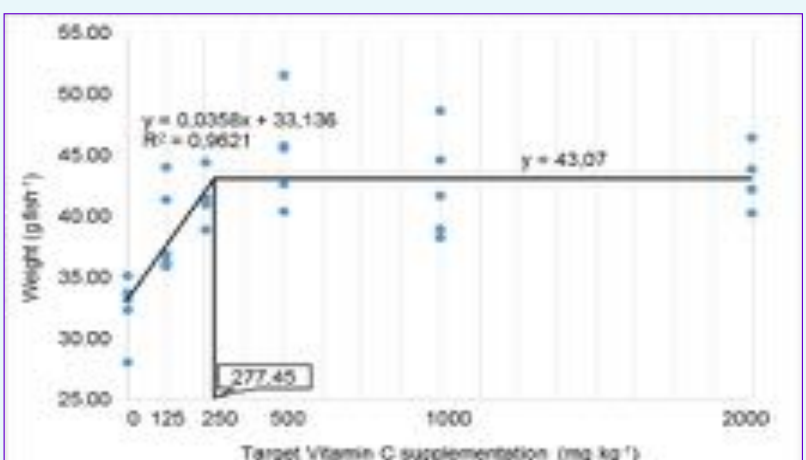
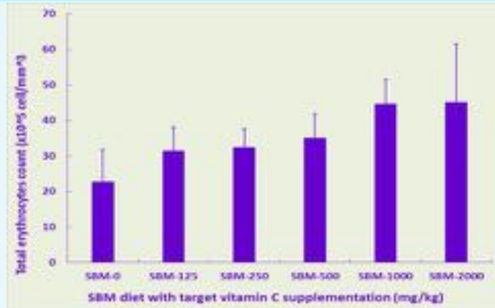


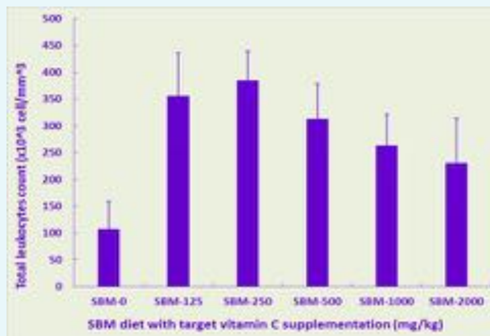
Fig. 1. Requirement of dietary vitamin C on growth responses of snakehead

II. Laboratory feeding trial (cont.)

Total erythrocytes



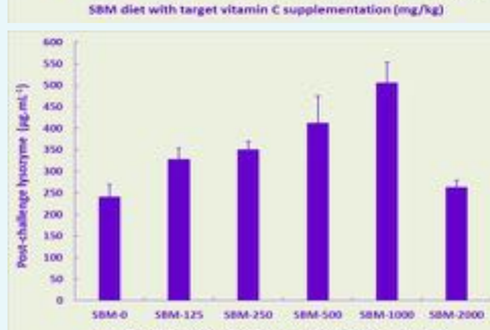
Total leukocytes



II. Laboratory feeding trial (cont.)

Lysozyme (after 8 weeks feeding diet with AA)

Lysozyme (after bacteria *A. hydrophila* injection)



II. Laboratory feeding trial (cont.)

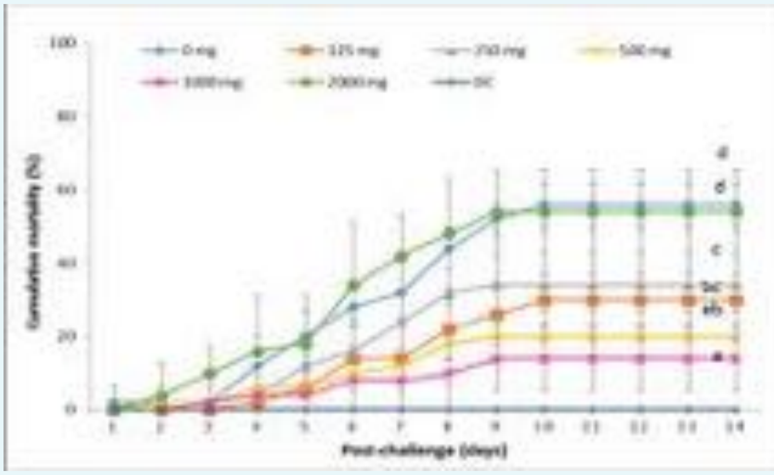


Fig. 2. Cumulative mortality over 14 d in snakehead fed diets with different levels of Vitamin C for 8 weeks, then inoculated intraperitoneally with *Aeromonas hydrophila.*

III. Farm feeding trial

3.1 Snakehead Hapa trial based on SBM diet with optimal vitamin C (AA)

Experimental design:

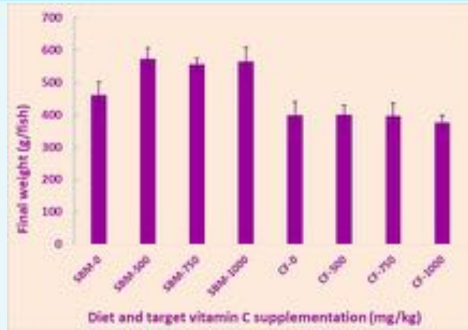
- •Commercial feed (CF)
- •CF + hand mixed 500 mg AA/kg feed
- •CF + hand-mixed 750 mg AA/kg feed
- •CF + hand mixed 1000 mg AA/kg feed
- •SBM diet without AA
- •SBM diet + 500 mg AA/kg feed
- •SBM diet + 750 mg AA/kg feed
- •SBM diet + 1000 mg AA/kg feed

Evaluation data: after 5 months culture

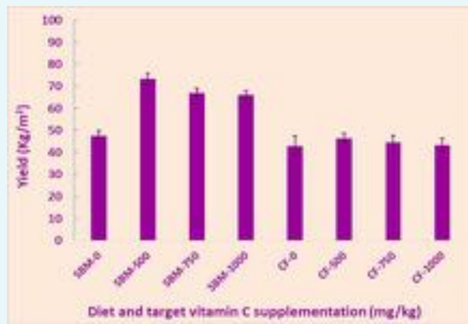
- •Grow performance: Wf; SR; FCR
- •Feed efficiency: PER
- •Requirement of dietary vitamin C on growth responses of snakehead

III. Farm feeding trial (cont.)

Growth rate



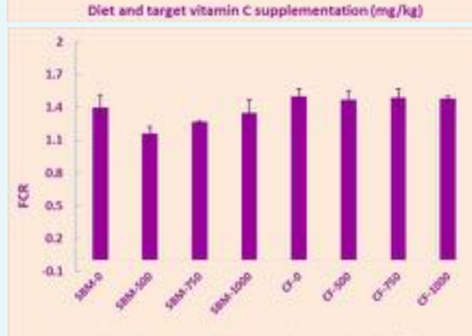
Yield



III. Farm feeding trial (cont.)

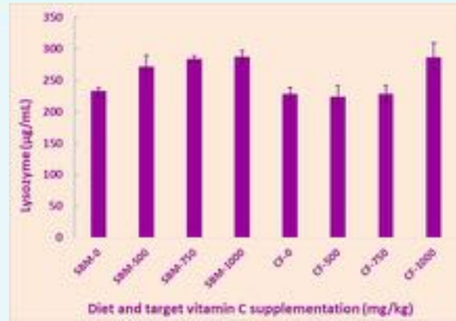
Survival rate

FCR

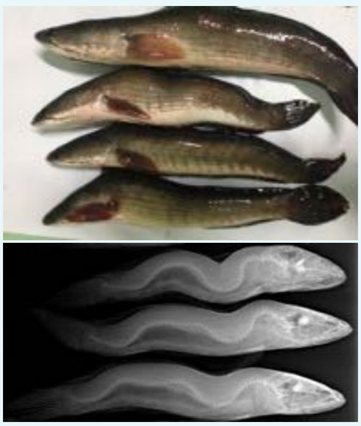


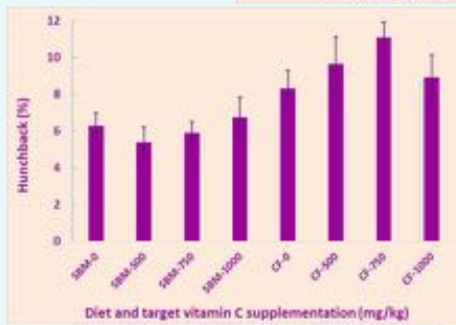
III. Farm feeding trial (cont.)

Lysozyme



Hunchback





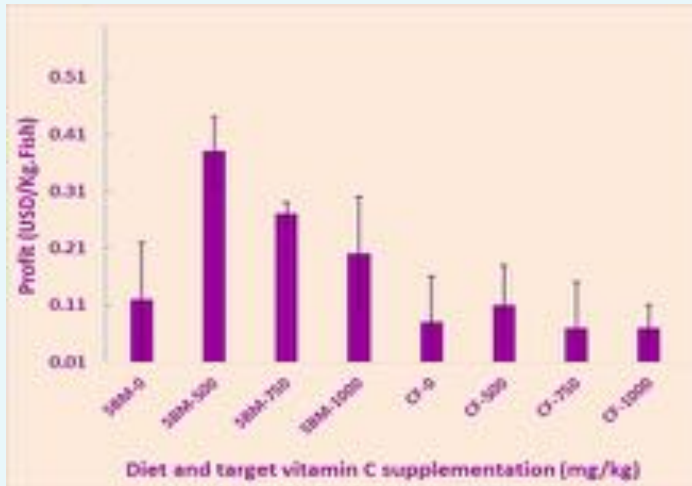
III. Farm feeding trial (cont.)

Production cost

Feed cost

III. Farm feeding trial (cont.)

Profit



III. Farm feeding trial (cont.)

- **In conclusion,** this study demonstrated that dietary AA supplementation is able to **improve growth performance, immune responses, and survival of snakehead against *A. hydrophila* infection**
- The requirement of AA by snakehead was determined as for growth rate **277 mg.kg^{-1} feed in the laboratory study**
- The diet supplemented with **AA at 500 to 1000 mg.kg^{-1} feed is an appropriate concentration range for improving growth performance and immunity of snakehead** in farms.

Funding for this research was provided by the

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Thank you for your attention!

College of Aquaculture and Fisheries - CTU

Development of technique for mass production of housefly *Musca domestica* maggots

Nazael A. Madalla*, Hezron Lugano, & Sebastian W. Chenyambuga

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Aquaculture in Tanzania has remained subsistence partly due to lack of quality affordable aquafeeds. This is because conventional sources of protein such as fishmeal and oil seed cakes are scarce and costly. Housefly maggots are locally available, affordable and contain high protein, thus potential alternative protein source. However, a limiting factor is lack of appropriate culture technique for mass production of maggots with convenient harvesting. Thus culture unit was designed composed of a plastic enclosure with 40 cm diameter and 21.5 cm height consisting of two chambers (Plate 1).

The top chamber served as a culture unit where the substrate was placed. The bottom chamber served as harvesting unit and was separated from the top chamber using a 2 mm nylon mesh. The mesh allowed dropping of maggots into harvesting unit due to photosensitivity of maggots when exposed to light upon opening of the culture unit. Five substrates in triplicates namely, cattle manure, poultry manure, pig manure, cattle offal and kitchen leftovers were used were used assess suitability of the developed system as well as the culture conditions. About 2.5 kg of substrate and 250 gm of attractant (mixture of blood, small pieces of meat debris and rotten eggs) were placed into culture unit and houseflies allowed to lay eggs. Harvesting was done from day four where maggots were cleaned with water, blanched and then weighed. Prior to harvesting, temperature was recorded. Substrates were refreshed weekly for the whole trial period of three weeks. Harvesting maggots was more convenient as they were easily collected from the harvest chamber after opening lid of the culture unit. Cattle offal resulted in significantly higher maggot yield while least was from cattle manure ($p<0.05$) (Table 1). Temperature was significantly higher in poultry manure ($p<0.05$); however, there was no relationship between temperature and yield, $r = .191$, p (one-tailed) > .10. Thus cattle offal where easily available is most suitable substrate for culturing housefly maggots. Efforts are now underway to upscale this production technique for production of larger volumes of maggots.

Plate 1:Side and top view of culture containers and housefly maggot cultures

Table 1: Yield and temperature from different types of substrates

No	Substrate	Yield (g)	Temperature (°C)
1	Cattle Manure	21.57 ± 0.21^{d}	32.66 ± 3.50^{b}
2	Poultry Manure	40.83 ± 0.67^{b}	41.60 ± 3.45^{a}
3	Pig Manure	27.25 ± 1.29^{c}	34.66 ± 3.25^{b}
4	Cattle Offal	50.47 ± 0.43^{a}	33.46 ± 5.05^{b}
5	Kitchen Leftovers	27.24 ± 0.33^{c}	34.86 ± 4.45^{b}

Technique for Mass Production of Housefly (*Musca domestica*) Maggots

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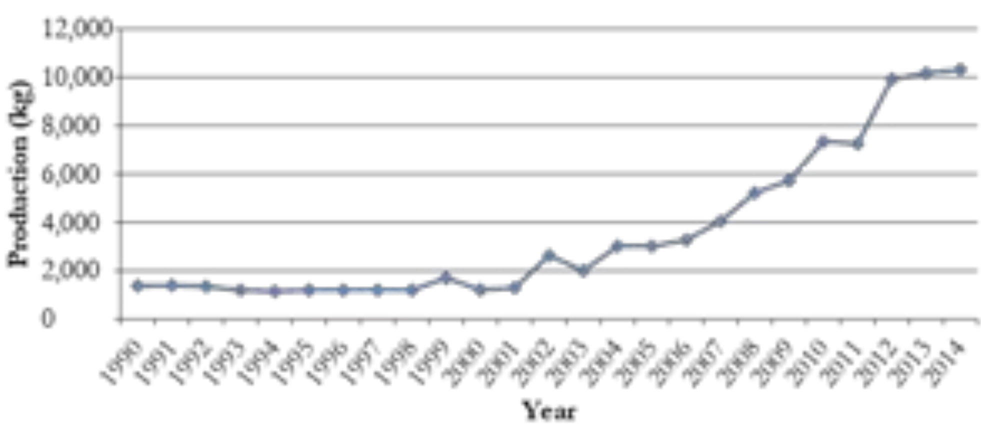
Introduction

- Recently aquaculture has shown positive growth in Tanzania



- Need for quality affordable protein sources to support the growing industry
  - Conventional protein sources such as fishmeal and oil seed cakes are scarce and costly

…Introduction

- Locally available, affordable and high protein content non-conventional sources such as housefly maggots are promising
  - Inclusion up to 40% in practical Nile tilapia diets without compromising biological and economical performance
- However, adequate volumes must be made available
- The current study therefore aimed to develop a technique for mass production of housefly maggots

Methodology

- A two-chambered plastic enclosure with 40 cm diameter and 21.5 cm height was designed as culture unit

…Methodology

- The chambers had the following functions:
  - Top chamber contained substrate for adult flies to lay eggs and support growth of maggots
  - Bottom chamber served as a harvesting unit
- The two chambers were separated by a 2 mm nylon mesh which allowed passage of maggots
  - Maggots are photosensitive

…Methodology

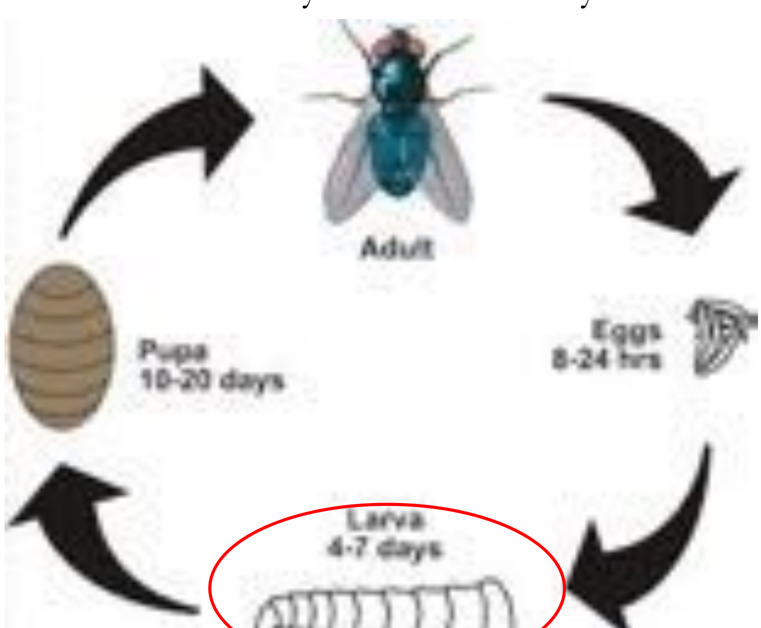
- Suitability of the culture unit was assessed using five freshly collected substrates in triplicates
  - Cattle manure, poultry manure, pig manure, cattle offals and kitchen leftovers
- Prior to culture the substrates were enclosed in an air tight 10L plastic buckets for 24 hours
  - To eliminate any housefly eggs and/or maggots
- A total of 2.5 kg of substrate and 250 gm of attractant were placed into the top chamber
  - The attractant was composed of a mixture of blood, meat trimmings and rotten eggs

…Methodology

- The substrate was exposed for 7 hrs to allow adult houseflies to oviposit and then covered
  - Substrates were refreshed weekly during the 3 weeks trial period
- Maggots were harvesting from day 4
  - Cleaned with water, blanched and then weighed.
- Temperature of substrate recorded prior to harvest

…Methodology

Life Cycle of House Fly



Source: https://bestpestcontroluk.wordpress.com/2014/08/10/life-cycle-of-a-house-fly/

…Results

- The two-chambered culture unit is simple and convenient to culture and harvest maggots
  - Maggots fall into harvesting chamber to hide away from light thus easily harvested
- Cattle offal yielded significantly higher amounts maggots ($p<0.05$)
- Temperature was significantly higher in poultry manure ($p<0.05$);
  - However, there was no relationship between temperature and yield, $r = .191$, p (one-tailed) $> .10$.

…Results

Yield and Temperature of Different Types of Substrates

No	Substrate	Yield (g)	Temperature (°C)
1.	Cattle Manure	21.57 ± 0.21^{d}	32.66 ± 3.50^{b}
2.	Poultry Manure	40.83 ± 0.67^{b}	41.60 ± 3.45^{a}
3.	Pig Manure	27.25 ± 1.29^{c}	34.66 ± 3.25^{b}
4.	Cattle Offal	50.47 ± 0.43^{a}	33.46 ± 5.05^{b}
5.	Kitchen Leftovers	27.24 ± 0.33^{c}	34.86 ± 4.45^{b}

Conclusion

- Conclusion
  - Two chambered culture unit is appropriate for mass production of maggots and convenient harvesting
  - Cattle offal produce high yield of maggots
- Further studies
  - Upscaling the two chambered culture unit for mass production of maggots
  - Improving "nutritive" value of poor yielding substrates

Funding for this research was provided by the

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Effects of stocking density on fry survival and growth of sahar *Tor putitora*

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

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Sahar (*Tor putitora)* is a high value indigenous fish species of Nepal. We achieved success in induced spawning of sahar using synthetic hormone in the sub-tropical climate of Nepal. An experiment was conducted for 90 days to determine the optimum density of sahar for fry rearing. Sahar fry of average initial weight 0.28 to 0.32 g were stocked at four different stocking densities in 2 m2 nylon hapas fitted in concrete tanks. The treatments were: 5 fish/m2 (T1); 10 fish/m2 (T2); 15 fish/m2 (T3); and 20 fish/m2 (T4). Each density treatment was replicated thrice. Fish were fed with commercial pelleted feed (32% CP) twice daily at 5% of the biomass. In situ water temperature, pH and dissolved oxygen were monitored weekly at 6.00-7.00 am.

The mean harvest weight and daily growth rate of fingerlings were highest in T1, intermediate in T2, and lowest in T3 and T4 (p<0.05; Table 1). The condition factor, specific growth rate and survival rate were not affected by stocking density (p>0.05). Temperature, pH and dissolved oxygen ranged from 28.5-31.5 oC, 7.3-9.6 and 6.0-9.5 mg/L, respectively. The present results demonstrated that sahar fry can be successfully reared up to density of 20 fish/m2 in nylon hapa with good survival and growth, although overall growth and harvested weight were considerably higher in the lowest density treatment.

TABLE 1. Growth and survival of sahar fry during the experimental period of 90 days (Mean±SE). Mean values with different superscripts in the same row are significantly different ($P<0.05$)

Parameter	Treatments			
	T_1 (5 fish/m^2)	T_2 (10 fish/m^2)	T_3 (15 fish/m^2)	T_4 (20 fish/m^2)
Mean stocking weight (g)	0.30 ± 0.01^a	0.29 ± 0.02^a	0.32 ± 0.02^a	0.28 ± 0.02^a
Stocking number (fish/hapa)	10.00 ± 0.00	20.00 ± 0.00	30.00 ± 0.00	40.00 ± 0.00
Average harvested weight (g)	6.13 ± 0.33^a	4.34 ± 0.98^{ab}	2.97 ± 0.55^b	2.84 ± 0.56^b
Harvest number (fish/hapa)	9.67 ± 0.33	19.00 ± 0.58	29.33 ± 0.33	36.33 ± 1.20
Daily growth rate (g/day)	0.08 ± 0.04^a	0.05 ± 0.01^{ab}	0.04 ± 0.01^b	0.03 ± 0.01^b
Specific growth rate (% BW/day)	1.46 ± 0.03^a	1.27 ± 0.15^a	1.06 ± 0.11^a	1.10 ± 0.14^a
Survival (%)	96.67 ± 3.33^a	95.00 ± 2.89^a	97.78 ± 1.11^a	90.83 ± 3.00^a

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EFFECT OF STOCKING DENSITY ON FRY SURVIVAL AND GROWTH OF SAHAR *Tor putitora*

Narayan P. Pandit*, Jay D. Bista, Rahul Ranjan, Madhav K. Shrestha and James S. Diana
Department of Aquaculture, Agriculture and Forestry University, Nepal

INTRODUCTION

- Sahar (*Tor putitora)* is a high-value indigenous riverine fish species of Nepal.

- This species is under threat of decline from its natural habitat.

- Sahar has a huge aquaculture potential.

- We have been working for establishing sahar aquaculture in Nepal.

Fig. *Tor putitora*

• We achieved success in induced spawning of sahar using synthetic hormone in the sub-tropical climate of Nepal.

• Nursery management of sahar is a major part of seed production.

• In the present study, we evaluated the effect of stocking density on fry survival and growth of sahar.

MATERIALS AND METHODS

Experimental design

- **Experiment site:** Agriculture and Forestry University, Nepal

- **Experimental period:** 90 days (10 June – 9 Sep, 2017)

- **Experiment unit:** Fine meshed nylon hapa (2m x 1m x 1.2 m) suspended in cemented pond

- **Treatments:** 4 different stocking densities

- **Replication:** 3

Fig. Fine meshed nylon hapas fitted in cemented ponds.

Treatments

1. 5 fish/m^2 (T_1)
2. 10 fish/m^2 (T_2)
3. 15 fish/m^2 (T_3)
4. 20 fish/m^2 (T_4)

Stock size: 0.28 to 0.32 g

Feeding

- **Feed:** 32% commercial pellet feed
- **Feeding rate:** 5% of total biomass
- **Feeding frequency:** Twice daily

Water quality monitoring

- **Parameters:** Temperature, pH, dissolved oxygen, Transparency
- Frequency: Weekly
- Method: In situ at 6.00-7.00 am

RESULTS

Table. Growth and survival of sahar fry in different stocking densities

Parameter	Treatments			
	T_1 (5 fish/m^2)	T_2 (10 fish/m^2)	T_3 (15 fish/m^2)	T_4 (20 fish/m^2)
Mean stocking weight (g)	0.30±0.01[a]	0.29±0.02[a]	0.32±0.02[a]	0.28±0.02[a]
Stocking number (fish/hapa)	10.00±0.00	20.00±0.00	30.00±0.00	40.00±0.00
Average harvested weight (g)	6.13±0.33[a]	4.34±0.98[ab]	2.97±0.55[b]	2.84±0.56[b]
Harvest number (fish/hapa)	9.67±0.33	19.00±0.58	29.33±0.33	36.33±1.20
Survival (%)	96.7±3.33[a]	95.0±2.89[a]	97.8±1.11[a]	90.8±3.00[a]

- Final harvest weight was significantly higher in T_1 than T_3 and T_4 ($p \leq 0.05$).
- No significant difference on survival among treatments.

Fig. Fingerlings of sahar at harvest.

Growth rate

Table. Growth rate of sahar fry in different stocking densities

Parameter	**Treatments**			
	T_1 (5 fish/m^2)	**T_2** (10 fish/m^2)	**T_3** (15 fish/m^2)	**T_4** (20 fish/m^2)
Daily growth rate (g/day)	0.08±0.04[a]	0.05±0.01[ab]	0.04±0.01[b]	0.03±0.01[b]
Specific growth rate (% BW/day)	1.46±0.03[a]	1.27±0.15[a]	1.06±0.11[a]	1.10±0.14[a]
Condition factor K = W / L3 x 100	1.56±0.11[a]	1.00±0.22[b]	0.92±0.18[b]	0.76±0.25[b]

- Daily growth rate and condition factor were significantly higher in T_1 than T_3 and T_4 ($p \leq 0.05$).
- No significant difference on specific growth rate among treatments.

Water quality

Table: Mean and range of water quality parameters during experimental period

Parameter	**Mean (Range)**
Temperature (°C)	30.1 (29.1-31.8)
Dissolved oxygen (mg/L)	7.7 (3.1-10.4)
pH	8.4 (7.3-9.3)
Secchi disk depth (cm)	30.5 (26.8-33.5)

Growth trend

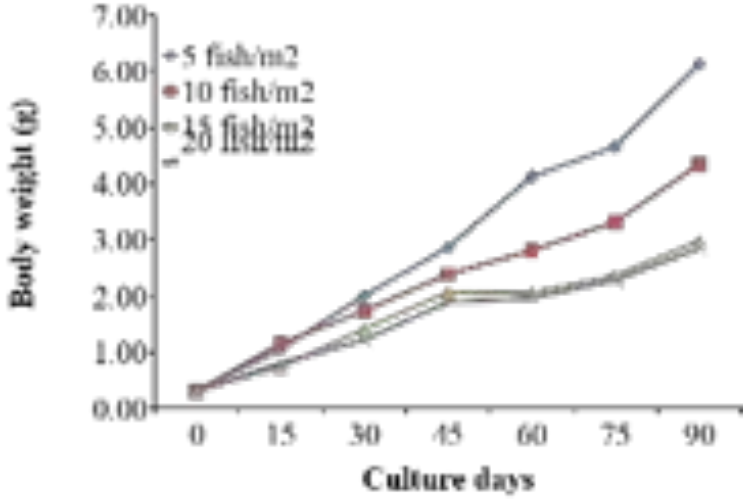

Figure: Growth trend of fish in different treatments during experimental period

Summary

• Final harvest weight, daily growth rate and condition factor were significantly higher in low density treatment.

• Stocking density of sahar fry from 5-20 fish/m^2 has no significant effect on survival.

Funding for this research was provided by the

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Thank You

Performance of domesticated (Vietnamese) vs. non-domesticated (Cambodian) snakehead *Channa striata* during weaning and growout

Phanna Nen*, Phen Chheng, Nam So, Tran Thi Thanh Hien, Bui Minh Tam, Hillary Egna and David A. Bengtson

Inland Fisheries Research and Development Institute, Phnom Penh, Cambodia

In Cambodia, snakehead *Channa striata* collected as wild juveniles have traditionally been cultured in small cages and ponds. The main type of feed used was small-sized or low-value fish (SS fish). The government of Cambodia put a ban on snakehead farming in September 2004 due to the potential negative impacts on wild fish populations from snakehead seed collection and on SS fish species diversity. New breeding, weaning and feed technologies from Vietnam were transferred to Cambodia. Because Cambodian broodstock fish have not yet been domesticated, the opportunity existed to evaluate the survival and growth of larvae from wild vs. domesticated broodstock and subsequent grow-out of the weaned fish.

The experiment was conducted at the Freshwater Aquaculture Research and Development Center (FARDeC), Prey Veng province, Cambodia. In addition to available breeders already at FARDeC (referred to here as F1, the offspring of Cambodian wild-caught fish), adult wild *C. striata* from Cambodian waters in Tonle Sap (TS) and The Mekong River (MR), were collected and conditioned for spawning at FARDeC. Domesticated snakehead (VN) were purchased from a hatchery in Vietnam and conditioned at FARDeC for spawning. Larvae were fed live *Moina*, followed by ground SS fish. The experiment began at 17 day after hatched with replacement of SS fish by formulated feed using the Vietnamese protocol. The experiment consisted of four treatments with six replicates each, with larvae originating from the four broodstock groups: F1, TS, MR and VN. All treatments were subjected to the same weaning protocol in 100-L tanks at 5 fish/L fed to satiation by hand twice daily. Following weaning, fish from each treatment and replicate were transferred to corresponding treatments and replicates in ponds at FARDeC for the 6-month grow-out phase of the study. Each replicate was now contained in a 3 m x 1 m x 1.5 m hapa net. Fish were fed commercial pelleted feed to satiation by hand twice daily.

Domesticated snakehead grew significantly faster (ca. 10 g) than non-domesticated Cambodian fish (ca. 4-5 g) in the hatchery, followed by continued rapid growth (to ca. 350 g vs. 140-150 g) in the grow-out phase, largely due to increased feed consumption. Cannibalism rates ranged from 40-42% in the hatchery phase except for MR fish (57%) and in the grow-out phase, cannibalism was lowest for domesticated snakehead and highest for MR non-domesticated snakehead (12-45%, respectively). Results will inform Cambodian aquaculture policy following the lifting of the ban in 2016.

This research was funded in the past by the AquaFish Innovation Lab under USAID CA/LWA No. EPP-A-00-06- 00012-00 and by US and Host Country partners. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the AquaFish Innovation Lab or the US Agency for International Development.

Sustainable Snakehead Aquaculture Development in the Lower Mekong River Basin of Cambodia

Performance of Domesticated (Vietnamese) vs. Non-Domesticated (Cambodian) Snakehead *Channa Straita* During Weaning and Grow-Out

Mr. Nen Phanna
Aquaculture America 2018
22 February 2018
Las Vegas

Outline

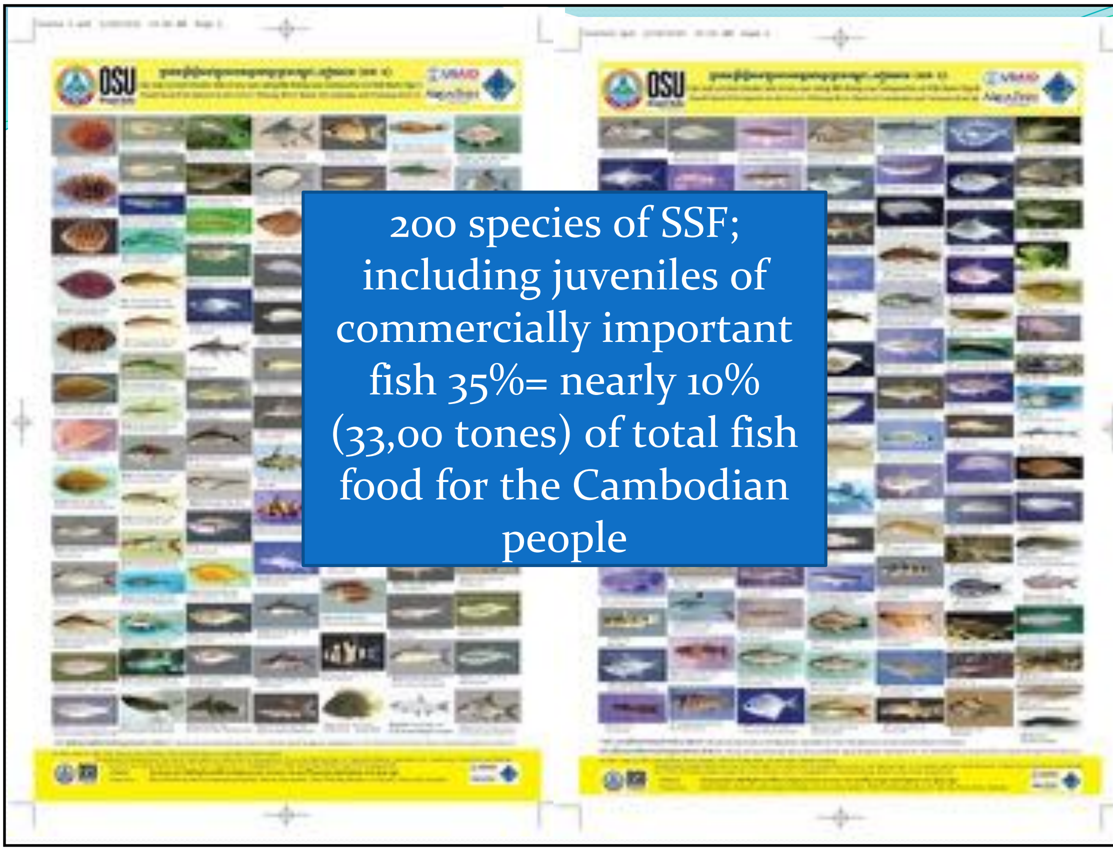
- Introduction
- Objective
- Methodology
- Result
- Conclusion

Introduction

▪Fish is the most important source of protein (> 80% of total animal protein) for consumption.

- Per capita consumption: 52.4 kg/ person/year

Use of Small- size fish in Snakehead culture



200 species of SSF; including juveniles of commercially important fish 35%= nearly 10% (33,00 tones) of total fish food for the Cambodian people

Objectives

- To continue the domestication and development of Cambodian snakehead *Channa striata* brooders in F_1 generation into F2 as comparing to the wild snakeheads in different natural water bodies and the domesticated-hatchery snakeheads.
- Compare growth performance and survival rate of different snakehead strains regarding to weaning and grow-out on formulated pellet

Methods

- Collection and condition of brood snakehead fish from different natural water bodies and hatcheries
- Conditioning and induced spawning
- **Weaning:** (F1 vs wild T. Sap vs wild Mekong vs Vietnam's brooders) using the protocol (Hien and Bengtson 2009; 2011): 4 treatments, each with 6 replicated tanks (100 L @ 5 fish/L).
- **Grow-out:** (F1 vs wild T. Sap vs wild Mekong vs Vietnam's brooders) on commercial pellet: 4 treatments each with 6 replicated hapas (3m x1.5mx1.5m, @ 300 fish/hapa) .

- Collection and condition of snakehead brooders

- Collection sites of wild snakehead brooders

Brooder conditioning

Induced spawning

- Induced spawning

- Egg collection and incubation

Weaning experiment

Stocking: 5 larvae/L (3-day old) in 50-L tank

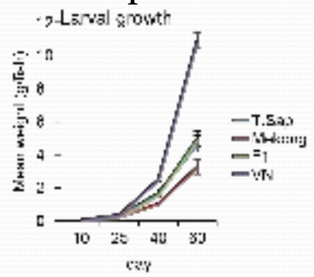
Feeding to satiation: 3-dah: live moina; 10-dah: dead moina+Trash fish(replaced 20%/d by TF); 17-dah: start weaning with TF + Formulated Feed (replaced 10%/d by FF) until TF was completely substituted by FF (day 30)

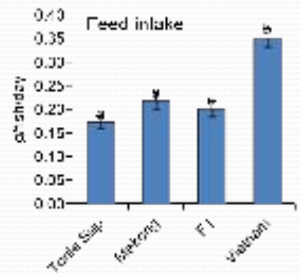
- Formulated feed preparation (wet)

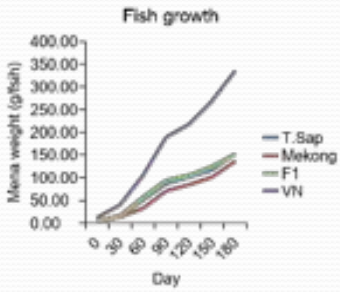
Grow-out in Hapa(3mx1mx1.5m)

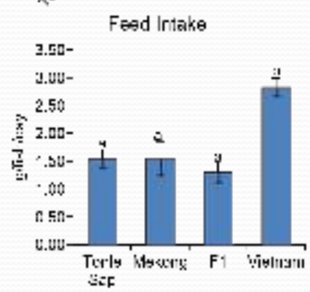
Result

- Growth performance and feed intake









Result(cont'd)

	Survival rate (%)	Cannibalism rate (%)	Weight gain ($g.fish^{-1}$)	FCR	Yield.$hapa^{-1}$ (kg)
Hatchery phase					
Vietnam	41.6 ± 3.4 B	41.1 ± 3.1 B	10.88 ± 0.47 A	1.63 ± 0.11 A	-
Tonle Sap	55.8 ± 2.9 A	42.0 ± 3.0 B	4.66 ± 0.50 B	1.91 ± 0.11 A	-
Mekong	39.0 ± 3.8 B	57.2 ± 4.0 A	3.24 ± 0.43 B	3.82 ± 0.86 B	-
F1	53.8 ± 3.6 A	40.2 ± 3.2 B	4.96 ± 0.46 B	2.06 ± 0.09 B	-
Grow-out phase					
Vietnam	80.8 ± 4.4 A	12.3 ± 4.0 A	324.2 ± 8.0 A	1.57 ± 0.06 A	81.0 ± 3.6 A
Tonle Sap	67.0 ± 5.6 A, B	27.4 ± 5.3 B	148.1 ± 16.4 B	1.90 ± 0.08 A	27.3 ± 1.93 B
Mekong	50.7 ± 9.4 B	45.1 ± 8.8 B	132.9 ± 19.0 B	2.08 ± 0.24 A	17.4 ± 2.91 B
F1	77.6 ± 5.0 A	21.0 ± 4.7 A	147.2 ± 17.7 B	1.59 ± 0.05 A	35.0 ± 3.44 B

Conclusion

- 1. Both strains of snakehead can accept formulated feed, however, domesticated snakehead show significantly higher survival and growth performance probably due to high feed intake, while maintaining an acceptable FCR.

- 2. The finding that the fish in the F1 treatment in our experiment were similar to fish in the other treatments derived directly from Cambodian wild-caught fish suggests that any selection in the hatchery probably does not occur in just one generation.

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Aquaculture of African lungfish *Protopterus aethiopicus* in Uganda: Captive breeding and larval rearing

J. Walakira*, C. Aruho, B. Kimera, E. Ganda, L. Nakasiga, J. Molnar, B. Readings and R. Borski

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 study reveals the genetic diversity of *P. aethiopicus* collected from Lakes Wamala, Kyoga, Nawampasa, Bisina, Edward and George, which guide its aquaculture and biodiversity. Lungfish fertilized eggs can hatch at a range of 24-32C but optimally at 27C. Hatchability in captivity is 21.7 ± 7.2 % (SD) while its mean fecundity (wild brood) =1922.41 ±1227.6. Salt and temperature improves hatchability. Larvae fed on decapsulated *Artemia sp.* and microdiet (35-57% Crude Protein) indicate a fish can be raised on artificial commercial diets. Developing low-cost sustainable breeding techniques will contribute to improve nutrition and livelihoods of vulnerable communities

AQUACULTURE OF AFRICAN LUNGFISH (*Protopterus aethiopicus*) IN UGANDA: CAPTIVE BREEDING AND LARVAL REARING

J. Walakira, C. Aruho, B. Kimera, E. Ganda, L. Nakasiga, J. Molnar, B. Readings, R. Borski et al.

America Aquaculture 2018

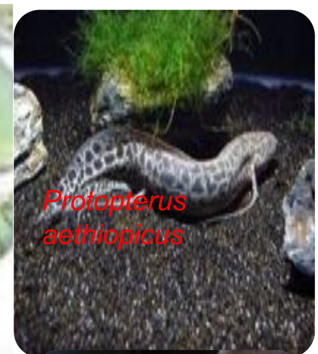
African lungfish

- Species: *Protopterus aethiopicus* (Haeckel 1851)
- Genus: Protopterus
  - African lungfish with 4 living species
- Class: Sarcopterygii
  - Lobe finned fishes
- Order: Ceratodontiformes
  - Australian, S. American and African species

Source: http://www.fishlinkworldwide.com

Distribution of African lungfish

Protopterus annectans



Protopterus aethiopicus

Protopterus dolloi

Source: Paugy et al. (2008); Froese and Pauly (2009); Otero, (2011). http://www.britannica.com/animal/lungfish

Why lungfish?

Improves food nutrition & Income

Highly demanded by low income earners

Aquaculture potential: BAIT & Food

- Bio-control agent against shistomiasis (Daffalla et al. 1985)
- Evolutionary Research

AFRICA THE 'MOST DANGEROUS' PLACE TO BE BORN - REPORT

The United Nations Children's Fund says global infant deaths remain alarmingly high, especially in the lower-income countries.

Problem & solution

- anthropogenic factors: decline in stocks (Goudswaard et al. 2002)
- Intervention: Aquaculture production
- Problem: Lack of breeding technologies

Objectives

Objective 1:

a)Understand the Genetic diversity of African lungfish for use in aquaculture in Uganda

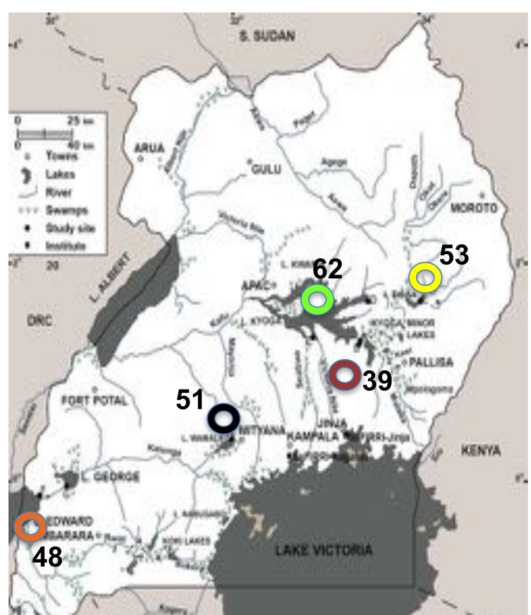
b)Develop a panel of SNP to guide the domestication of African lungfish

Objective 2:

a)Understand the reproductive biology of A. lungfish

b)Develop protocols for producing lungfish seed ,

Diversity lungfish populations using mtDNA



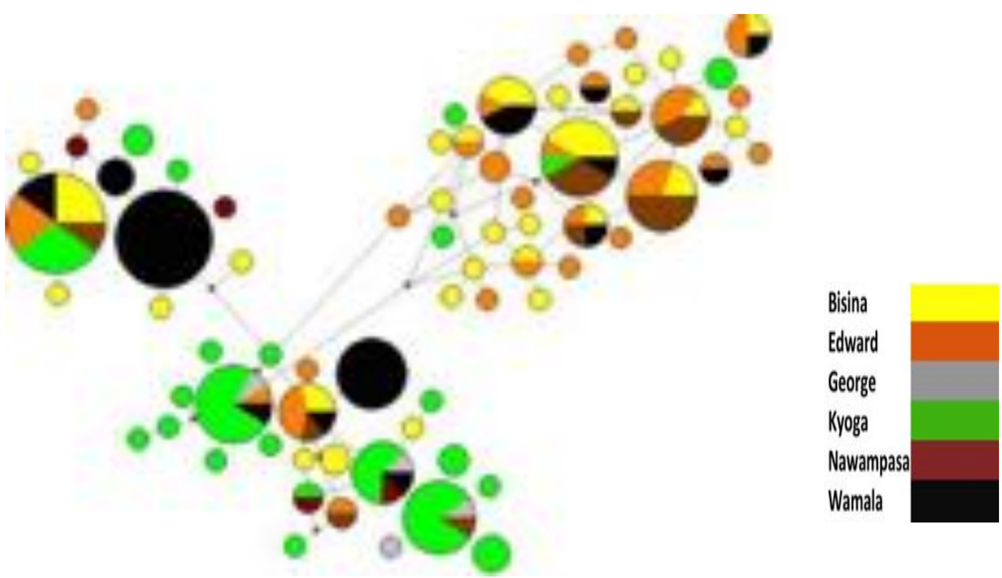
AMOVA

Source of Variation	d.f.	Sum of Squares	Variance components	Percentage of variation
Among populations	5	182.885	1.009 V_a	20.91
Within populations	197	751.608	3.815 V_b	79.09
Total	202	934.493	4.824	

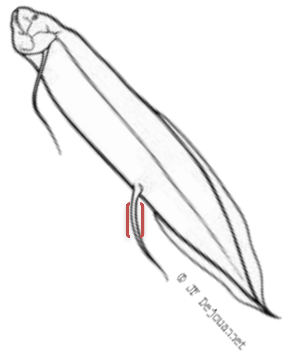
Fixation Index F_{ST} : 0.209

All values significant $P < 0.001$

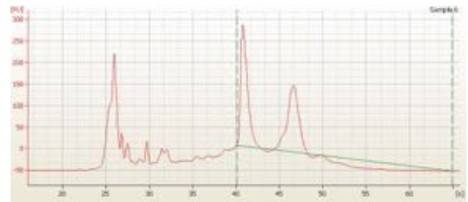
ADMIXTURE, RECURENT AND HISTORICAL GENEFLOW

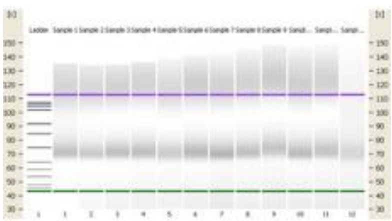


Nucleotide diversity: SNP panel using RNA Seq



Total RNA from 30/60 : Trizol protocol



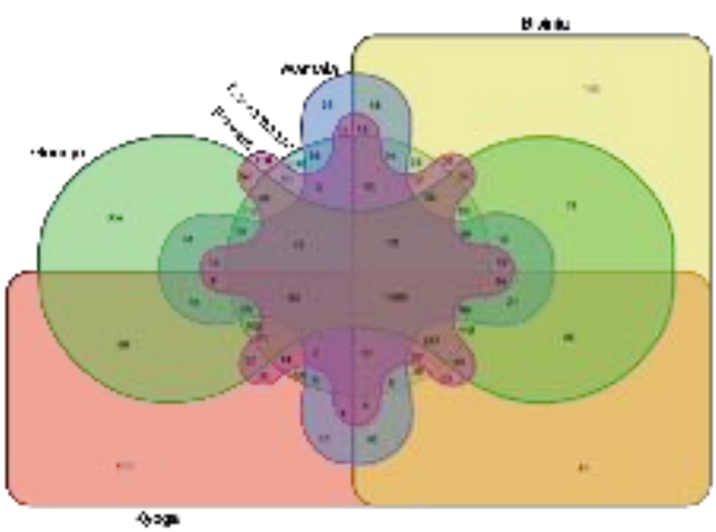


cDNA, MiSeq platform

mRNA from 18 samples (3/lake); QubIt: 10.4 - 46.7, BIOANALYSER

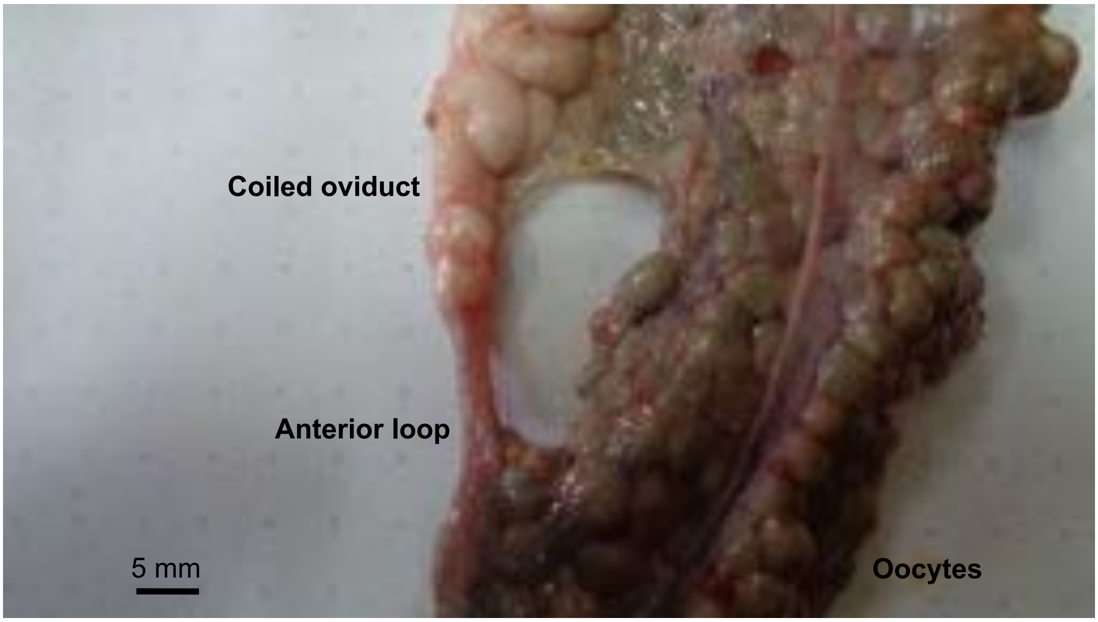
71191331 reads; Paired end 2X 300; 35 – 301 bp

Generated a novel informative panel of 198 SNPs

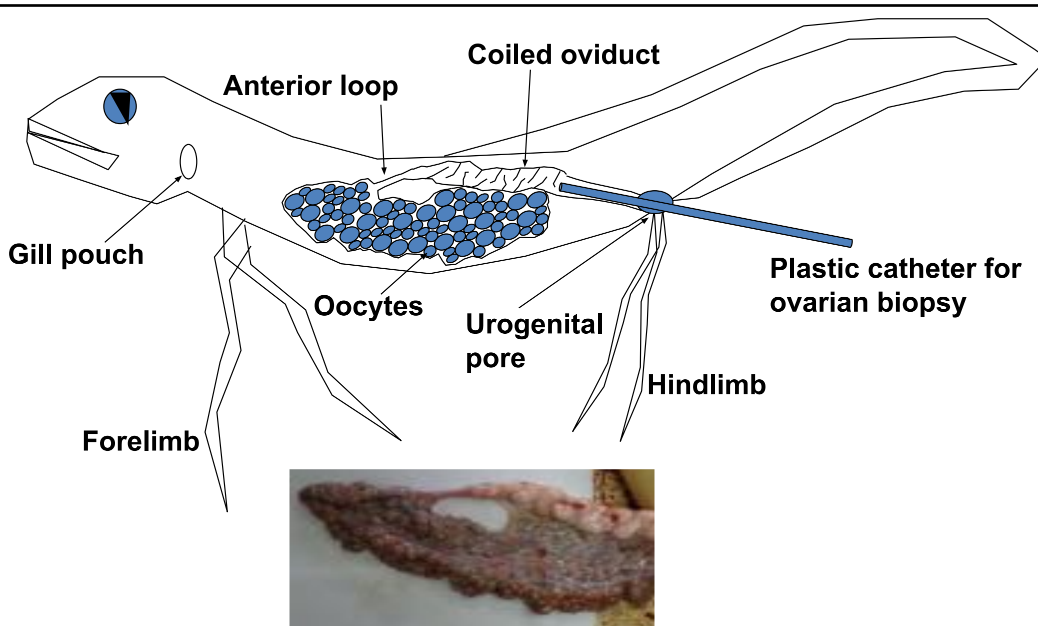


Reproductive biology

A plastic catheter has been inserted several centimeters into the oviduct of the African lungfish (*Protopterus aethiopicus*) and the tip of the scalpel indicates where the duct begins coiling. Oocytes pass down the oviduct from anterior to posterior. Due to the anterior loop leading from the ovary proper, it is not possible to sample oocytes directly from the ovary using the biopsy tool unless the oocytes have been ovulated and are present in the posterior oviduct near the urogenital pore.



African lungfish (*Protopterus aethiopicus*) ovary showing the olive colored oocytes, with the largest clutch being about 3.5-4.5 mm in diameter. A short anterior loop connects the ovarian sac containing the oocytes to a coiled oviduct that extends posterior to the urogenital pore. Scale bar = 5 mm.



The plastic catheter can only be inserted into the urogenital pore as far as the oviduct is straight. Maturing oocytes in the anterior part of the ovary pass through the anterior loop and then descend posteriorly toward the urogenital pore through the coiled oviduct. The African lungfish (*Protopterus aethiopicus*) has an asynchronous ovary and will ovulate a small clutch (200-500) oocytes at a time that will travel down the oviduct for spawning. Females spawn multiple times during the breeding season.

Gonad somatic index (GSI) and seasonality: L. Wamala

Female ($F_{6\text{-}330}$ = 1.7, p = 0.099); (May –July)
Male ($F_{6\text{-}115}$ = 0.0972, p=0.448); (August –Sept)

GSI and seasonality: L. Bisina

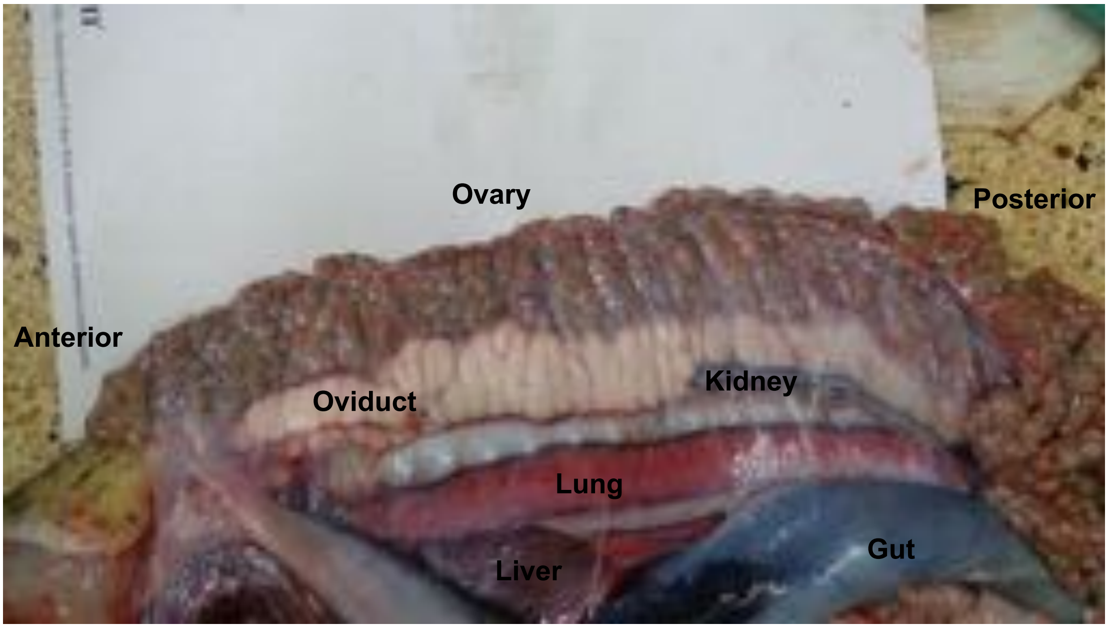
Female ($F_{6\text{-}295}$ = 2.775, p = 0.013) (Aug, Sept & Nov)
Male ($F_{6\text{-}209}$ = 1.497, p = 0.18); (July & November)

Batch Fecundity: L. Wamala

Eggs per g = 0.8±0.4

Batch Fecundity: L. Bisina

eggs per gram was 0.9±0.5



African lungfish (*Protopterus aethiopicus*) gross abdominal dissection showing the olive colored oocytes within the ovary, the white, coiled oviduct and associated with the kidney, the lung, the liver and the gut (alimentary canal).

Hormonal impact

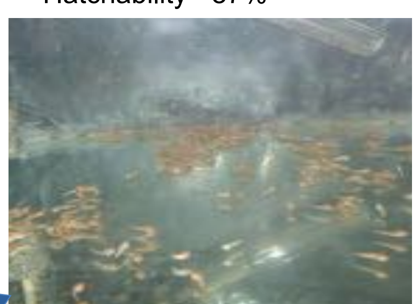
HORMONE USED	MASS (g)	40% VOLUME/mls 1st DAY	60% VOLUME/mls 2nd DAY	TOTAL VOLUME/mls	RESPONSE
LHRHA CONC. 300ug/Kg	187	0.24	0.36	0.6	None
	221	0.24	0.36	0.6	None
	361	0.32	0.48	0.8	Active
	354	0.32	0.48	0.8	Active
	768	0.56	0.84	1.4	Active
	877	0.64	0.96	1.6	Active
	480	0.4	0.6	1.0	Active
	460	0.4	0.6	1.0	Active
HCG CONC. 400 IU/Kg	172	0.24	0.36	0.6	None
	674	0.48	0.72	1.2	Active
	258	0.24	0.36	0.6	None
	184	0.24	0.36	0.6	None
	153	0.24	0.36	0.6	None
	174	0.24	0.36	0.6	None
	354	0.32	0.48	0.8	Active
	344	0.32	0.48	0.8	Active

Optimum Hatchability temp

Lungfish Seed production

(34-45)mm

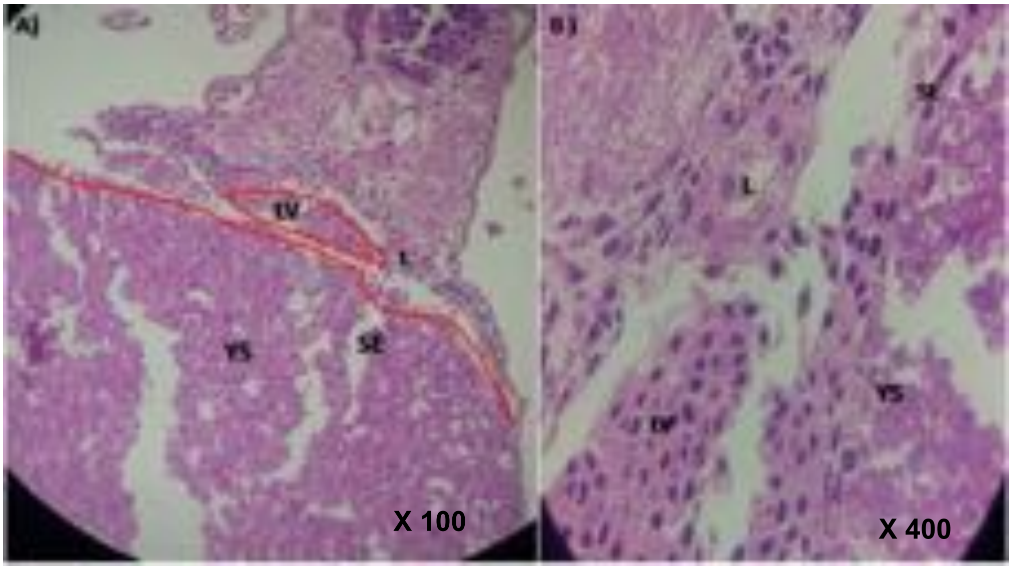
Hatchability= 87%



(90-120)mm

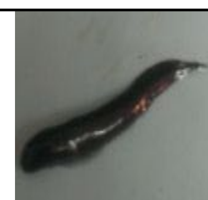
survival= 74-%

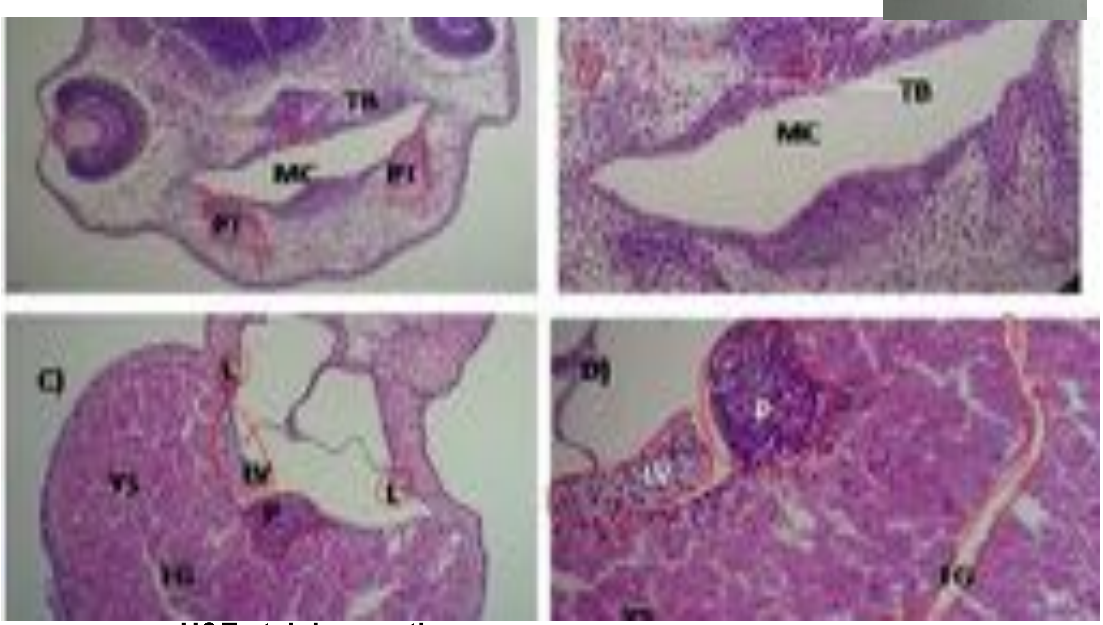
4 DAH



H&E staining sections

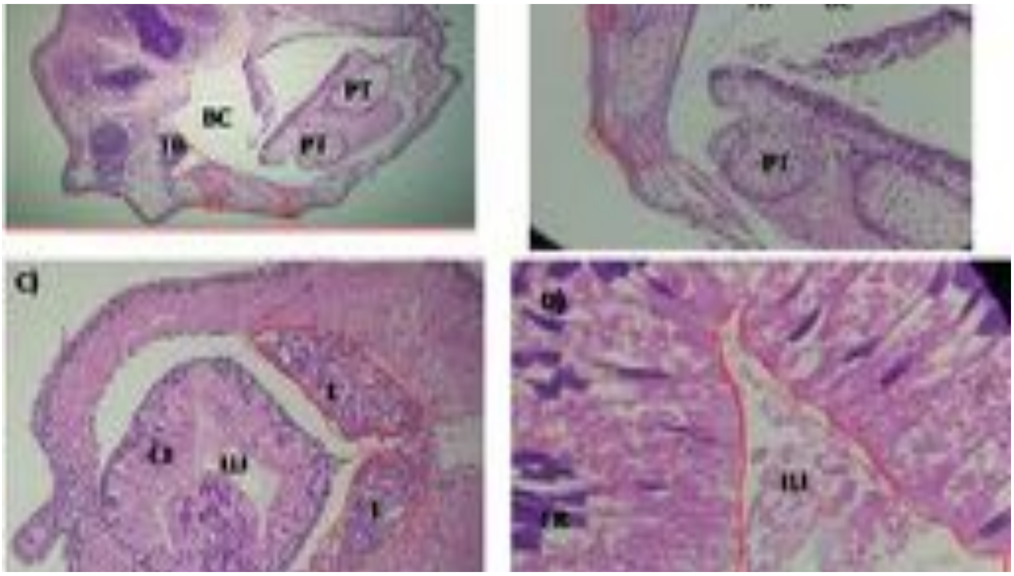
From 14 DAH





H&E staining sections

18 DAH



H&E staining sections

Nursing lungfish has improved survival

EXPERIMENTAL FISH larvae			
PARAMETERS	DRY FEED	ARTEMIA	MIXTURE
INNITIAL MEAN WEIGHT(g)	0.053± 0.006	0.053 ± 0.006	0.053± 0.006
FINAL MEAN WEIGHT (g)	0.138± 0.008^{b}	0.219 ± 0.001^{a}	0.202 ± 0.009^{a}
SPECIFIC GROWTH RATE	0.972±0.002^{b}	1.1957 ± 0.014^{a}	1.1603 ± 000^{a}
FEED CONVERSION RATIO	0.973 ± 0.003^{a}	0.554± 0.004^{b}	0.611± 0.004^{b}
WEIGHT GAIN (%)	155.598±0.000	313.270±0.000	279.201±0.000
MEAN SURVIVAL (%)	48.330 ±0.410	**73.330 ± 0.736**	61.670 ± 0.833

Growth trends

Conclusions

- Lungfish is less diversified based on mtDNA
- A total of novel 198 SNPs with a maximum heterozygosity values is considered highly informative
- induced spawning is feasible using LRHa and HCG
- Weaning of larvae should start after 14 DAH.
- Basic information for breeding, conservation, management and genetic diversity

Funding for this research was provided by the

AQUAFISH INNOVATION LAB

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Potential for polyculture of tilapia *Oreochromis nilotius* and freshwater perch *Anabas testudineus* with pangasius catfish *Pangasius hypopthalamus* in the hyposaline waters of southern Bangladesh

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M. Jabir Al Mehedi, and Russell Borski

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Pangasius catfish (*Pangasius hypopthalamus*), tilapia (*Oreochromis niloticus*), and freshwater perch (*Anabas testudineus*; locally known as *Koi*) are three of the most successful freshwater aquaculture species in Bangladesh. We previously established that *Pangasius* can be cultured in hyposaline waters, allowing for use of coastal waters affected by salinity encroachment. In the present study, we assessed the potential for culturing *Pangasius* with the higher valued tilapia and freshwater Koi in hyposaline waters of coastal Bangladesh as a means of improving the food security and economic viability of these salinity affected region's poor communities. The experiment was conducted in 16 farmer's ponds in the Patuakhali district of Bangladesh at a salinity of 5-6 ppt. Four culture types were examined (Table 1) with fish being fed commercial pellet feed (CP 28-30%) twice daily at a total rate of 10% down to 3% body weight per day.

The study revealed that Koi can be cultured in saline waters as high as 6 ppt and that the highest yields could be obtained through solo culture of *Pangasius* (T1). However, due to the higher market value of tilapia and greater increases in body weight of both *Pangasius* and tilapia, the largest profit came from the co-culture of these two species (T2). This was followed by co-culture of Pangasius with Koi (T3). Conversely, the lowest yield and profit resulted from the culture of all three species together (T4). Thus, the results suggest that tilapia is the optimal candidate for polyculture with *Pangasius* in hyposaline waters with a *Koi* polyculture providing the second greatest profit margin. Adoption of such aquaculture practices in coastal Bangladesh could increase earnings and improve the livelihoods of the people inhabiting these areas.

(Supported by the AquaFish Innovation Lab - USAID)

Table 1. Production parameters for cultures of *Pangasius*, Tilapia, and *Koi*.

Parameters	T1	T2		T3		T4		
	Pangasius	Pangasius	Tilapia	Pangasius	Koi	Pangasius	Tilapia	Koi
Stocking (/m^2)	4	2	2	2	2	2	1	1
Initial weight (g)	6.52±0.03	6.52±0.03	0.54±0.01	6.52±0.03	0.50±0.02	6.52±0.03	0.54±0.01	0.50±0.02
Final weight (g)	637±6.41	687±6.60	282±6.12	646±8.12	169±6.50	672±7.63	276±4.21	123±4.85
Weight gain (g)	630±3.66^a	680±2.39^b	282±3.87^c	642±1.45^a	171±1.20^c	665±2.29^a	275±1.94^c	122±2.40^c
Survival rate (%)	94.38±0.95^a	94.58±0.41^a	90.83±1.10^a	94.17±0.41^a	87.92±1.10^b	92.50±1.14^a	87.5±1.14^b	85.83±2.21^c
SGR (% per day)	3.05±0.003^a	3.11±0.003^b	4.23±0.009^c	3.07±0.003^a	3.89±0.006^c	3.09±0.003^{ab}	4.21±0.006^f	3.67±0.011^c
FCR	1.35	1.30		1.33		1.33		
Yield (kg/ha)	22292±141^a	12837±62	5064±123	12065±52	2980±53	6138±87	2431±12	1022±13
		17901 ± 66^b		15045 ±73^c		9590±65^d		
Profit (USD/ha)	3607.37^a	6259.76^b		4126.71^a		2852.53^c		

Welcome To My Presentation

POTENTIAL FOR POLYCULTURE OF TILAPIA *Oreochromis nilotius* AND FRESHWATER PERCH *Anabas testudineus* WITH PANGASIUS CATFISH *Pangasius hypopthalamus* IN THE HYPOSALINE WATERS OF SOUTHERN BANGLADESH

Presented By
Dr. Md. Lokman Ali
Professor
Faculty of Fisheries
Patuakhali Science and Technology University, Banglsdesh

2

Background

- The river catfish (*Pangasius hypopthalamus*) was introduced to Bangladesh in 1990's, and since then it has become a thriving aquaculture industry with over 300,000 tones produced annually.

- Pangasius catfish (*Pangasius hypopthalamus*), tilapia (*Oreochromis niloticus*), and freshwater perch (*Anabas testudineus*: locally known as Koi) are three of the most successful freshwater aquaculture species in Bangladesh.



Background

- We previously established that Pangasius can be cultured in hyposaline waters, allowing for use of coastal waters affected by salinity encroachment. In the present study, we assessed the potential for culturing Pangasius with the higher valued tilapia and freshwater climbing perch (Koi) in hyposaline waters of coastal Bangladesh as a means of improving the food security and economic viability of these salinity affected region's poor communities.


OBJECTIVES

1) **Evaluate if freshwater Koi (climbing perch) can be successfully cultured in seawater-encroached hyposaline waters of coastal Southern region of Bangladesh.**

2) Assess production performance and economic impacts of tilapia and Koi polycultured with *Pangasius* in brackish waters.

MATERIALS AND METHODS

➢ **Location and description of the study area**

- To implement this experiment, 16 farmer's pond were selected. Ponds were situated beside the Andharmanik river of Kalapara upazila under Patuakhali district of Southern Bangladesh those were affected by salinity intrusion.

Fig. Location of the study area of Kalapara Upazila under Patuakhali district in Bangladesh

➢ **Study period:**

The study was conducted for a period of five months from March, 2017 to July, 2017.

➢ **Experimental design:**

Parameter	**Treatment 1**	**Treatment 2**	**Treatment 3**	**Treatment 4**
***Pangasius* (fish/decimal)**	160 ($4.0/m^2$)	80 ($2.0/m^2$)	80 ($2.0/m^2$)	80 ($2.0/m^2$)
Tilapia (fish/decimal)	-	80 ($2.0/m^2$)	-	40 ($1.0/m^2$)
Koi (fish/decimal)	-	-	80 ($2.0/m^2$)	40 ($1.0/m^2$)
Salinity range (ppt)	5-8	5-8	5-8	5-8
Replication	4	4	4	4

- **Pond preparation**
  - Ponds were dried and 5 days later lime was applied at the rate of 1 Kg per decimal.
  - Then water was supplied in the experimental ponds from the Andharmanik river maintaining salinity of 5-6 ppt by adding freshwater.

Fig. Drying and liming to prepare pond for culture

- **Stocking:**

After pond preparation, fingerling of *Pangasius* and fry of Tilapia and Koi stocked.

The average initial weight of different fishes were 6.5g, 0.50g, and 0.50g for Panasius, Tilapia, and Koi, respectively.

Fig. Stocking of fry and fingerlings

- **Feeding**

The fishes were fed with commercial pellet feed (Lily Brand tilapia feed with CP 28-30%) at 10% down to 3% body weight twice daily.

- **Sampling procedure**

Fortnightly subsampling of the experimental fish were done using a cast net to measure growth performance of fish and to adjust feeding rate.

Fig. Sampling procedure

Training of Farmers


and Koi in Hyposaline Water

Sampling of Fish

Fish Harvesting :

Fish were harvested after 150-days of culture period. During harvesting length and weight of 10 fish from each pond were measured to calculate growth parameters. As well as the number of total fish was counted to observe survival rate.

RESULTS

- Significant difference (P>0.05) were observed in weight gain, survival rate, specific weight gain (SGR), total yield, and net profit among the species in different treatment.
- No significant difference were observed feed conversation ration (FCR).

RESULTS

- Although higher yield were found in T1 *(Pangasius* only), the profit was found higher in T2 (Pangasius and Tilapia) as the market price of Tilapia is higher than the Pangas.
- Second largest profit was found in T3 where Pangasius cultured with Koi
- Lowest yield and profit was found in T4 (Pangas, Tilapia, and *Koi*).

Table . Production parameters for cultures of Pangasius, Tilapia, and Koi.

Parameters	T1	T2		T3		T4		
	Pangasius	Pangasius	Tilapia	Pangasius	Koi	Pangasius	Tilapia	Koi
Stocking (/m^2)	**4**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
Initial weight (g)	**6.52±0.03**	**6.52±0.03**	**0.54±0.01**	**6.52±0.03**	**0.50±0.02**	**6.52±0.03**	**0.54±0.01**	**0.50±0.02**
Final weight (g)	**637±6.41**	**687±6.60**	**282±6.12**	**646±8.12**	**169±6.50**	**672±7.63**	**276±4.21**	**123±4.85**
Weight gain (g)	**630±3.66^{a}**	**680±2.39^{b}**	**282±3.87^{c}**	**642±1.45^{a}**	**171±1.20^{c}**	**665±2.29^{a}**	**275±1.94^{c}**	**122±2.40^{c}**
Survival rate (%)	**94.38±0.95^{a}**	**94.58±0.41^{a}**	**90.83±1.10^{a}**	**94.17±0.41^{a}**	**87.92±1.10^{b}**	**92.50±1.14^{a}**	**87.5±1.14^{b}**	**85.83±2.21^{c}**
SGR (% per day)	**3.05±0.003^{a}**	**3.11±0.003^{b}**	**4.23±0.009^{c}**	**3.07±0.003^{a}**	**3.89±0.006^{c}**	**3.09±0.003^{ab}**	**4.21±0.006^{c}**	**3.67±0.011^{c}**
FCR	**1.35**	**1.30**		**1.33**		**1.33**		
Yield (kg/ha)	**22292±141^{a}**	**12837±62**	**5064±123**	**12065±52**	**2980±53**	**6138±87**	**2431±12**	**1022±13**
		17901 ± 66^{b}		**15045 ±73^{c}**		**9590±65^{d}**		
Profit (USD/ha)	**3607.37^{a}**	**6259.76^{b}**		**4126.71^{a}**		**2852.53^{c}**		

➢ Weight gain (g):

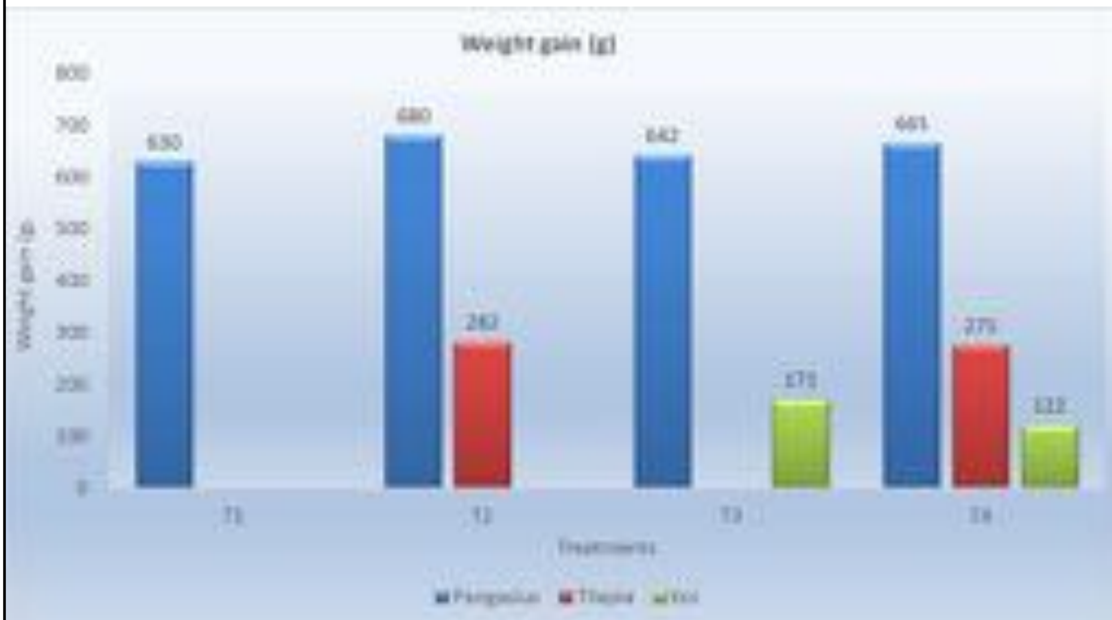

Fig: Weight gain (g) of *Pangasius*, Tilapia and Koi in different treatments through the study period

➢ Survival rate (%):

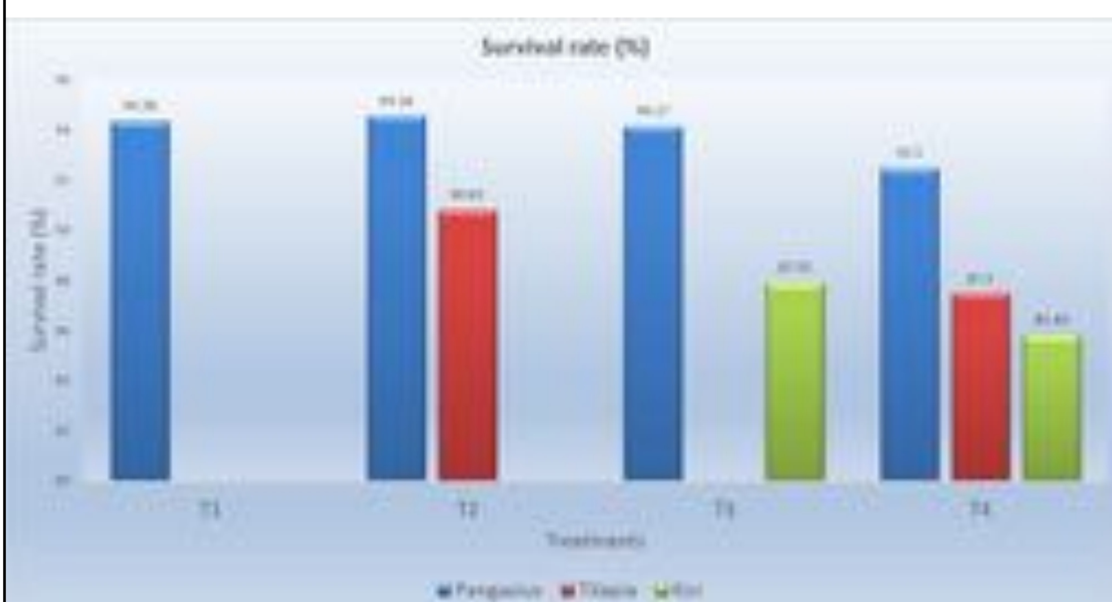

Fig: Survival rate of *Pangasius*, Tilapia and Koi in different treatments through the study period

➢ Specific Growth Rate (SGR)(% per day):

Fig: SGR of *Pangasius*, Tilapia and Koi in different treatments through the study period

➢ Total Yield (kg/ha):

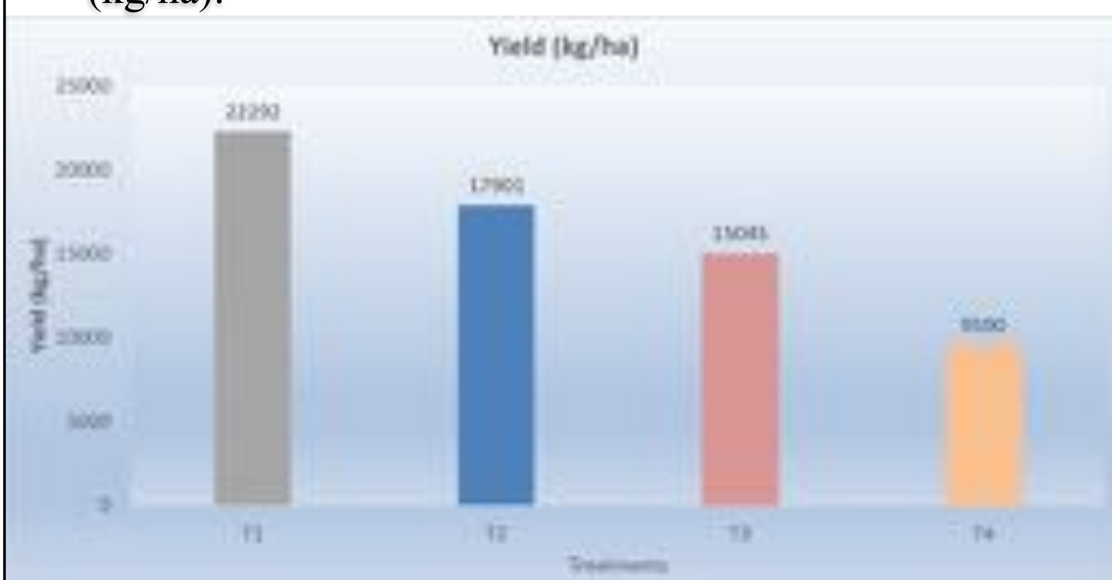

Fig: Total Yield (kg/ha) of *Pangasius*, Tilapia and Koi in different treatments through the study period

➢ Profit (USD/ha):

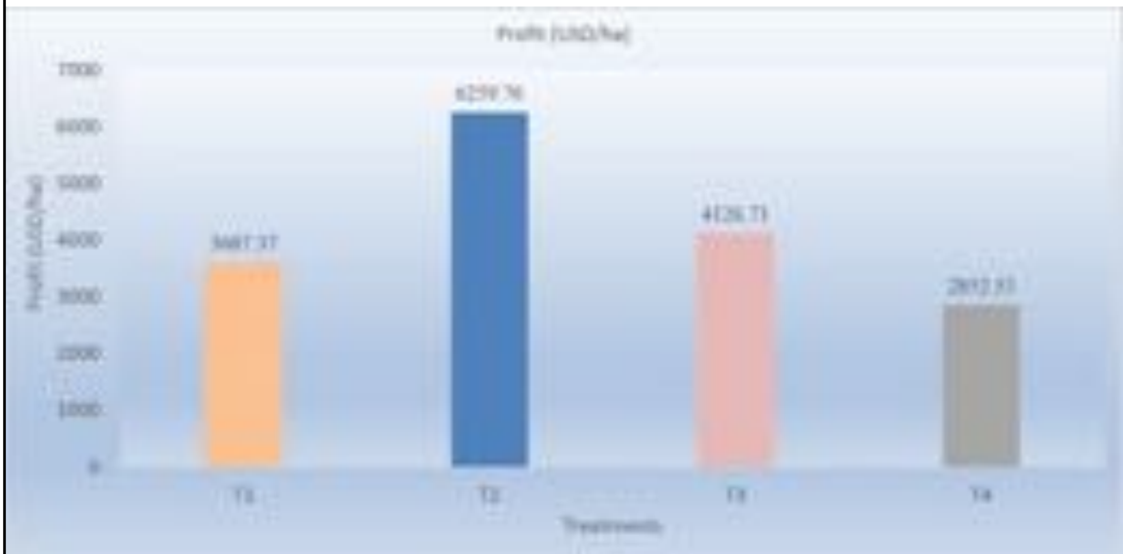

Fig: Profit (USD/ha) of *Pangasius*, Tilapia and Koi in different treatments through the study period

Conclusion

- ❖ The study revealed that Koi can be cultured in saline waters as high as 6 ppt.
- ❖ Tilapia is the optimal candidate for polyculture with *Pangasius* in hyposaline waters.
- ❖ Koi polyculture with *Pangasius* providing the second greatest profit margin.
- ❖ Tilapia and Koi should not culture with *Pangasius* together due to some antagonistic relation among three species.
- ❖ Adoption of Tilapia and Koi separately in *Pangasius* aquaculture in hyposaline waters could increase the income and improve the livelihood of the peoples in climate affected area.

Acknowledgement

PATUAKHALI SCIENCE AND TECHNOLOGY UNIVERSITY
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NORTH CAROLINA STATE UNIVERSITY

USAID
FROM THE AMERICAN PEOPLE

AQUA FISH
COLLABORATIVE RESEARCH
SUPPORT PROGRAM

Thanks To All

Induced spawning of sahar *Tor putitora* in Terai region of Nepal

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Sahar (*Tor putitora)* is a high value indigenous riverine species of Nepal which is declining in its natural habitat and has been declared an endangered species. Limited seed production using natural propagation has restricted its expansion in culture as well as rehabilitation in natural waters. We achieved success in artificial propagation of sahar using synthetic hormone. The breeding program was conducted at the Agriculture and Forestry University (AFU), Rampur, Chitwan and the Center for Aquaculture Research and Production (CARP), Kathar, Chitwan, Nepal during February to April 2017. Sixty five male (0.5-1.8 kg) and forty five female (1.1-2.1 kg) brood fish were reared in 500 m2 earthen ponds at 1000 kg/ha and transferred to 25 m2 concrete tanks one month before the breeding season. Fish were fed with 32% crude protein feed at 3% body weight per day. Maturity was observed weekly by sampling fish and testing softness of the abdomen. Female broodfish with a soft and extended abdomen were injected with synthetic hormone (Ovulin) at 0.6 mL/kg body weight. Males did not receive any hormone. 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. A total of 16 females were induced to spawn, and they produced 1630.80±184.30 (mean±SE) eggs per kg body weight. Mean hatching and larval survival rates were78.4±1.9 and 74.7±1.1%, respectively (Table 1). This study demonstrated that mass seed production and larval rearing of sahar is possible in the subtropical region of Nepal using induced breeding. When using natural spawning, a high frequency of females are not taken until they are overly mature, even with daily evaluation of maturity. Induced spawning reduces the number of over-matured females by synchronizing the stripping time of injected brood fish.

TABLE 1. Breeding performance of sahar using inducing hormone.

Parameter	Mean±SE
Breeding duration	2017-2-26 to 2017-4-9
Water temperature (°C)	21.4-28.5
Total female spawners	16
Mean weight of females (kg)	1.47±0.09
Mean weight of males (kg)	0.76±0.05
Mean total egg spawned (count)	2331.40±270.80
Mean egg number per kg body weight	1630.80±184.30
Mean egg number per gram egg weight	104.1±2.5
Mean fertilization rate (%)	96.8±1.5
Mean incubation period (hour)	79-90
Mean hatching rate (%)	78.4±1.9
Mean hatchling survival (%)	74.7±1.1

A F U

INDUCED SPAWNING OF SAHAR *Tor putitora* IN TERAI REGION OF NEPAL

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

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Introduction

- Sahar (*Tor putitora*) is economically important high value indigenous species of Nepal and well-known as sport fishing
- Despite their importance, their biological diversity is being threatened by various anthropogenic activities.
- It is long migratory, migrate upward to small rivers for natural spawning during rainy season.
- Sahar is still taken in capture fisheries in lakes and rivers but at present attempts to culture and conserve of Tor spp. has been initiated in Nepal

Sahar is one of the best candidate for :

Sport fishing

Ranching for conservation and sustainable use

Aquaculture

Objective

General objective

- To assess the breeding performance of Sahar in Terai region of Nepal

Specific objectives

- To assess the breeding season of sahar in Terai
- To evaluate the breeding performance of sahar with inducement of hormone
- To assess the growth and survival rate of fry in tropical climate

Methodology

- **Experimental setup**
  - at aquaculture farm (AFU) from August 2016 to April 2017
- **Brood fish selection**
  - 110 broods (45 female and 65 male)
  - Rearing in one earthen pond (400 m^2) and 35 female broods were shifted one month before spawning season
  - Two cemented pond (25 m^2)

- **Feeding management**
  - Fed with 32 % CP containing feed @ 3% of total biomass
- **Maturity observation**
  - Brood fish (only female) were checked for maturity in alternate day during season
- **Spawning method**
  - Induced spawning method was applied by using Ovaprime hormone

Maturity observation

Brood fish hauling

Maturity observation

Use of hormone

Ovaprim (Gonadotropine Releasing Hormone) was applied @ 0.5 ml/kg of female body weight as practiced in carps hatcheries in Nepal.



Hatchery operation




Egg incubation



Nursing of hatchlings

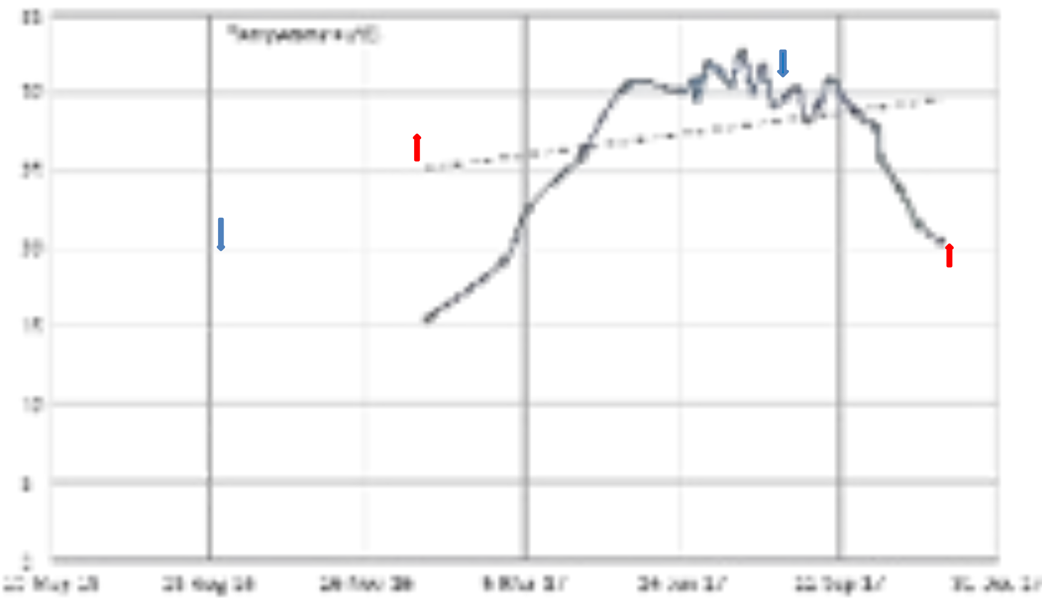
- Nursing and fry rearing was done as practiced in carp species
  - -Pond drying
  - -Liming
  - -Manuring
  - -Water management and
  - -Stocking of hatchling

Proximate composition of Floating feed

S.N	Description	%
1	Crude Protein	32
2	Crude Fat	9
3	Ash	8
4	Fiber	8
5	NFEE*	32
6	Moisture	10

* Nitrogen free ether extract

Result and discussion



Performance of induced spawning

Parameter	Mean±SE
Breeding duration	2017-2-26 to 2017-4-9
Water temperature (°C)	21.4-28.5
Total female spawners	16
Mean weight of females (kg)	1.47±0.09
Mean weight of males (kg)	0.76±0.05
Mean total egg spawned (count)	2331.40±270.80
Mean egg number per kg body weight	1630.80±184.30
Mean egg number per gr egg weight	104.1±2.5
Mean fertilization rate (%)	96.8±1.5
Incubation period (hour)	79-90
Mean hatching rate (%)	78.4±1.9
Mean hatchling survival (%)	74.7±1.1

Breeding performance

Description	Natural	Induced
Total no of spawners	6	16
Over matured brood	6	0
Not responded	0	5
Total egg spawned (gr)	115.0	329.5
Hatchling production	8970	25701
Hatchling to fry	6727	19276
	26000	

Reproductive behavior of Sahar

- Male get maturity within one year, though the size of fish even smaller (50-100 gm.)
- Female fish get maturity at the age of 3^{+} years (> 700 g).
- The mature broods get over maturity within very short time
- Sahar is well responded to induced spawning as practiced in other carps in Nepal
- Fecundity is lower then other carps but
- Can breed twice in a year which is not in carps
- Survival of hatchling to fry is higher then other carps

Conclusion and Recommendation

- Pond reared Sahar breed twice in a year in Autumn and Spring but spring is more favorable in Nepal.
- Higher spawning rate can be achieved by frequent checking of female and inducing hormone to avoid over maturity.
- Mass scale seed production can be possible by inducing hormone to large numbers of female at a time.
- This technology need to be giving out in Government and private hatcheries for producing large number of fry and made available to fish grower.
- Recently Five Govt Farms in tropical region start to culture sahar to grow up brood fish for hatchery operation.
- This is the immediate impact of this project.
- But the growth is very slow need to be assess further research on growth related aspects.

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WORLD FISHERIES DAY
21st November 2016
विश्व मत्स्य दिवस
६ मंसिर २०७३
सचेतना र्‍याली
खानका लागि माछापालन गरौं
प्राकृतिक जलाशयमा माछा संरक्षण गरौं ।
आयोजक
मत्स्य विज्ञान कार्यक्रम परिवार
कृषि तथा वनविज्ञान विश्वविद्यालय
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AQUA FISH

THANK YOU !

Consumer preferences and consumption patterns for fish in Uganda

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The current government policy on aquaculture is promotion of the subsector to complement dwindling capture fisheries supplies from the wild to improve nutrition and eradicate poverty. Much as the government is pursuing this policy there exists limited information on consumer behavior between captured and farmed fish. The objective of this study was to establish consumer preferences and consumption patterns for the two categories of fish. This study was carried out in selected districts representative of Uganda's fish consuming community that is, Nebbi, Kampala, Busia, Kasese, Kisoro and Kabale. A total of 350 consumers were randomly selected and interviewed using a structured questionnaire. Descriptive statistics and regression analysis were used to analyze the data.

The results show that consumers' average age was 33 years, had a household size of 6.74 persons and earning 628,200UGx monthly. Distance to the fish source was 3.49km and 70% of the respondents had eaten fish as a protein source for an average of 23 years. 92.5% bought tilapia which was mainly (62.2%) captured fish. When buying fish, 70% of fish consumers considered fish species as the most important attribute. The majority (55%) of consumers purchased their fish from traditional markets and the rest from roadside markets and landing sites. On average, consumers bought fish about 6 times per month, resulting in total consumption of 13.86kgs. There was a general preference (56%) for fish above 500gm. Many consumers (67.5%) preferred smoked fish and mainly (75%) prepared fish by boiling. 30% of the Consumers indicated that farmed fish in most cases was small size (< 300gm) and bonny. Some considered small size as a deterrent to their taking farmed fish as their purchase choice. 33% testified to have ever tasted farmed fish and noted its soil like smell.

Econometric results show that distance to fish market / supply source, annual household income, education level and perceived quality significantly affected fish consumption patterns. In view of the results, it is recommended that researchers should breed fleshy easy to farm fish species which can grow to 500gm preferred by consumers. In order to address the issue of muddy fish smell, there may be a need to design fish production systems that avoid fish proximity with mud during the production process or have fish flushed with flesh water for the last week before sell to have any debris cleaned from the gills area.

Do household fish ponds improve family nutrition? A study in Nepal

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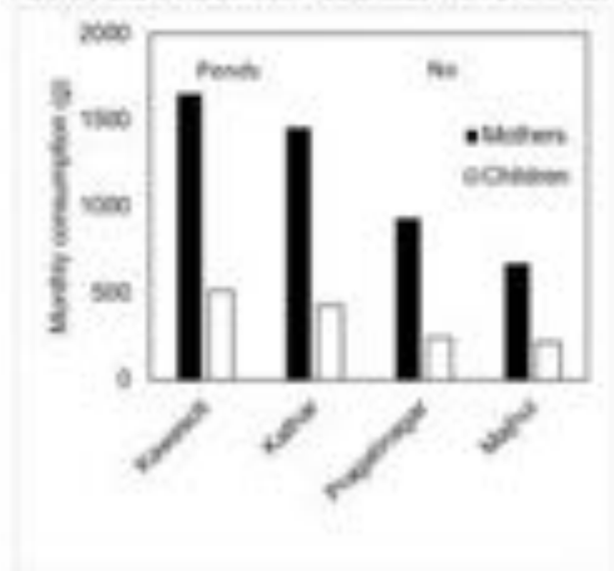
Malnutrition and micronutrient deficiencies are major concerns afflicting the people of Nepal and other countries in the region. Fish has been recognized as a nutritionally beneficial food source around the world, and small-scale fish culture has recently increased in this region with the inclusion of household ponds in rural communities. This study focused on the value of household ponds by comparing fish consumption and indicators of health for children and women in households with fishponds, to those without ponds. In Kathar, Chitwan and Kawasoti, Nawalparasi, 51 and 55 households, respectively, each including children between the ages of one and five years and owning at least one fish pond were recruited for participation through door-to-door visits. Similarly, in Majhui, Chitwan and Pragatinagar, Nawalparasi, 54 and 55 households, respectively, that did not own fish ponds were recruited.

Mothers from locations with fish ponds consumed significantly more fish than those without ponds (132% more), and also reported 126% higher rates of fish consumption by their children. Owners of household ponds also consumed fish more frequently (97% more) than did households without ponds. Health of children evaluated using details on stunting and wasting indicated that there were no significant differences between households with or without ponds. However, children from our study groups averaged 19% underweight, 18% stunted, and 12% wasted. These values are quite low, compared to 2013 estimates for the entire country for stunted (40.5%) and underweight (28.8%), but not for wasted (10.9%) children, and suggest that the inclusion of fish in child diets may provide essential nutrition to promote healthy growth and development for children in the region.

Figure 1. Monthly estimates of fish consumption by mothers and children from households with or without



DO HOUSEHOLD FISH PONDS IMPROVE FAMILY NUTRITION? A STUDY IN NEPAL

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Agriculture and Forestry University, Nepal

Background

- Malnutrition and micronutrient deficiencies are major concerns in Nepal and the region
- Fish consumption has been considered one solution to this problem
- Many organizations have used aquaculture to promote fish consumption to poor rural communities throughout the world
- To accomplish this in Nepal, AFU (formerly IAAS) began a program producing household ponds for rural people and promoting them through local community organizations

Household pond system

- Small ponds constructed by hand – 61 total, 40 – 700 m^2

Fry provided one time by project

Local community expanded this effort

Significant consumption and economic returns

	Kathar	Kawasoti	Total
Ponds constructed	33	28	61
Pond size (m^2)	63-696	40-255	40-696
Fish production (kg)	2557	762	3319
Mean production (ton/ha)	3.45	2.35	3.11
Home consumption (kg)	38.1 (49%)	8.1 (30%)	24.3 (45%)
Fish sales (kg)	39.4 (51%)	19.1 (70%)	30.1 (55%)
Income (NRs)	4727	2297	3611

Objectives

- Our first objective was to determine if residents from households with fish ponds ate more fish than those without ponds
- Secondarily, we determined whether or not households with ponds had children with better indicators of health than households without ponds

Methods

- We used a standard survey to determine the frequency and amount of consumption of fish, meat, and some other protein rich foods in the household

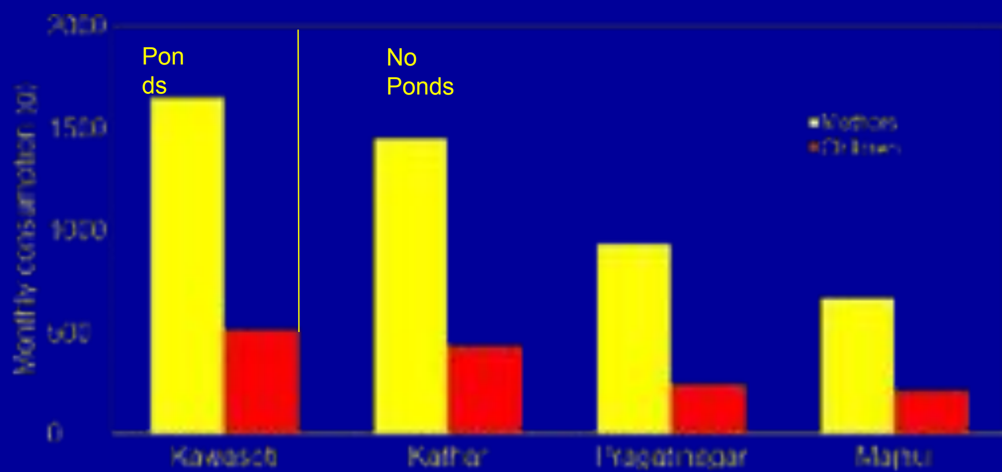
Methods

- We also measured height and weight for children less than five years old in each household to calculate health statistics such as frequency of wasting or stunting

Methods

- We selected about 50 households in 4 communities for surveys – 2 communities with ponds (Kathar and Kawasoti) and 2 without ponds (Mahjui and Pragatinagaar)

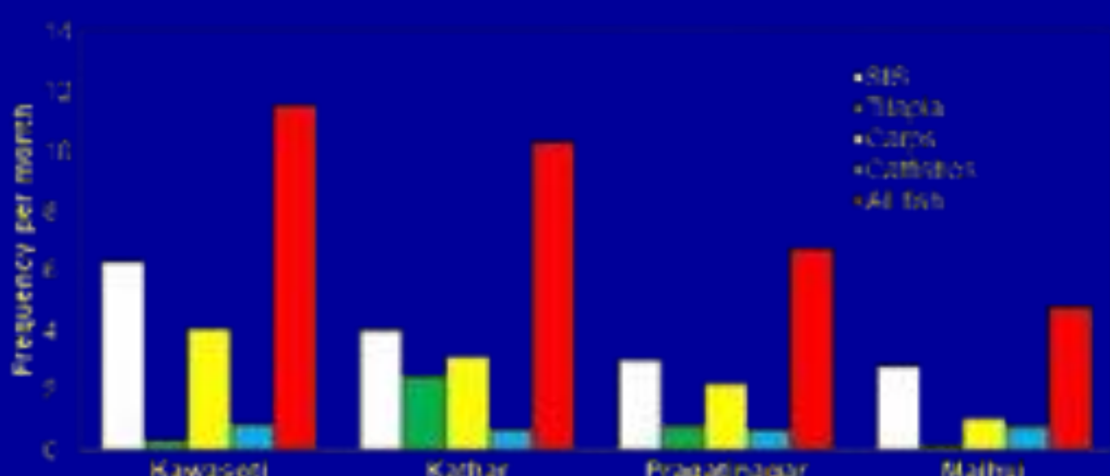
Monthly fish consumption by mothers and children



Mothers 93% more

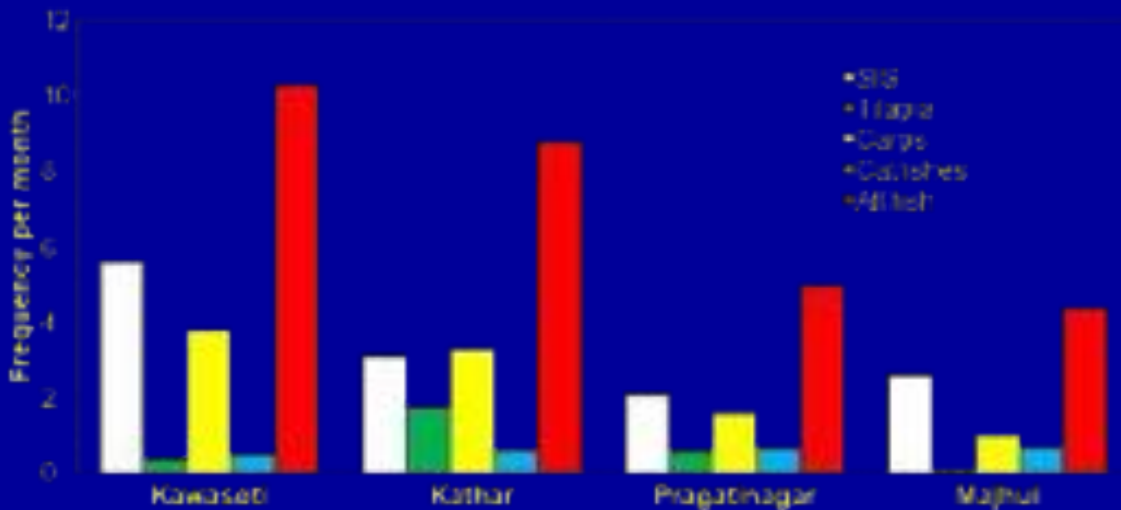
Children 105% more

Mothers with ponds ate fish 90% more often



90% more frequently

Children with ponds ate fish 104% more often



104% more frequently

Both groups ate meat about the same amount and frequency

- Meat consumed 9.5 times a month for women and 8.4 times for children, with a similar serving size and no significant difference among the two household types
- Chicken (5.8x), mutton (2.1x), and pork (0.5x) consumed at similar frequency in both groups

Child health did not differ among communities

	Underweight	Stunted	Wasted
Kawasoti	26.7% (16/60)	20% (12/60)	16.9% (10/59)
Kathar	19.6% (10/51)	21.6% (11/51)	8.3% (4/48)
Average	23.4% (26/111)	20.7% (23/111)	13.1% (14/107)
Pragatinagaar	12.7% (7/55)	20.7% (12/58)	3.5% (2/57)
Majhui	16.4% (9/55)	12.7% (7/55)	20% (11/55)
Average	14.5% (16/110)	16.8% (19/113)	11.6% (13/112)
Nepal Average*	28.8	40.5%	10.9%

*UNICEF 2015

Conclusions

- Households with ponds ate much more fish and similar amounts of meat as households without ponds
- Children from both groups had relatively high growth standards compared to overall Nepal averages and were not significantly different from each other
- Children from the Terai may have enough alternate sources of protein to grow better than overall Nepal averages

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Involving women in field-testing of a periphyton enhanced aquaculture system for nutrition security

Sunila Rai*, Madhav Shrestha, James S. Diana and Hillary Egna

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An on-farm trial of carp polyculture was carried out with participation of women farmers from Sundardeep Women Fish Farmer's Cooperative (15 farmers) in Chitwan District and Mishrit Fish Farmer's Cooperative (22 farmers) in Nawalparasi District to field-test the enhancing effect of periphyton on feed ration and fish production. Farmers stocked 6 carp species and 2 small indigenous species (SIS) in ponds. Farmers were divided into two groups. One group fed their fish with dough of rice bran and mustard oil cake with 50% feeding, while the other group installed bamboo substrates in their ponds and fed their fish with half the amount of the feed used by the first group. Farmers netted and weighed fish monthly to check fish growth and calculate ration. Farmers were provided with a book to record fish that were consumed, sold, or died. Final harvest was done by netting fish in December 2015 after eight months of culture. The netted fish were counted, weighed, and returned to the pond as the farmers wanted to keep fish for their biggest festival, "Maghi", in mid-January. In aggregate, 84% of farmers consumed fish at home, and 40% of farmers sold carps. About 95% farmers sold carps at the pond site, while 5% sold in nearby local markets. In case of farm site sales, both men and women were involved, whereas selling at local markets was solely done by women. The trial showed that culturing carps and SIS with 50% feeding rates and with bamboo substrates in ponds resulted in 22% higher fish production compared to culture of carps with normal feeding. More interestingly, the gross margin of the half-fed, periphyton enhanced carp polyculture was almost double that of the normal fed polyculture system. Periphyton enhanced Carp-SIS polyculture has a potential of enhancing family nutrition and women empowerment among small scale women farmers.

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Involving Women in Field-Testing of Periphyton Enhanced Aquaculture System for Nutrition Security

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Introduction

- **Carp-SIS (Small Indigenous Species) polyculture:** Has been beneficial to small scale farmers in Terai, Nepal for improvement of family nutrition and income generation (Rai, 2012, 2013).
- However, feed accounts >53% of total operational costs (Gupta et al. 2014).
- Needs low cost feed sources such as periphyton (Azim et al. 2002, Rai et al. 2008).
- Since the combination of species and type of feed influence the yield and income in a system, it is necessary to test the full combination of feed inputs, periphyton enhancement, and production to understand the best system for production

Objectives

- **To transfer the Carp-SIS polyculture in periphyton enhanced technology to farmers**

Farm Trial

- Two best treatments from on-station trial were tested in farm in Tharu community

  T_1 - Carp+100% feed

  T_2 - Carp + SIS + 50% Feed + Substrate

- Trial period: 8 months (Apr. 2015-Dec. 2016)

Trial Sites

Mishrit cooperative

Sundardeep women cooperative

Women Participation

Cooperative	Carp + 100 % Feed	Carp + SIS + 50% Feed + Substrate	Total
Sundardeep women cooperative	7	8	15
Mishrit cooperative	12	10	22
Total	**19**	**18**	**37**

All farmers were women
92% of participants were Tharus, ethnic group of Nepal

Pond Preparation

- Fertilization: Urea - 470 g/100 m^2 and DAP- 350 g/100 m^2
- Substrate installation: Split bamboo mat
- Float: Plastic bottles as float at top edges of mat
- Sinker: Brick/stone as weight at bottom edges of the mat
- Vertical positioning

Pond stocking was done by both men and women but substrate installation was done by men

Stocking Combination

Species	Carp+100% feed	Carp + SIS + 50% Feed + Substrate
Carp		
Silver carp	3000	3000
Bighead carp	750	750
Grass carp	2250	2250
Common carp	3000	3000
Rohu	3750	3750
Mrigal	2250	2250
Sub-total	**15000**	**15000**
SIS		
Pothi (*Puntius sp.*)		25000
Dedhuwa (*Esomus sp.*)		25000
Sub-total		**50000**

Farmers fed carp with dough of rice bran and mustard oil cake at 3% of body weight and grass carp with grass, vegetables leaves, banana leaves at 50% of body weight.

Record Keeping

- A note book was provided to each farmer to record fish consumed, sold and died.
- Partial harvesting of SIS from July
- Maximum 3 times per month

Record keeping and partial harvesting are done by both men and women

Final Harvesting

 

Harvesting was performed by both men and women

- Farmers did not empty their ponds on final harvesting because they kept fish for "Maghi", their biggest festival that fell in mid-January.
- During Maghi, major sales of fish occur because fish is an important food item for this celebration.
- Some farmers also saved fish in ponds for year-round consumption and to fetch higher prices later when there were less fish in the village.

Fish production, consumption and profit earned by farmers in two systems in 8 months

	Carp	Carp + SIS + 50% Feed + Substrate
Production (kg/100 m^2)	46.5 ± 16.2^b	56.7 ± 17.8^a
Profit (NRs./100 m^2)	3586 ± 2984^b	6823 ± 3045^a
Consumption (kg/household)	14.7 ± 13.4^a	15.3 ± 12.7^a

T-test

Fish consumption and sell

No. of farmers	Carp	Carp + SIS + 50% Feed + Substrate	Total
Consumed fish	16	15	31 (84%)
Sold fish	7	8	15 (41%)

Carp marketing

- About 95% farmers sold carps on the pond site, while 5% sold in the nearby local market directly to consumers without involvement of middleman.
- In case of on the pond site sales, both men and women were involved whereas selling at local market was solely done by women.
- Income earned by women from selling fish was used to pay children education fee, buy stationery to children, kitchen items and other domestic needs

Workshop to transfer technology

35 (7 men and 28 women) nonadopters participated

Conclusion

- Carp + SIS + 50% Feed + Substrate has a potential of enhancing family nutrition and income and reducing feed cost compared to the existing carp polyculture.
- Both technologies can be instrumental to women farmers to improve their group cohesion and socio-economic status because fish farming was carried out through cooperatives, the activity gave them opportunity to meet each other regularly and benefit from micro-finance.
- To increase women participation and empowerment, both carp polyculture and carp-SIS polyculture with

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A school pond education program for creating awareness on aquaculture in Nepal

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Malnutrition among children is a global health concern, especially prevalent in Asia and Africa. Proper nutrition in school age children is essential for maintaining growth, cognitive development and lifelong health. Our objective was to create awareness on the nutritional value of fish as a supplement to regular diets by establishing fish ponds in schools and educating adolescent students on aquaculture. One pond each was established in four schools in the Chitwan and Nawalparasi districts of Nepal. A total of 121 students, including 57 males and 64 females, were trained in this program. Carps and tilapia were provided for each school from nearby government fish hatcheries, and were stocked in each pond at normal densities. The materials necessary to maintain ponds, including feed and fertilizer, were provided to each school. Pre- and post-training tests were conducted for participating students. Results showed the knowledge of students on fish culture and nutritive value of fish was significantly increased ($p<0.05$). The 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 increase in consumption of fish (13.1±7.1times per year) and its frequent inclusion in the diet after training as compared to before training (7.7±3.3, $p<0.05$). The reason for this increased consumption was better awareness about nutritive value of fish. Surprisingly, members in 14.5% of participating students families constructed ponds after getting training. Thus, development of school ponds increased awareness on the value of nutrition and fish consumption in rural households by teaching school children and participating teachers about aquaculture.

In the second phase of program two additional fish ponds were constructed, one each in two public schools of Chitwan and Nawalparasi districts. Forty students of grade 8, 9 and 10 and three teachers were selected from each school to provide regular training on different aspects of fish culture along with role of fish in human nutrition. In addition to the new ponds, phase two also included providing water quality testing materials and nets to participating schools from both phases. In addition to student training, informal education activities were also carried out for women groups, which included forming two women's fish farming groups in the school community for each district. A linkage was developed so that the women's fish farming groups could ultimately work with the teachers and students to ensure the long term sustainability of the school ponds.

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A school pond education program for creating awareness on aquaculture in Nepal

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Introduction

- Malnutrition among children is a global health concern

- **Why Proper Nutrition in school age children ?**

- Proper growth
- Cognitive development
- Lifelong health

2

AFU

- Also childhood and adolescence is a critical period need high nutrients

- Fish provides valuable nutrients including high quality proteins

3

AFU

- Research alone cannot be effective in changing paradigms

- Social interactions play important role

- Women are key to aquaculture development as facing many problems like lack of time, absence of land ownership, not having access to credit facility and training etc.

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Objective

To create awareness on the nutritional value of fish as a supplement to regular diets by establishing fish ponds in schools and educating adolescent students on aquaculture.

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Methods

Number of schools: 4

One pond each was established in four schools in the Chitwan and Nawalparasi districts

Total number of trained students: 121
Male: 57
Female: 64

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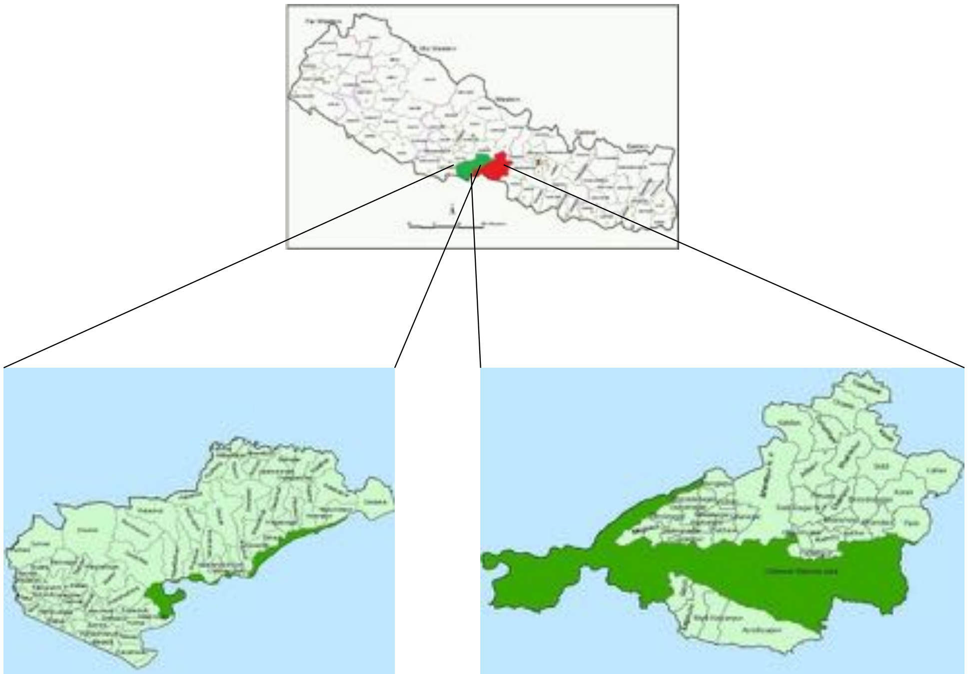

Nawalparasi district

Chitwan district

7

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Nepal HSS

Kathar HSS

Prithvi SS

Janata HSS

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9

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Training topics

➢**Topics on fish farming:**
Pond preparation and management, species choice, water color, fertilizing, feeding, growing, and harvesting of fish

➢**Topics on health and nutrition:** Nutritional value of fish and its importance of regular consumption , fish preparation

➢Role of women in household nutrition
Also a brief introduction on golden 1000 days

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RESULTS

12

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Pre- and post-training test

Table 1. Household pond and fish consumption status of the participating students before and after training

School name	**Number of students (n)**	**Having fish pond (% response)**		**Fish consumption (times/year)**	
		Before training	After training	Before training	After training
Nepal	35	5.7	8.6	4.3 ± 4.1	7.7 ± 4.3
Kathar	31	12.9	25.8	22.4 ± 30.3	27.1 ± 41.1
Prithivi	28	7.1	7.1	2.9 ± 3.1	7.3 ± 4.5
Janta	23	17.4	17.4	3.0 ± 3.7	7.7 ± 5.6
Mean	**29.3 ± 2.5**	**10.8 ± 2.7^{a}**	**14.7 ± 4.3^{a}**	**8.2 ± 4.8^{a}**	**12.5 ± 4.9^{b}**

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Pre- and post-training test

Table 2. Knowledge of students on fish production and nutritive value of fish at different schools before and after training. Data indicates the mean per cent response of the participant students (n) getting different range of scores

School name	**Score obtained (%)**							
	Before training				**After training**			
	<40	40-60	61-80	>80	<40	40-60	61-80	>80
Nepal	80.0	17.1	2.9	0.0	0.0	23.0	57.0	20
Kathar	71.0	29.0	0.0	0.0	0.0	0.0	42.0	58.0
Prithivi	50.0	35.7	14.3	0.0	3.6	17.9	42.9	35.9
Janta	82.6	8.7	9.7	0.0	0.0	8.7	60.1	30.2
Mean	**70.9 ± 7.4^{b}**	**22.6 ± 6.0^{A}**	**6.7 ± 3.2^{a}**	**0.0 ± 0.0^{a}**	**0.9 ± 0.9^{a}**	**12.4 ± 5.1^{A}**	**50.5 ± 4.7^{b}**	**36.0 ± 8.0^{b}**

14

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Phase-II

- Two schools 1 each in Chitwan & Nawalparasi
- Total number of students trained :40+40=80
- Total number of women trained: 20+20=40
- Total number of teachers trained: 3+3=6
- Water quality test kits provided

15

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16

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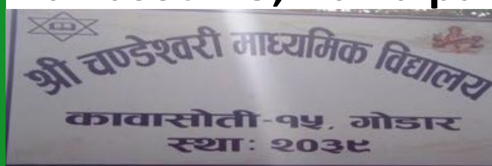
Shree Chandeshwory Secondary School, Godar, Kawasoti-15; Nawalparasi



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Annapurna Higher Secondary School in Parwatipur, Chitwan

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A F U

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A F U

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School pond concept was found very effective to bring

- the multiplier effect in aquaculture development
- knowledge transfer and learning
- family nutrition improvement

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Thus, development of school ponds increased awareness on the value of nutrition and fish consumption in rural households by teaching school children and participating teachers about aquaculture

Also a linkage was developed so that the women's fish farming groups could ultimately work with the teachers and students to ensure the long term sustainability of the school ponds

27

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Economic benefits of reduced inputs and polyculture of tilapia with major Indian carps

Mst. Kaniz Fatema*, Md. Abdul Wahab, S. A. S. A.Tahmid, Amit Pandit, S. M. Masud Rana, Sagiya Sharmin Suchana, Tajmin Naher, Md. Faridujjaman, Shahroz Mahean Haque, Hillary Egna and Russell J. Borski

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The aim of these studies was to determine if reductions in feed inputs and introduction of native Indian carp, rohu (*Labeo rohita*) and catla (*Catla catla)*, can increase economic benefits of tilapia culture in earthen ponds in Bangladesh. Two on-station pond trials were carried out for 150 days at the Fisheries Field Laboratory at Bangladesh Agricultural University. In the first study, ponds consisting of four treatments (T1, T2, T3, and T4) with four replications each were stocked with sex-reversed Nile tilapia (*Oreochromis niloticus*, 5 fish/m^2) without (T1) or with (T2) addition of rohu (0.25 fish/m^2) and fed a full daily ration of feed (CP, 35% protein; 10%-3% body weight/day). Ponds were fertilized weekly (28 kg N and 5.6 kg P ha/week) in the other treatments and tilapia were grown in the absence (T3) or presence of *Rohu* (T4) at half the daily feed ration as T1 and T2. The survival rates (75-81 %) of tilapia was similar among treatments. The specific growth rate (SGR, %/day) of tilapia was higher in the T3 (1.87 ± 0.00) and T4 (1.85 ± 0.03) than the T2 (1.76 ± 0.05), and T1 (1.71 ± 0.06) groups ($p < 0.05$). Feed efficiency was significantly better in the T3 and T4 groups relative to those treatment fish fed the full ration. Gross production of tilapia was higher in the T4 (5,385.23 ± 276.98a kg/ha) followed by T3 (5,340.62 ± 156.47 kg/ha), T2 (4,440.99 ± 440.04 kg/ha) and T1 (4,089.83 ± 518.46 kg/ha) groups, respectively. Rohu gross production was similar among the T2 and T4 groups. A significantly higher net return (BDT 743,977/ha; benefit cost ratio of 2.92) was found in T3 followed by T4 (BDT 673,750/ha; benefit cost ratio of 2.72), T2 (BDT 286,469/ha; benefit cost ratio of 1.49) and T1 (BDT 226,675/ha; benefit cost ratio of 1.37) groups, respectively.

In the second study, ponds consisting of three treatments (T1, T2, and T3; 4 replicates each) were stocked with sex-reversed Nile tilapia (5 fish/m^2) and rohu (0.625 fish/m^2; T1), or catla (0.625 fish/m^2; T2), or with both rohu and catla (0.32 fish/m^2 and 0.31 fish/m^2, respectively; T3). All ponds were fed a half daily ration of feed and ponds were fertilized weekly. Gross production of tilapia was higher in T2 (7,737.78 ± 646.51 kg/ha) followed by T1 (6,867.11 ± 570.36 kg/ha), and T3 (6,272.23 ± 183.44 kg/ha), respectively. Rohu gross production was higher in T1 and catla production was higher in T2. There was no significant difference in net return or benefit cost ratio between treatments.

Based on the higher net return and benefit-cost ratio it may be concluded that pond fertilization with feeding at half ration is substantially more cost effective over standard full feeding for growout of tilapia. Addition of major Indian carps to tilapia culture may also provide further income benefits to farmers as net production of fishes is greater in polyculture than tilapia monoculture systems regardless of the feeding regimen applied. Since tilapia growth was little impacted by feeding at half ration, but tended to grow better when polycultured with either Catla or Rohu alone compared with Rohu-Catla combined, it might be preferential to polyculture tilapia with only one of the carp species. Regardless, the results indicate profits can increase by 200% if tilapia are grown with native Indian carps and provided half the standard ration level typically used for tilapia monoculture.

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ECONOMIC BENEFITS OF REDUCED FEED INPUTS AND POLYCULTURE OF TILAPIA WITH MAJOR INDIAN CARPS

Mst. Kaniz Fatema*, **Md. Abdul Wahab, S. A. S. A.Tahmid, Amit Pandit, S. M. Masud Rana, Sagiya Sharmin Suchana, Tajmin Naher, Md. Faridujjaman, Shahroz Mahean Haque, Hillary Egna and Russell J. Borski**

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AquaFish Innovation Lab Project Investigation

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&

PI, AquaFish Innovation Lab Project, Bangladesh

Topic :

Economic and environmental benefits of reduced feed inputs in the polyculture of tilapia and major Indian carps

Objectives:

The aim of these studies was to determine if reductions in feed inputs and introduction of native Indian carp, rohu (*Labeo rohita*) and catla (*Catla catla)*, can increase economic benefits of tilapia culture in earthen ponds in Bangladesh.

Two on-station pond trials were carried out for 150 days at the Fisheries Field Laboratory at Bangladesh Agricultural University.

Topic :

Economic and environmental benefits of reduced feed inputs in the polyculture of tilapia and major Indian carps

Study 1

Evaluation of production parameters and potential economic and environmental benefits of reducing feed inputs with adoption of carp (Rui) into the grow out of tilapia in earthen ponds

Study 2

Evaluation of production performance of Tilapia in Tilapia– Rohu Polyculture with addition of a second major carp Catla in 50% feed reduction strategy

Experimental site

Study: 1

Evaluation of production parameters and potential economic and environmental benefits of reducing feed inputs with adoption of carp (Rui) into the grow out of tilapia in earthen ponds

Table 1: Research Design

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Rui *(L. rohita)*	0	25 (0.25/m^2)	0	25 (0.25/m^2)
Tilapia	500 (5.0/m^2)	500 (5.0/m^2)	500 (5.0/m^2)	500 (5.0/m^2)
Fertilization	0	0	4:1 (N:P)	4:1 (N:P)
Feeding Protocol	**100%** daily	100% daily	50% daily	50% daily
Replicates (n)	4	4	4	4

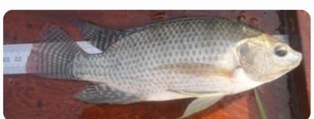


Table 2: Suggested tilapia feeding rates as percentage of body weight per day for optimum feed conversion efficiency

Fish weight (g)	Production system	
		Semi-intensive
0-15		10.0
15-60		5.0
60-100		3.0
100-200		2.0
200-300		1.5
300-500		1.4
>500		1.3

Source: Aquanutro 2002

Sampling and Health Monitoring

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



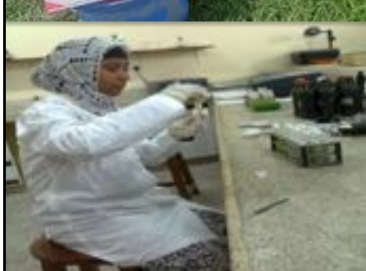



Results

Study: 1

Evaluation of production parameters and potential economic and environmental benefits of reducing feed inputs with adoption of carp (Rui) into the grow out of tilapia in earthen ponds



Reducing feed levels by half increases profits by 100% in tilapia monoculture or polyculture with carps (Rohu/Catla)

Economic Analyses (mean ± SD).

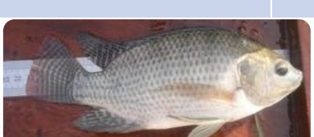
	Tilapia 100% Feed	Tilapia + Carp 100% Feed	Tilapia Alone 50% Feed + Fert	Tilapia + Carp 50% Feed + Fert
Fingerlings cost (Tk/ha)	99,505 ± 1,411[b]	111,943 ± 1,587[a]	100,917 ± 1,411[b]	112,737 ± 1,833[a]
Feed cost (Tk/ha)	118,210 ± 4,309[a]	118,210 ± 4,309[a]	62,777 ± 1,074[b]	60,407 ± 981[b]
Lime Cost (Tk/ha)	1,885 ± 935	1,389 ± 1,273	1,896 ± 1,784	2,172 ± 1457
Fertilizers cost(Tk/ha)	NA	NA	6,661± 93[a]	6,614 ± 108[a]
Labor cost (Tk/ha)	42,664 ± 568[a]	43,560 ± 555[a]	26,948 ± 431[b]	27,244 ± 747[b]
Total Expenditure (Tk/ha)	611,524 ± 8,154[a]	624,362 ± 7,955[a]	386,257 ± 6,178[b]	390,505 ± 10,711[b]
Gross return (Tk/ha)	838,200 ± 116,951[c]	932,932 ± 77,451[bc]	1,130,234 ± 86,477[a]	1,064,254 ± 89,098[ab]
Net return (Tk/ha)	226,675 ± 110,128[b]	308,570 ± 95,884[b]	743,976 ± 80,584[a]	673,749 ± 79,584[a]
Benefit Cost Ratio (BCR)	1.37 ± 0.17[b]	1.49 ± 0.11[b]	2.92 ± 0.18[a]	2.72 ± 0.17[a]

Study 2

Evaluation of production performance of Tilapia in Tilapia– Rohu Polyculture with addition of a second major carp Catla in 50% feed reduction strategy

Table 2: Research Design

Parameter	Treatment 1	Treatment 2	Treatment 3
Rohu (*L. rohita*)	25 (0.625/m^2)	0	13 (0.32/m^2)
Catla (*C. catla*)	0	25 (0.625/m^2)	12 (0.31/m^2)
Tilapia (*O. niloticus*)	500 (5.0/m^2)	500 (5.0/m^2)	500 (5.0/m^2)
Feeding	50% level	50% level	50% level
Fertilization	4:1 (N:P)	4:1 (N:P)	4:1 (N:P)



Study: 2

Evaluation of production performance of Tilapia in Tilapia– Rohu Polyculture with addition of a second major carp Catla in 50% feed reduction strategy

Table: Production Performance of Tilapia (*Oreochromis niloticus*) in Different Treatments

Variable	Treatment 1 (Tilapia, Rui)	Treatment 2 (Tilapia, Catla)	Treatment 3 (Tilapia, Rui, Catla)	Significant level
Mean Stocking Weight (g)	9.14±0.00	9.14±0.00	9.14±0.00	NS
Mean Harvesting Weight(g)	133.50^{b}±8.80	**149.58^{a}±11.32**	121.25^{c}±7.02	**
Mean Weight Gain (g)	124.36^{b}±8.80	**140.44^{a}±11.32**	112.11^{c}±7.02	**
Survival Rate (%)	92.96±2.91	**97.41±1.50**	94.80±2.59	NS
Specific Growth Rate, SGR (% day^{-1})	1.60^{b}±0.04	**1.66^{a}±0.05**	1.54^{c}±0.03	**
Gross Production (kg ha^{-1})	6130.21±443.60	**7199.18±569.21**	5672.81±214.50	NS
Net Production (kg ha^{-1})	5710.49^{b}±438.71	**6759.36^{a}±566.85**	5244.76^{c}±221.47	*

Cont'd

Table: Production Performance of Rui (*Labeo rohita*) in Different Treatments

Variable	Treatment 1 (Tilapia, Rui)	Treatment 2 (Tilapia, Catla)	Treatment 3 (Tilapia, Rui, Catla)	Significant level
Mean Stocking Weight (g)	34.70±0.00	-	34.70±0.00	NS
Mean Harvesting Weight(g)	**146.67±43.96**	-	122.00±9.70	NS
Mean Weight Gain (g)	**111.97±43.96**	-	87.30±9.70	NS
Survival Rate (%)	$81.11^{b}\pm2.30$	-	**$88.68^{a}\pm2.11$**	**
Specific Growth Rate, SGR (% day^{-1})	**0.84±0.17**	-	0.75±0.05	NS
Gross Production (kg ha^{-1})	**$736.89^{a}\pm221.29$**	-	$345.14^{b}\pm22.31$	*
Net Production	**$562.62^{a}\pm220.73$**		$246.88^{b}\pm23.43$	*

Cont'd

Table: Production Performance of Catla (*Catla catla*) in Different Treatments

Variable	Treatment 1 (Tilapia, Rui)	Treatment 2 (Tilapia, Catla)	Treatment 3 (Tilapia, Rui, Catla)	Significant level
Mean Stocking Weight (g)	-	22.92±0.00	22.92±0.00	NS
Mean Harvesting Weight(g)	-	**108.17±32.41**	102.88±9.72	NS
Mean Weight Gain (g)	-	**85.25±32.41**	79.96±9.72	NS
Survival Rate (%)	-	**82.34±8.82**	80.64±13.99	NS
Specific Growth Rate, SGR (% day^{-1})	-	**0.90±0.17**	0.89±0.05	NS
Gross Production (kg ha^{-1})	-	**$538.59^{a}\pm100.36$**	$254.28^{b}\pm42.66$	**
Net Production (kg ha^{-1})	-	**$421.73^{a}\pm112.48$**	$197.46^{b}\pm34.62$	*

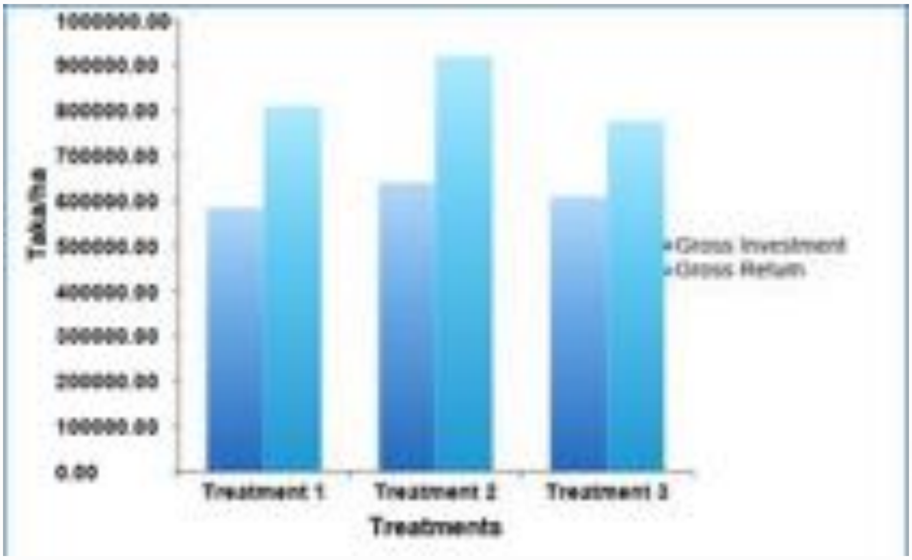


Figure: Gross investment and return from three different treatments

Study 2

❖ Gross production of tilapia was higher in T2 (7,737.78 ± 646.51 kg/ha) followed by T1 (6,867.11 ± 570.36 kg/ha), and T3 (6,272.23 ± 183.44 kg/ha), respectively.

❖ Rohu gross production was higher in T1 and catla production was higher in T2. There was no significant difference in net return or benefit cost ratio between treatments.

❖The gross and net production were recorded highest in **treatment 2** and the highest net return and BCR (benefit-cost ratio) were also obtained from **treatment 2 (Tilapia with Catla).**

❖**Treatment 2** might be recommended for polyculture of sex reversed Nile Tilapia in the seasonal ponds of farmers to get higher production and net return.

❖These feed minimization technique and additional production of carps are very much beneficial for poor fish farmers of Bangladesh.



Research finding

❖ Based on the higher net return and benefit-cost ratio it may be concluded that pond fertilization with feeding at half ration is substantially more cost effective over standard full feeding for growout of tilapia.

❖ Addition of major Indian carps to tilapia culture may also provide further income benefits to farmers as net production of fishes is greater in polyculture than tilapia monoculture systems regardless of the feeding regimen applied.

Research finding

❖ Since tilapia growth was little impacted by feeding at half ration, but tended to grow better when polycultured with either Catla or Rohu alone compared with Rohu-Catla combined, it might be preferential to polyculture tilapia with only one of the carp species.

❖ Regardless, the results indicate **profits can increase by 200%** if tilapia are grown with native Indian carps and provided half the standard ration level typically used for tilapia monoculture.

Determination of water quality parameters

Research Activities

Research activities

5 students have completed MS degree and went for job

S. A. S. A.Tahmid
Tajmine Naher
Sagiya Sharmin Suchana
Md Faridujjaman
Amit pandit

APA16

Surabaya, Indonesia
April 26 - 29, 2016

protein for healthy life

IEDAP

International Exhibition on Dairy, Aqua & Pet Animal

International Exhibition of Dairy, Aqua and Pet Animal-2016 (IEDAP), Bangladesh

Dissemination workshop

Farmers Day Workshop

26/8/2015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AQUAFISH ALUMNI CORNER

WHERE ARE THEY NOW?: SAGIYA SHARMIN SUCHANA

By Lindsay Carroll, AquaFish Innovation Lab

"How do fish live in the water? What are the feeding habits of fish? How do different water quality parameters affect fish?" These questions that originally attracted Bangladesh native, Sagiya Sharmin Suchana, to study fisheries and aquaculture gradually transformed into thoughtful objectives, including "How can I reduce fish production costs for small-scale farmers, especially in the remote areas of Bangladesh?"

To answer her questions and help address the challenges facing Bangladeshi aquaculture farmers, Suchana set her sights on a career in fisheries. In 2014, she completed her Bachelor's degree in Fisheries from Hajee Mohammad Danesh Science and Technology University in Dinajpur, Bangladesh. Then, in August 2016, with the support of AquaFish and mentoring of AquaFish research partner, Dr. Md. Kaniz Fatema, she earned her Master's degree in Fisheries Management from Bangladesh Agricultural University.

Her thesis was titled, "Evaluation of production performance and potential economic and environmental benefits of reduced feed rations in tilapia (*Oreochromis niloticus*)-carp (Rui, *Labeo rohita* and Catla, *Catla catla*) polyculture systems," simply stated, "my research mainly focus[ed] on how to [maximize] fish growth and [minimize] production costs while reducing feed rations in [tilapia-carp polyculture systems]," said Suchana.

(Photo courtesy Sagiya Sharmin Suchana)
Sagiya Sharmin Suchana, AquaFish alumni from Bangladesh Agricultural University.

Polyculture, growing more than one species in the same system, has proven to be an environmentally friendly way to maximize use of the entire pond system. Carps are ideal species to use in polyculture because carp prefer to feed on the naturally occurring organisms (e.g., plankton and zooplankton) that are enhanced by pond fertilization, fish waste, and feed inputs. Previous AquaFish research that focused on tilapia-carp polyculture determined that farmers could reduce production costs and increase profits by cutting tilapia feed rations in half and boosting plankton growth for carp through pond fertilization.

With these previous findings in mind, Suchana helped investigate the impact of feed reductions on the production performance among different carp tilapia polyculture (tilapia-Rui and tilapia-Catla) and mixed polyculture (tilapia-Rui-Catla) combinations. The study determined that tilapia-Catla polyculture resulted in the highest survival and growth rates of tilapia as well as the highest net returns and cost-benefit ratios compared

(Photo courtesy Sagiya Sharmin Suchana)
Sagiya Sharmin Suchana (middle) measures tilapia alongside advisor and AquaFish partner, Dr. Md Kaniz Fatema (left).

ALUMNI continued on page 11...

... ALUMNI continued from page 10

to the other combinations. Considering these findings, she hopes farmers are able to increase their profits by adopting tilapia-Catla polyculture methods determined through AquaFish research.

For Suchana, her research was more than just science, it was an experience. "When I dropped feed into the ponds, the fish [came] together and sometimes jumped out of the water! [Seeing that] gave me a lot of joy," she said. She was also thrilled with "finding life in the mud," as she reflected on coming across benthos for the first time in her pond mud samples.

Now, Suchana works as a lecturer for the Department of Fisheries at the Institute of Applied Science and Technology, a private institute affiliated with Rajshahi University in Rangpur, Bangladesh. When asked about her future plans, she said, "I hope to possibly complete a PhD abroad with a similar research focus to my master's work."

Suchana's curious and analytical mind provided the initial spark that ignited her interest in fisheries and aquaculture. These qualities combined with her education, ambition, and passion to help others, will continue to fuel her to find ways to help reduce fish production costs for farmers and further conquer other aquaculture challenges in Bangladesh.

(Photo courtesy Sagiya Sharmin Suchana)
Sagiya Sharmin Suchana collects fish from experimental aquaculture pond at Bangladesh Agricultural University.

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AquaFish Student Corner

Graduate Student Profile: Nusrat Hossain

By Lindsay Carroll, AquaFish Innovation Lab

(Photo courtesy of Nusrat Hossain)

Nusrat Hossain, an AquaFish Master's degree student at Bangladesh Agricultural University.

Native Bangladeshi, Nusrat Hossain, was drawn to aquaculture because she was interested in finding "sustainable ways to increase fish production for poverty alleviation and nutritional security," she said.

Hossain is an AquaFish Master's student at Bangladesh Agricultural University (BAU), seeking a degree in Fisheries Management. She is working under the mentorship of Dr. Md. Kaniz Fatema on the impacts of nutritional conditioning on the growth performance and nutrient uptake of tilapia.

Nutritional conditioning is the process of programming an animal by adding or removing key dietary nutrients early in development in order to influence growth and function during later stages of life. Studies show that conditioning can lead to more efficient uptake and use of nutrients leading to increased growth and better overall health.

Student continued on page 9 ...

AquaFish Student Corner

Funding for this research was provided by:

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বাংলাদেশ কৃষি বিশ্ববিদ্যালয়

NC STATE UNIVERSITY

Sustainable pearl farming using new techniques of spat collectors in Zanzibar

Narriman.S Jiddawi , Maria Haws*

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Marine pearl culture is an important aquaculture industry in the world. Currently, there is a growing interest in pearl culture production among Tanzanian coastal societies primarily due to opportunity as an alternative income generation activity and also a way of using the ocean in a sustainable manner. Attempts to culture pearls have been successful but in Zanzibar and order to make it sustainable spat collection experiments were initiated in two villages of Bweleo and Nyamanzi. Community were trained on how to use these various spat collection techniques and how to maintain them until the oysters are ready for seeding. Different types of **spat collectors** were used and this will be elaborated in the presentation. The targeted species were *P. margaritifera* and *Pteria* sp. Based on the results of this study, it is possible to obtain good numbers of pearl oyster spats and grow them. It is also possible to produce relatively good quality half-pearls within a short period of 9 months using *P. margaritifera*. The establishment of such an industry would provide much needed alternative income activity among Tanzanian coastal communities while serving in utilizing coastal resources in a sustainable way. The women were also involved in the experiments and ere provided more training on entrepreneurship skills.

Ensuring sustainable pearl farming using spat collection in Zanzibar TANZANIA

Narriman S. Jiddawi and Maria Haws

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WIOMSA

Study Area

- Zanzibar is part of United Republic of Tanzania with a population of 1.3 million
- Fishing, tourism, trade and agriculture are the main economic activities in Zanzibar
- The study sites are at Nyamanzi

Introduction

- Pearl production is a thriving business for coastal communities in many parts of the world. However the farming of half pearls (mabe) in Zanzibar, Tanzania is a new venture which started in 2006

- The most common species of pearl oyster found along the East African coast is the black-lip pearl oyster, *Pinctada margaritifera* and the Winged Pearl Oyster, *Pteria sp.*

Introduction

- Women in coastal Zanzibar have always depended on the intertidal area for economic activities e.g collecting clams, oysters, mussels and cockles for food or commercial purposes.
- However, uncontrolled harvesting has contributed to a decline in bivalve populations and increased poverty.

Introduction

Half pearl farming and jewellery making has helped to increase income and improve management of marine resources in the first trial sites.

However this activity needs to be sustainable in order for the women to continue to earn their **income. One way is ensuring the availability of spat** which can be grown to adult size and used for seeding.

Benefits of pearl culture

- Pearl farming is an attractive business venture because:
  - high value of the final product
  - the relative ease of producing half-pearls.
  - large, high quality mabe sells for $10-20 each.
  - A single pearl oyster can produce between 4 to 6 half pearls
  - final product is lightweight and nonperishable

1st pearls harvested in Zanzibar in 2008

Women of Zanzibar wearing pearl necklaces
2016

Obtaining pearl oysters

- Pearl oysters can be:
  - Collected from the reef as either adults or young pearl oysters (called spat), The farmers usually had to go to the reefs to collect adult oysters.
  - In Zanzibar, it is common to see small pearl oysters attached to wooden stakes, used to grow shellfish or on seaweed
  - Putting artificial material in water where small pearl oyster larvae can set on the material as spats, grow and then be removed to be implanted was thus found to be a feasible idea
  - .

Spat collection

- All pearl farms need a steady supply of young pearl oysters (spat) to keep the farm in operation.
- Spat collection is the process of attracting larval pearl oysters onto artificial substrates, a process commonly used in the pearl faming industry because it is cheap and simple than using a hatchery

Spat collection

- Usually the spat collectors are hung in areas where there is the presence of enough adult pearl oysters in the surrounding waters to reliably produce high numbers of spat

- Spat collection occurs when any material designed to attract spat settlement is placed in the water and tended. Properly designed spat collectors also protect the small spat while they grow

Spat collection

- It is important to select the correct type of material, choose the right areas, place the collectors into the water at the right time, and provide proper maintenance of the collectors and the lines.

- In this his experiment we used mesh bags cloth, coconut shells and rubber tryres and hung on submerged mainlines anchored to the bottom and suspended with floats.

Spat collectors

Coconut shells

Rubber tyres

Mesh bags

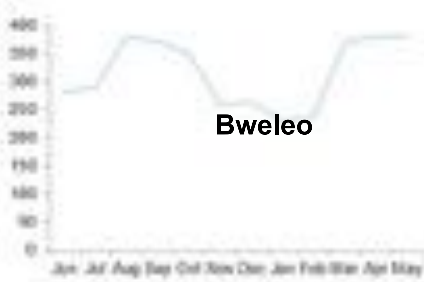
Spat collection

- About a month after the collectors have been set out, they were checked and some were found hiding beneath the shells and inside the clothing mesh bags
- The choice of material is very important as it will influence the likelihood of pearl oyster larvae setting upon it, and the ease and cost of collecting spat.
- Pearl oyster larvae set on a wide variety of materials in nature, but appear to prefer dark materials and the undersides of hard objects, which may offer protection.

Spat collection

- The spat collection experiment involving women using new spat collectors was done from May 2016 to June 2017 and produced a total of 3354 *Pinctada margaritifera* spat and 3861 *Pteria* spats at Bweleo and Nyamanzi respectively

Monthly numbers of spat settlement at Bweleo and Nyamanzi



- The highest number of spats were observed between August and October as well as March –April coinciding with the rainy season for both sites.

- Previous results observed highest spats to be around the same periods March and April as well as October-November. (Jiddawi, 1995) but Ishengoma observed highest catches in June, Ishengoma et al., 2011) But previous trials of 2016 indicated similar results

- Based on the results it is possible to obtain good number of pearl oyster spat and grow them

Spat

Problems encountered

- The main problems facing the farming plots was the fouling organism such as different sponges species and other forms of algae.

- High spat mortality was observed during first month but later on they continued to settle with high concentrations between October and November.

- The major effect of fouling organisms reduce the water circulation within a cage by blocking the nets pores and causing low supply of food and oxygen –hypoxia.

- Also some predators such as juvenile crabs, polychaetes, fishes and other marine organisms such as snails were observed.

Achievements

- Training has been done with the community on how to maintain and grow the spats to a size they can use to seed the pearls
- The community have accepted this very well as this technique may release them from going out in deeper waters to collect the large shells
- They are also ready to train others so as to make this activity sustainable and feasible by having enough shells

Funding for this research was provided by the

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Growth and production performance of air-breathing climbing perch *Anabas testudenius* and major carps in polyculture

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The use of Koi or climbing perch (*Anabas testudenius)* in aquaculture has grown substantially over the past decade in Bangladesh because it has a high market value and is rich in nutrients. Further, being an air-breathing fish, Koi have a strong capacity to tolerate poor oxygen environments. Koi production is currently limited to monoculture systems with intensive use of commercial-grade feeds. Feed constitutes almost 80% of the total costs for producing Koi and thus methods to reduce feed inputs can provide significant economic benefits, particularly if fish are co-cultured with carps that rely primarily on natural pond productivity rather than direct consumption of formulated feeds. Thus, the aim of the present study was to investigate growth and production of Koi when used in polyculture with major Indian carp species, Rui (*Labeo rohita*) and *Catla* (*Catla catla*) relative to that observed in with monocultures. We also examined the effects of combining reduced feed ration and pond fertilization on Koi-carp polyculture.

The experiment consisted of four treatments, with three replicates each (12 ponds; 100 m^2 area, 1.5 m depth). T1 consisted of a Koi monoculture (5/m^2) with full daily feeding while the other three treatments consisted of a Koi-carp polyculture (Catla, 0.2/m^2; Rui, 0.8/m^2; Koi, 5/m^2) with full daily feeding (T2), 75% daily feeding (T3), or 50% daily feeding (T4). Additionally, the ponds for T3 and T4 were fertilized weekly with urea and triple super phosphate (28 kg/ha N, 5.6 Kg P/ha) to boost pond productivity. Koi were fed a full daily ration of commercial feed (CP feed) according to current practice (20% down to 5% body weight/day) or a fraction of this based on treatment groups.

After 126 days, the average weight gains for Koi were 54.79, 96.63, 119.6 g, and 120.5g in T1-4, respectively. The body lengths for Koi were highest in T3 (18.22 cm), followed by T4 (17.97 cm), and lowest in T1 (9.5 cm). Average weights of Rui at the end of the study were 273, 298, and 340 g for T2-T4, respectively, while that for *Catla* was 456, 339 and 396 g for T2-T4, respectively. Survival of Koi ranged from 45 - 57% with the highest rate occurring in T4. *Catla* and Rui survival was 67- 80% and 58 - 61%, respectively. The results demonstrate 1) that Koi growth is enhanced when polycultured with carps versus in monoculture, 2) addition of carps to Koi culture improves overall fish production over monoculture alone, and 3) reducing daily ration by 50% along with pond fertilization has little impact on growth of Koi or carps. Based on this research, Koi polyculture with carps is substantially more beneficial in terms of fish production than the current practice of Koi monoculture. This along with reductions in feed ration allow considerable improvement in feed conversion and cost savings with little impact on fish production. (Supported by the AquaFish Innovation Lab - USAID)

GROWTH AND PRODUCTION PERFORMANCE OF AIR-BREATHING CLIMBING PERCH (*Anabas testudenius*) AND MAJOR CARPS IN POLYCULTURE

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Introduction

- To meet the demand for protein source, majority of the people of Bangladesh depend largely on fishes which are cheap in comparison to other protein sources

- There is increasing interest in hardy fishes particularly those of air breathing fish farming in Bangladesh. Among various production inputs, the choice of fast growing species with desirable aquaculture traits is a prerequisite for enhancing fish production in culture based fisheries

Introduction

•Air-breathing fishes 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.

• 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…

Currently, in Bangladesh production of Koi (*Anabas testudineus,* climbing perch) is limited to monoculture systems with intensive stocking and use of commercial-grade feeds. As feed can comprise up to 60% of total production costs, the current culture practices for these fish limit participation by small homesteads and therefore comprise a significant impediment to further expansion of this industry.

Further, the use of high-levels of feed inputs has led to a persistent deterioration of pond water quality.

Introduction cont'd…

Polyculture is an environmental friendly fish culture approach, mainly based on natural utilization of water and nutrients with little dependence on supplemental feed

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.

Objectives:

- To evaluate the feasibility and profitability of semi-intensive polyculture of Koi with Indian carps (Rohu and Catla) in ponds,
-
- To evaluate the effect of reduced feed and fertilization regimes on the production of fishes in different treatments;
- To examine the effects of combining reduced feed ration and pond fertilization on Koi-carp polyculture.
- To find out economically feasible polyculture system, to maximize cost-benefits for local farmers

Materials And Methods cont'd…

Table: Experimental design

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Rohu (*L. rohita*)	0	**80 (0.8/m^2)**	80 (0.8/m^2)	80 (0.8/m^2)
Catla (*C. catla*)	0	20 (0.2/m^2)	20 (0.2/m^2)	20 (0.2/m^2)
Koi (*A.testudineus*)	**500 (5/m^2)**	**500 (5/m^2)**	**500 (5/m^2)**	**500 (5/m^2)**
Fertilization	**0**	**0**	**4:1 (N:P)**	**4:1 (N:P)**
Feeding protocol	**100% satiation daily**	**100% satiation daily**	**75% satiation daily**	**50% satiation daily**
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 :** 126 days (21th March to 26th July, 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*).

Materials & Method…

Pond Preparation

- Pond drying
- Excavation
- Liming (1 Kg CaO per decimal)
- Water filling
- Fertilization (Urea and TSP at 28 kg N/ha and 7 kg P/ha)

Feeding

Utilization of feed was well considered as the treatments, where pellet feed was only used calculated based on the body weight of koi. 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	Rui	Catla
(~2g)	(~20 g)	(~25 g)

Stocked on 21th March, 2017

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) and Catla (~25 g) were collected from local supplier and were acclimatized and stocked in 12 experimental ponds on 21th March 2017.

Feeding Strategy

- Commercial fish feed was used twice a day (early morning and evening)
- Feed was applied based on the body weight of Koi . Koi were fed a full daily ration of commercial feed (CP feed) according to current practice (20% down to 5% body weight/day) or a fraction of this based on treatment groups (at 50%(10% - 2.5% bw/day)

Full daily feeding (T1 and T2), 75% daily feeding (T3), or 50% daily feeding (T4).

Additionally, the ponds for T3 and T4 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 field fortnightly . 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

Physical Parameter

- Temperature (ºC)
- Transparency (cm)

Chemical Parameter

- pH (Hydrogen ion concentration)
- Dissolved oxygen (mgl^{-1})
- Total alkalinity
- Nitrate-nitrogen (mgl^{-1})
- Nitrite-nitrogen (mgl^{-1})
- Ammonia-nitrogen (mgl^{-1})
- Phosphate-phosphorus (mgl^{-1})
- Chlorophyll-a (μgl^{-1})

Water Quality Parameter Monitoring

Water Sample Collection and Analysis of Water Quality Parameters

Materials & Method…

Figure: Chollorophyll-a analysis process

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)

- 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

- **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 126 days of culture periods, all fishes were harvested on 26th July, 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):

$$N \text{ (cells/L)} = (P \times C \times 100) / L$$

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):

$$N = O \times 10000 / A \times S$$

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)
- $$\text{Survival rate (\%)} = \frac{\text{No. of fishes harvested}}{\text{No. of fishes stocked}} \times 100$$
- $$\text{SGR (\% per day)} = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$
- $$\text{FCR (Food Conversion Ratio)} = \frac{\text{Total feed used (kg)}}{\text{Total weight gain (kg)}}$$
- BCR (Benefit Cost Ratio) = Gross return (Tk) ÷ Total investment (Tk)

Final Fish Sampling:

Length and weight of fish were measured

Statistical analysis

- SPSS version-16.0
- One-way ANOVA
- Significance **was assigned at 0.05% level**

Results

Table: Mean (±SD) values of Water Quality parameters recorded from the ponds among four treatments

Parameters	Treatment				Level of significance
	Treatment 1	Treatment 2	Treatment 3	Treatment 4	
Temperature (°C)	29.42±0.47	28.88±0.88	29.63±0.25	31.38±1.32	NS
Transparency(cm)	37.92±1.58	38.33±2.93	38.71±0.51	37.71±2.39	NS
Alkalinity (mgl^{-1})	122.92±46.72	92.42±2.13	87.63±9.19	95.08±8.16	NS
pH	7.21±0.17	7.03±0.14	7.22±0.13	7.32±0.44	NS
Dissolved Oxygen (mgl^{-1})	6.41±0.20	6.25±0.38	6.04±0.37	5.77±0.53	NS
Nitrate (mgl^{-1})	0.04±0.01	0.04±0.01	0.06±0.03	0.04±0.01	NS
Nitrite (mgl^{-1})	0.20±0.07	0.36±0.05	0.30±0.02	0.31±0.11	NS
Ammonia (mgl^{-1})	0.10±0.04	0.15±0.09	0.13±0.03	0.28±0.23	NS
Phosphate (mgl^{-1})	1.51±0.05	1.57±0.47	1.65±0.15	1.87±0.50	NS
Chlorophyll-a (μgl^{-1})	191.96d±11.88	221.91a±16.89	208.01b±17.77	199.52c±20.58	*

Table: Mean abundance (±SE) (× 10³ cells/l) of plankton populations recorded from the ponds among four treatments

Variables	TREATMENT				Level of Significance
	Treatment 1	Treatment 2	Treatment 3	Treatment 4	
Bacillariophyceae	80.50 ±7.63	42.83 ±0.73	59.54±2.27	52.88±4.49	NS
Chlorophyceae	123.71±12.16	76.25±14.62	96.08±21.07	91.29±4.40	NS
Crysophyceae	2.67±1.12	0.63±0.25	1.92±1.05	1.38±0.57	NS
Cyanophyceae	104.33±23.57	44.71±4.16	81.33±9.28	60.54±2.19	NS
Euglenophyceae	45.38±7.16	12.63±1.15	31.38±2.95	24.54±0.79	NS
Rhodophyceae	8.79±2.15	4.00±1.13	6.50±1.75	5.75±0.76	NS
Total phytoplankton	365.38±19.65	181.04±18.00	**276.75±24.88**	**236.38±10.26**	*
Copepoda	8.54±1.15	11.17±0.95	14.92±1.00	15.92±2.06	NS
Rotifera	10.88±2.43	15.63±1.42	21.50±3.90	30.46±1.44	*
Cladocera	5.67±0.38	7.17±1.23	8.25±0.87	11.88±2.82	NS
Total Zooplankton	25.08±2.77	33.96±1.44	44.67±4.15	58.25±5.31	NS
Total Plankton	390.46±17.62	215.00±16.64	321.42±22.64	294.63±9.39	*

Results

Table: Mean (±SD) values of different groups of benthic fauna (Individual/m^2) from four different treatments

Group	Treatment				Level of significance
	T_1	T_2	T_3	T_4	
Oligochaeta	261.73±46.01	385.19±59.61	425.93±66.97	651.85±31.64	*
Chironomid	225.93±19.60	433.33±105.86	446.91±89.61	586.42±60.90	*
Mollusk	203.70±3.70	222.22±3.70	241.98±53.46	293.83±4.28	NS
Unidentified	6.17±4.28	9.88±5.66	12.35±5.66	25.93±16.14	NS
Total	697.53±66.70	1050.62±56.70	1127.16±201.55	1558.02±79.21	*

Results

Table : Initial and final length and weight and survival rate of koi (*Anabas testudineus*) in four different treatments

	Treatment	Initial wt- In Ln	Final wt- Final Ln	Survival Rate
koi	**T1**	0.69gm-3.1cm	54.79gm-9.5cm	51
	T2	0.69gm- 3.1 cm	96.63gm- 14.27cm	47
	T3	0.69gm- 3.1 cm	119.6gm-18.22cm-	45
	T4	0.69gm- 3.1 cm	**120.5 gm -17.97cm**	**57**

Results

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

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Significant level
Initial Weight (g)	0.669±0.040	0.669±0.04091	0.669±0.040	0.669±0.0409	NS
Final Weight (g)	55.79gm	97.30	120.27	121.10	NS
Survival Rate (%)	51.0±2.65	46.67±8.14	44.53±5.78	**57.26±9.91**	NS
Specific Growth Rate, SGR	3.05±.01	3.05±0.18	3.12±.11	4.28±.06	NS
Gross Production (kg ha^{-1})	1401.28 ±279.69	2241.97±663.17	2660.74 ±453.42	**3424.19 ±826.81**	**

Results

Table : Initial and final length and weight and survival rate of Rui (*Labeo rohita*) in four different treatments

	Treatment	Initial wt- Initia l Ln	Final wt- Final Ln	Survival Rate
Rui	T1	Absent	-	-
	T2	22gm-12,08cm	273.3gm- 27.00cm	61
	T3	22gm-12,08cm	298.00gm- 27.92cm	58
	T4	22gm-12,08cm	340gm - 29.77cm	61

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

Variable	T1	T2	T3	T4	Significant level
Mean stocking weight(g)	Absent	22±5.077	22±5.077	22±5.077	NS
Mean Harvesting Weight(g)	Absent	269.66	226.6	348.66	NS
Mean Weight Gain(g)	Absent	247.67±68.37	204.67±33.08	326.67 ±136.65	NS
Survival Rate (%)	Absent	61.25±9.92	58.33±22.79	60±23.95 61	NS
Specific Growth Rate, SGR (% day-1)	Absent	1.48±0.16	1.38±0.06	1.61±0.23	
Gross Production (kg ha-1)	Absent	1983.44±483.1	2221±497.84	2565±921.23	**

Results

Table : Initial and final length and weight and survival rate of Catla (*Catla catla*) in four different treatments

	Treatment	Initial wt- Initial Ln	Final wt- Final Ln	Survival Rate
Catla	T1	Absent	-	-
	T2	32.27 gm, 14.71 cm	456gm- 30.46cm	71
	T3	32.27 gm, 14.71 cm	339 gm- 29.48cm	67
	T4	32.27 gm, 14.71 cm	396gm - 29.75 cm	80

Results

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

Variable	T1	T2	T3	T4	Significant level
Mean stocking weight(g)	Absent	32.1±11.20	32.1±11.20	32.1±11.20	
Mean Harvesting Weight(g)	Absent	492	338	396	
Mean Weight Gain(g)	Absent	456.9±114.33	338.67 ±135.43	396.9±66.09	
Survival Rate (%)	Absent	71.6±2.89 85	58.0±35.47 93	80±10 95	
Specific Growth Rate, SGR (%	Absent	1.61±0.13	1.37±0.24	1.49±.1	

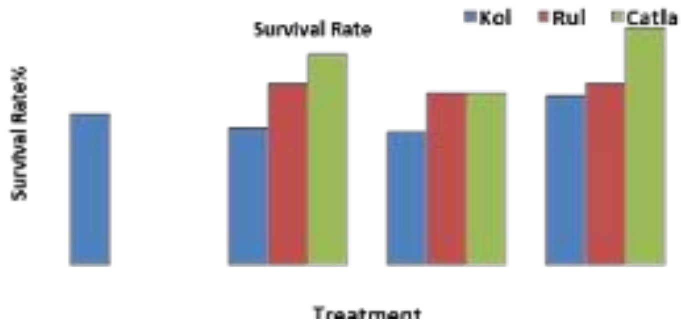

Figure: Mean survival rate of three fish species in four different treatments

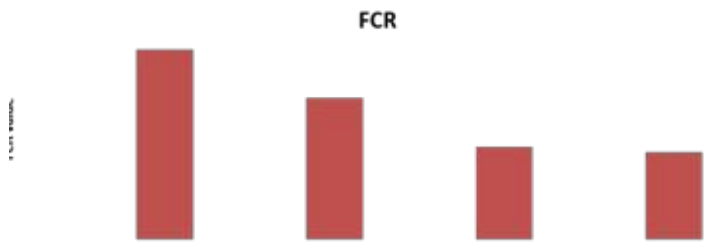

Figure: FCR value in four different treatments

Results

Combined production performance of Koi (*Anabas testudineus*), Catla Catla catla) *and rohu (Labeo rohita)*

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Gross Production (kg ha-1)	**T1**	**T2**	**T3**	**T4**
Koi	**1401.28±279.69[b]**	**2241.97±663.17**	**2660.740±453.42**	**3424.19±826.81[a]**
Rohu	-	**1983.44**±483.14	**2221.722**±497.84	**2565.94**±921.23
Catla	-	**767.920**±94.86	**622.12**±81.85	**743.111**±97.08
Total Production	**1401.28[b]**	**4993.33**	**5504.585**	**6733.24[a]**

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

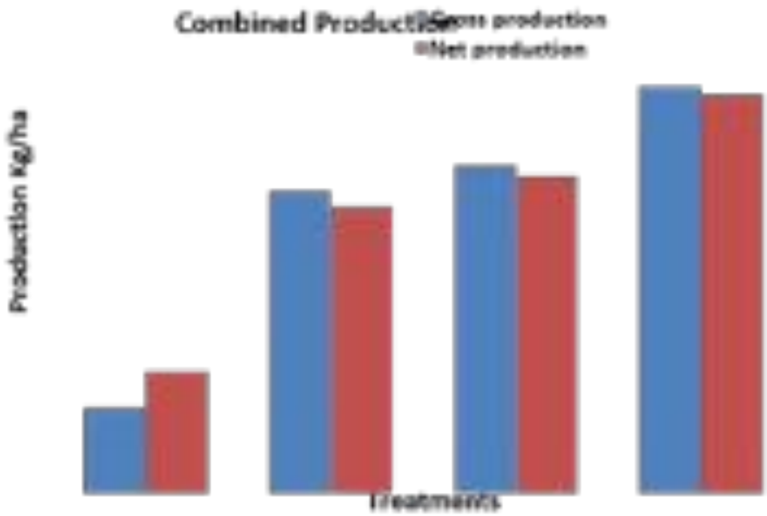

Figure: Combined production of three fish species in four different treatments

Findings

After 126 days, the average weight gains for Koi were 54.79, 96.63, 119.6 g, and 120.5g in T1-4, respectively.

The body lengths for Koi were highest in T3 (18.22 cm), followed by T4 (17.97 cm), and lowest in T1 (9.5 cm).

Average weights of Rui at the end of the study were 273, 298, and 340 g for T2-T4, respectively, while that for *Catla* was 456, 339 and 396 g for T2-T4, respectively.

Survival of Koi ranged from 45 - 57% with the highest rate occurring in T4. *Catla* and Rui survival was 67- 80% and 58 - 61%, respectively.

Conclusion

The results demonstrate

1) The growth of Koi is enhanced when poly cultured with carps versus in monoculture,

2) addition of carps to Koi culture improves overall fish production over Koi monoculture alone, and

3) reducing daily ration by 50% along with pond fertilization has little impact on growth of Koi or carps.

Koi polyculture with carps is substantially more beneficial in terms of fish production than the current practice of Koi monoculture. This along with reductions in feed ration allow considerable improvement in feed conversion and cost savings with little impact on fish production.

So, Reduced feed Ration (50% Satiation) of Koi-Carp Polyculture Systems can be suggested to the fish farmers.

Aquaculture America 2018

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Integration of mola *Amblypharyngodon mola* in prawn-carp gher farming systems to increase household nutrition and earnings for rural farmers in southwest Bangladesh

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

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The fish farmers of the Southwest Bangladesh Khulna region use a combined freshwater prawn (*Machrobrachium rosenbergii*) and carp (*Labeo rohita*) culture in seasonal paddy fields, a practice referred to as "*gher farming*". The farmers typically sell the prawns in overseas markets to fetch higher prices, leaving family members (particularly women and children) malnourished from lack of complete protein and vitamins. The present study sought to mitigate this problem by incorporating nutrient-rich Mola (*Amblypharyngodon mola*) for home consumption into traditional prawn-carp gher farming systems. Mola is a nutrient-dense, small indigenous fish that self-recruits and lives off natural pond biota. Hence it can be grown at little additional costs to farmers, yet can provide an important source of nutrition for them.

The first experiment investigated the effect of Mola incorporation on prawn production using the following treatments: a traditional prawn-carp culture (T1), a prawn-Mola culture (T2), and a prawn-carp-Mola culture (T3) with stocking densities of 2, 1, and 0.1/m2 for prawn, Mola, and carp, respectively. The biomass produced by the end of the 6-month experimental period is shown in Table 1. Results indicate that production of prawn increases, while carp production is little effected by introduction of Mola. These findings indicate that integrating Mola into prawn-carp gher farming systems has no negative impact on the production of either species and could enhance total seafood production.

A second experiment sought to optimize Mola stocking densities in prawn-carp gher ponds. Three experimental systems were examined containing 2/m2 prawn, 0.1/m2 carp, and either 1 (T1), 2 (T2), or 4/m2 (T3) Mola. A fourth control system (T4) contained only carp and prawn stocked at the same densities. The biomass recorded at the end of the study period was 455.58±14.69, 462.77±15.60, 456.28±13.94, and 362.25±17.84 kg/ha for prawn and 588.11±16.47, 572.19±17.28, 586.75±15.39, and 502.92±16.84 kg/ha for carp in T1-4 while Mola production was 298.55±11.55, 376.21±15.34, and 397.66±18.41 kg/ha in T1-3. Considering the initial stocking weight for Mola in T2 was lower than T4, and final production was similar between the two groups, the results suggest that stocking brood Mola at a density of 2 pieces/m2 in prawn-carp gher farming systems provides optimal production of all three species.

(Supported by the AquaFish Innovation Lab - USAID)

Table 1. Production (kg/ha) of prawn, Mola, and Rohu. Values with different letters are significantly different ($P < 0.05$). (mean ± SD)

	Treatment 1	*Treatment 2*	*Treatment 3*
Prawn	417.4±12.70^b	446.8±11.03^a	462.6±12.74^a
Mola	NA	308.0±20.33^a	255.5±23.08^b
Rohu	569.5±25.50	NA	573.5±28.12

INTEGRATION OF MOLA (*Amblypharyngodon mola*) IN PRAWN-CARP GHER FARMING SYSTEMS TO INCREASE HOUSEHOLD NUTRITION AND EARNINGS FOR THE RURAL FARMERS IN SOUTHWEST BANGLADESH

US PI: Prof Russell Borski, North Carolina State University

BD Co- Principal Investigator

Professor Dr. Khandaker Anisul Huq

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Bangladesh

Background

Fisheries sector has been playing a vital role in Bangladesh

-In alleviating protein shortage (60% of animal protein)

- providing employment sources for young & women (10% of total population)
- role on local markets and enhance to earn foreign currencies
- contribute to food security & socioeconomic development (GDP 3.69%, 2016)

- In Bangladesh rice and fish comprise the **main diet** of low-income families, particularly during the production season of these crops.
- Integrated fish farming practices hold **significant promises for increasing dietary nutrition, productivity, and profitability of farming households** in rural Bangladesh.

Resources and Production Potentials (2015-2016)

- Total fish production (2015-2016) : 38.78 m mt

Aquaculture contributes : 56.82%

- Contribution to GDP : 3.69%
- In Agriculture commodity :23.81%
- Total amount exported : 75338mt
- Export earnings (Crore Taka) : 4282.82
- Contribution to Export earnings : 1.97%
- Per capita fish consumption :24.08, 60g/c/dkg/yr
- Contribution to animal protein : 60%
- Growth rate during last 5 years : 5.27%

Employment (full time & part time) :17.80 million (≈ 11% of total population)

Women employment : :1.40 million

Cont……..

- Farmers typically sell the prawns in overseas markets and carps in domestic markets, meanwhile family members (particularly women and children) malnourished due to lack of complete protein, vitamins, and other minerals in their diets.
- Mola is a small fish with big nutritional value.

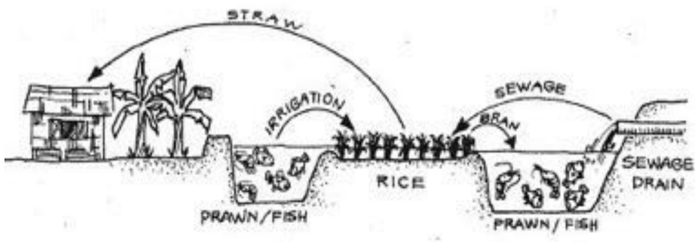
Macrobrachium rosenbergii

Amblypharyngodon mola

Labeo rohita

Integrated aquaculture in gher system (Paddy: Jan-April, Fish: June-Dec, Dike Vegetable: year round)

Cont……..



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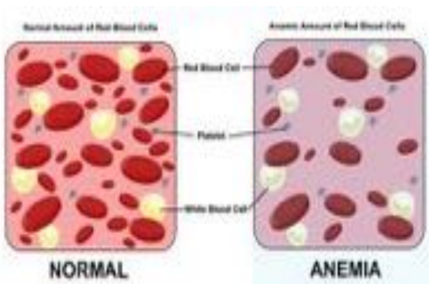
Nutritional contribution of mola fish

Cont……..

Iron deficiency

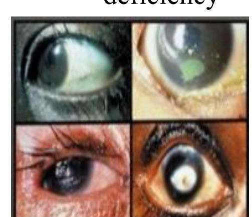


Calcium deficiency

Rickets

Mola contain Vitamin A, Zinc, Calcium, Iron and other minerals

Vitamin A deficiency



Night Blindness, Xerosis Conjunctiva, Xerosis Cornea, Bitot's Spots

Zinc deficiency

Acrodermatitis enteropathica

Objectives

1. Evaluate production potentials of *Mola* fish (*Amblypharyngodon mola*) integrated with existing practices of prawn-carp gher farming systems.
2. Better identify of *Mola* stocking densities for prawn-carp gher farming systems to increased production and household consumption.
3. Investigate the effect fertilizers on the production performance of prawn-rohu-mola in integrated gher farming system.
4. Disseminate the technology of Mola fish and dyke vegetables production with existing gher farming in Bangladesh and other developing countries.
5. Evaluate the potential use of gher/pond mud as fertilizer for growing leafy and fruit vegetables on gher/pond dykes (Dr. Ashraful Islam, BAU).
6. Assess the nutritional benefits and economic returns of the households practicing integrated prawn-mola farming with dike vegetables (Prof. Sadika Hauqe, BAU).

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Study Location

Methodology

Exp. 1: Production potentials of *Mola* with prawn-carp gher farming

Experimental design for Exp. 1 (July to January)

Species	T1	T2	T3
Prawn PL	$2/m^2$	$2/m^2$	$2/m^2$
Brood Mola	0	$1/m^2$	$1/m^2$
Rohu fingerling	$0.1/ m^2$	0	$0.1/m^2$
Replication	5	5	5

9

Cont………
……

- Farmers selection: 30 households (15 intervened and 15 non-intervened)
- Cultured Species: Freshwater prawn, rohu and mola
- Design: 3 Treatment, 5 Replications
- Activities: Pond preparation, PL nursing, stocking, feeding, sampling and health checking, water quality recording, harvesting etc.

Pond preparation (April-May):(pond size .15-.30ha). drying, liming (250 kg/ha), water filling (1-1.5 m), fertilization urea 50 kg/ha, TSP 25 kg/ha, mixture of molasses 30kg and yeast 300 g/ha

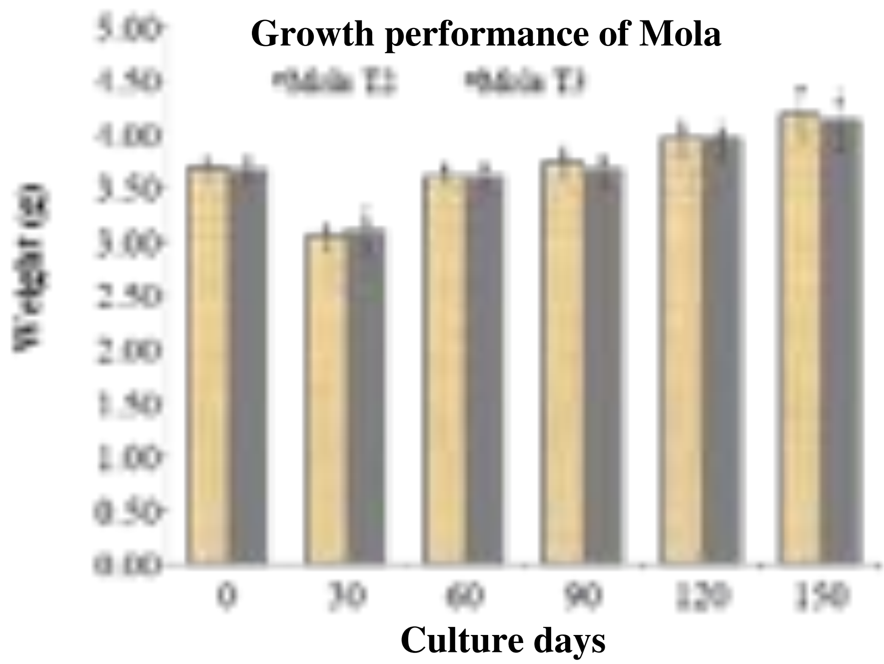
Cont………
……

- **Feeding**: Mega grower feed (30% crude protein) in the grow-out pond at 5% of their body weight, which was gradually decreased to 2% at the end. Feeding frequency was thrice a week.
- **On-growing fertilization Monthly**: **organic fertilizer** (mixture of molasses 15 kg/ha and yeast powder 150 g/ha); **inorganic fertilizer** (urea 15 kg/ha, TSP 7.5 kg/ha)
- **Water quality**: pH, DO, transparency, alkalinity, nitrate nitrogen, phosphate phosphorus, and Chlorophyll-a were measured fortnightly.
- **Monitoring:** monthly growth performance and health checking
- **Monthly focus group discussion and on-farm training**

Result

Water parameters in prawn gher (July to January)

Parameters	T_1	T_2	T_3
Temperature (^oC)	31.98±1.68	31.86±2.21	31.46±2.42
Transparency (cm)	26.2±5.45	27.2±4.66	27.0±7.63
pH	7.38±0.29	7.32±0.23	7.3±0.18
DO (mg/L)	5.68±0.51	5.22±0.36	5.76±0.84
Alkalinity (mg/L)	200±50	170±27.38	190±41.83
Ammonia (NH_3-N mg/L)	0.33±.03	0.34±.021	0.35±0.03
Nitrate Nitrogen (NO_3-N mg/L)	2.99±0.93	3.46±0.94	3.86±1.12
Phosphate phosphorus (PO_{4-}P mg/L)	0.48±0.23	0.59±0.32	0.47±0.23
Chlorophyll-a in µg/L	73.74±4.25	61.90±6.54	55.78±2.03



T2 Prawn 2/m2, Mola 1/m2
T3 Prawn 2/m2, Rohu 0.8/m2, Mola 1/m2

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Cont.....................

Production (kg/ha) of prawn, mola and rohu from July to January

Fish	T1	T2	T3
Prawn	417.4±13.28[a]	446.8±10.16[b]	462.6±9.07[b]
Mola	---	308±11.29[a]	255.5±8.29[b]
Rohu	569.5±14.0[a]	---	573.5±12.48[a]
Total Production	986.95±13.19[a]	755.18±5.09[b]	1291.73±11.63[c]

Video 1

Video 2

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Cont…………….

…….

Consumption of prawn, rohu and mola

Fish	T1 (kg)	T2 (kg)	T3 (kg)
Prawn	12.2±1.48	17.6±2.82	20±4.90
Mola	Nil	116.1±13.37	92±17.18
Rohu	137±23.14	Nill	132±27.29

Experiment 2: Methodology

Identification of better mola stocking densities for prawn-carp gher farming

Experimental design of exp. 2 (July to December)

Species	T1	T2	T3	T4
Prawn	$2/m^2$	$2/m^2$	$2/m^2$	$2/m^2$
Rohu	$0.1/ m^2$	$0.1/ m^2$	$0.1/m^2$	$0.1/m^2$
Mola	$1/m^2$	$2/m^2$	$4/m^2$	Nil
Replication	5	5	5	5

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Cont...........
....

Production (kg/ha) of prawn, mola and rohu from July to December

Fish	T1	T2	T3	T4
Prawn	455.58±14.69[a]	462.77±15.60[a]	456.28±13.94[a]	362.25±17.84[b]
Mola	298.55±11.55[a] (30kg/ha)	**376.21±15.34[b]** (60kg/ha)	397.66±18.41[b] (120kg/ha)	Nil
Rohu	588.11±16.47[a]	572.19±17.28[a]	586.75±15.39[a]	502.92±16.84[b]
Total Production	1342.4	1411.17	1440.44	865.17

Values in the same row with different superscripts are significantly different ($p<0.05$).

T1- Prawn 2/m^2, Rohu 0.1m^2, mola 1/m^2
T2- Prawn 2/m^2, Rohu 0.1m^2, mola 2/m^2
T3- Prawn 2/m^2, Rohu 0.1m^2, mola 4/m^2
T4- Prawn 2/m^2, Rohu 0.1m^2, mola nil

17

Cont...........
....

Exp-2: Consumption of prawn, mola and ruhu

Fish	T1 (kg)	T2 (kg)	T3 (kg)	T4 (kg)
Prawn	18.93±1.1	13.2±0.49	14.86±0.6	9.98±0.82
Mola	109.22±2.25	118.55±1.64	124.4±2.03	Nil
Rohu	135.25±4.01	125.69±2.89	132.36±2.78	130.67±8.89

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Achievements

Exp-1

a) Integration of mola in prawn gher farming system showed no negative impact on the production of main crop. Even, it could enhance the total fish production.

b) It enhanced household fish consumption, hence, contributed to fulfill nutrition deficiency; and additional income. Thus, livelihood of the farmers could be improved.

Exp-2

Stocking density of brood mola in gher farming system with prawn and rohu at $2/m^2$ could be suggested considering production performance and economic benefit.

Exp-3

a) Fertilizer could increase the production of traditional gher farming system compared to non-fertilizing ghers.

b) Application of fertilizers and molasses showed better production performance in gher farming system.

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- Simple and low cost culture technology of Mola fish and dyke vegetables was disseminated to 120 farmers through on-farm training and focus group discussion.

- From this research 3 master and 2 undergraduate students have been completed their dissertation.

Outreach of AquaFish Innovation Lab Project in Bangladesh

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Dissemination

- This study has been conducted in farmers ponds (mola, prawn, carp). Through on farm training and focus group discussion 120 farmers were trained (50% woman) for mola-prawn-carp and dyke vegetables cultivation.
- Develop a network with the community, local farmers, CBOs and Union Parisad.
- Establishing communication with Department of Fisheries (DoF) and Bangladesh Fisheries Research Institute (BFRI) regarding the research events.
- Growing interest to the other farmers and developing secondary adaptors for practicing through-

training (technologies transfer) : 100 farmers, 50% Women
community level orientation
maintaining record books at farm level
court-yard meeting
-development of communicating materials i.e. leaflets : 5000 copies and supply to UFO in 4 District to disseminate the technology among the rural farmers
-workshop. (DoF, BFRI, DAE, WorldFish BD, Blue Gold, Winrock Int. and other national NGOs
Presentation: Nepal, South Africa, Khulna, Dhaka, Mymenshingh, BD
-Print media Publication: 8 regional print media, Farmers' magazine (Krishi kotha, 75,000),

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AQUAFISH INNOVATION LAB

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Photo Gallery

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Training, FGD





Experimental Plots




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Mola brood collection, transport and stocking

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Brood stocking & farm management

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Sampling




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Harvesting




30

Dyke vegetables on the experimental ghers

Demonstration

Thank you

for kind attention

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AquaFish-Supported
Abstracts and Presentations

The potential effect of aquaculture on the genetic purity of natural populations of Nile tilapia *Oreochromis niloticus* in Ghana

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Aquaculture is undoubtedly one of the avenues of ensuring food security in a growing Africa. However, the rapid expansion of aquaculture in the region, particularly in sub-Saharan Africa, could threaten the local adaptation and genetic diversity within wild populations. Hatchery operations and the sale of fingerlings are loosely regulated, which could result in the importation of alien strains deemed to have growth advantage over native strains. The purpose of this study was to obtain baseline information about the genetic impact of aquaculture on natural populations of the Nile tilapia *Oreochromis niloticus* in Ghana.
We employed a combination of methods to provide data. First, we interviewed local fishers and key informants to assess indigenous knowledge of sympatric tilapia species including *O. niloticus, Sarotherodon spp., and Coptodon (Tilapia) zillii*, which naturally occur in major rivers in Ghana. We then surveyed selected farms and hatcheries in the Eastern and Western regions near two rivers: Volta and Tano, to obtain information about their sources of broodstock and fingerlings, and to collect *O. niloticus* samples for genetic analysis. Finally, we collected wild samples of *O. niloticus* from an upstream location "distal" to the aquaculture facilities, and from a downstream location "proximal" to the aquaculture facilities.

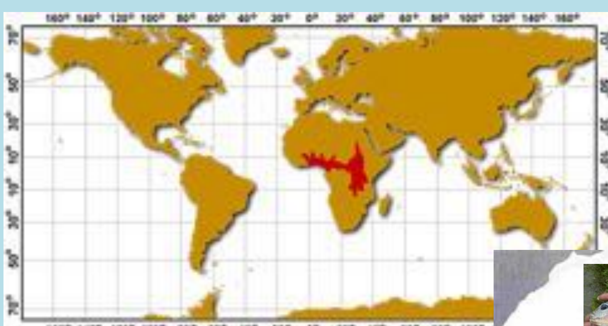
We found a high level of indigenous knowledge of sympatric tilapia species from our interviews with the local fishers and key informants. Of the 47 individuals interviewed, about 96% were familiar with *O. niloticus* and the common co-occurring tilapia species even though *O. niloticus* was sometimes confused with *Coptodon zillii* due to their morphological similarities. Interestingly, some fishers described *O. niloticus* as "fish farm tilapia" and all other tilapia species as "local tilapia". In the Western region, locals reported an increasing number of *O. niloticus* in the catches from the Juen lagoon in recent times and attributed that to *O. niloticus* escape into the wild after a cage farm operated on the Tano River suffered structural damage. Regarding broodstock and fingerling sources, majority of the farmers reported growing the Akosombo strain of *O. niloticus*, which is the government approved strain, but some did not disclose their sources. A few farmers stated that they sometimes resorted to wild broodstock. We found morphological differences in terms of body shape and coloration between *O. niloticus* samples collected from farms and those collected from the wild. Additionally, *O. niloticus* samples were different when compared among cage farms than among pond farms. It is unclear whether the morphological differences observed are driven by environmental conditions or due to farmers growing different strains. Ongoing genetic analysis should provide answers about the genetic makeup of samples collected and help unravel this mystery. Pending genetic results, it is evident from the survey responses that an effective monitoring plan is required to safeguard *O. niloticus* genetic purity in Ghana.

THE POTENTIAL EFFECT OF AQUACULTURE ON THE GENETIC PURITY OF NATURAL POPULATIONS OF NILE TILAPIA *Oreochromis niloticus* IN GHANA

Gifty Anane-Taabeah, Emmanuel A. Frimpong,
and Eric Hallerman

Virginia Polytechnic Institute and State University
Department of Fish and Wildlife Conservation
Blacksburg, Virginia, USA

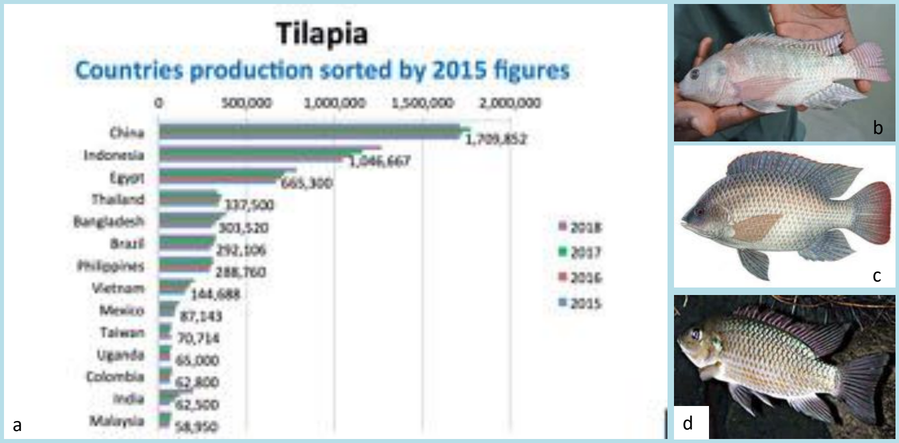
Nile tilapia native range


Source: FAO, 2018.

- Africa
- Middle East


Source: Ragnon *et al*., 1996.

Global aquaculture production



Sources: (a) Tveteras (2016); (b) Dr. Emmanunuel Frimpong; (c) www.sms.si.edu; (d) www.myfwc.com

Aquaculture in Ghana: Current status

- Rapid expansion within last decade
  - ➢Research and development
    - ➢"Akosombo strain"
- Active lobbying for superior strains
  - ➢ Genetically Improved Farmed Tilapia (GIFT)
- Comparative study of the GIFT strain and Akosombo strain
- No information about strains grown by farms

Goal

To obtain baseline information about the genetic impact of aquaculture on natural populations of the Nile tilapia *Oreochromis niloticus* in Ghana.

Research questions

- Which strains of Nile tilapia are currently farmed in Ghana?
- Is there a signal of alien strains?
- How is aquaculture impacting wild populations of Nile tilapia?

Surveys and sampling

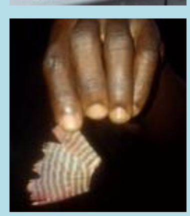
- Assessed indigenous knowledge
- Assessed morphological variations
- Obtained tilapia fin-clips
  - Farmed populations
    - ➢Government hatcheries
    - ➢Cluster of major farms
  - Wild populations
    - ➢Downstream “proximal”
    - ➢Upstream “distal”

Genetic analysis

- Extracted DNA, PCR standardization
- Genetically characterize populations
  - Mitchondrial DNA
    - *D-loop, ND1, CO1*
  - 10 microsatellites loci
    - *UNH 130, UNH180, UNH858, UNH178, UNH991*

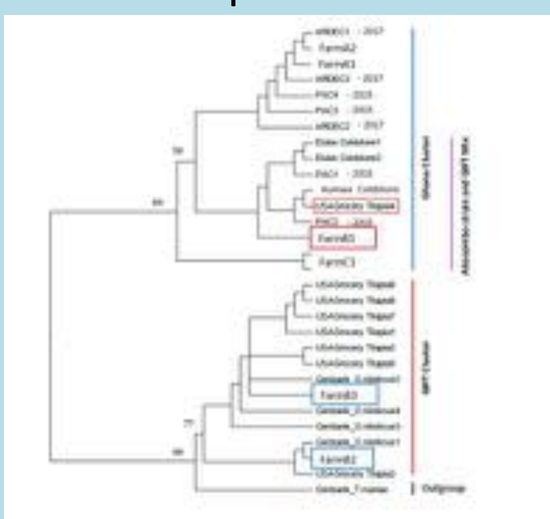
Indigenous knowledge

Sarotherodon sp.



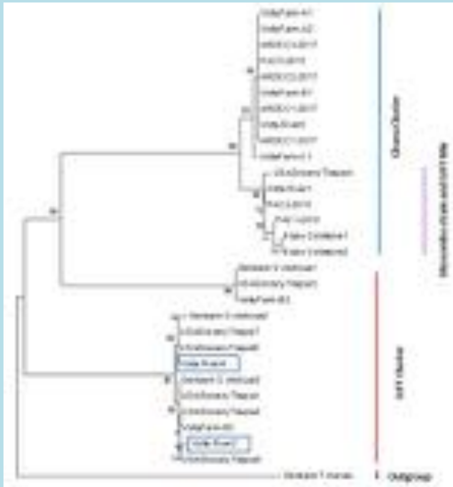
Morphological variations

Tilapia strains farmed in Ghana



- USA Grocery tilapia
  - ➢ Walmart
  - ➢ Kroger

Impact of aquaculture on wild populations



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- Pilot Aquaculture Centre (PAC), Kona, Ashanti Region
- Global Change Center, Virginia Tech
- CART 4D – Consulting
- Ghana Aquaculture Association
- Raanan Feed Limited

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Actor perspectives on aquaculture extension service provision in central and northern Uganda

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The purpose of extension service provision to farmers is to meet farmers' needs including knowledge, skills and other services so as to improve productivity and general socio-economic wellbeing of household members. Such interventions are needed in aquaculture as a way of increasing fish production since fish supply from the natural sources has drastically declined. Drawing from the Actor Oriented Perspective, this paper explores individual farmer and household level characteristics that influence interactions between aquaculture extension service providers with members of households practicing fish farming in ponds.

Survey data were collected from a random sample of households involved in fish farming and supplemented with information obtained from Focus Group Discussions (FGDs) with fish farmers. Additional information was got from interviews with extension service providers. Data obtained from the survey was analysed using SPSS while Atlas.ti was used to analyse information from FGDs. Findings revealed that fish farmers perceived the level of extension service provision as low as demonstrated by few and erratic farm visits. Yet, fish farmers experienced various constraints related to technical competence about rearing fish and financing of the fish enterprises. Alongside government fisheries extension staff, farmer to farmer extension encounters were common while use of Information Communication Technologies such as radio and cell phones was minimal. Membership to fish farmer groups significantly influenced the frequency of extension visits ($p<0.05$) compared to individual farmer demographic and socio-economic factors. Relevant training is necessary to enable extension staff help farmers build and sustain farmer organisations. Strong farmer groups promote effective delivery of extension services; enhance learning, knowledge sharing and application.

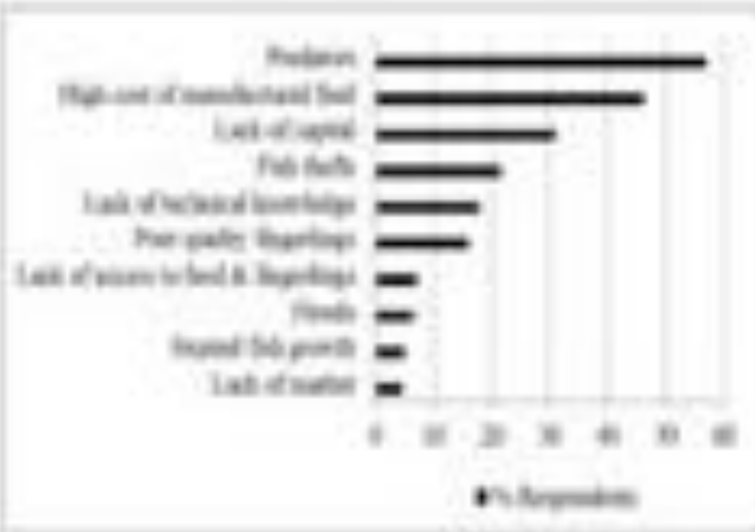


FIGURE 1. Constraints encountered by fish farmers in the study area

TABLE 1. Relationship between incidence of extension visits by government staff and characteristics of respondents

Respondents' characteristics	χ^2	Sig
Age	1.231	0.746
Gender	0.406	0.357
Education	8.178	0.225
Land owned	1.115	0.953
Income from pond fish	7.311	0.316
Total pond area	3.310	0.507
Experience in fish farming	2.536	0.638
Member to farmer group	7.560	0.0065*
Region of residence	3.277	0.070

Significant difference at 5%

INSTITUTIONAL FACTORS INFLUENCING THE ROLE OF WOMEN IN AQUACULTURE VALUE CHAIN IN UGANDA

Gertrude Atukunda *et.al*

Aquaculture America Conference

Paris Las Vegas Hotel & Convention Centre, NV USA.

20-22 February 2018

Introduction

- Aquaculture started in the 1950s and was aimed at promoting access to fish by rural poor communities.
  - dominated by earthen ponds on household land with water sources
- Fish ponds mainly owned by household head
  - patriarchal system ascribes ownership of land to men
- Women bear decisions and responsibilities of food provisioning at house hold level
- gender relations influence decisions and actions in undertaking fish farming including utilisation of benefits.
- Gender relations in fish farming overlooked at household, community and policy level)

Statement of the research problem

The role of women in aquaculture does not seem to be fully understood:

- Obscured by official statistics that do not disaggregate data by gender
- Limited studies on factors influencing women's roles and benefits along the aquaculture value chain

Objectives

1. To establish the gender division of labour in the aquaculture value chain
2. Asses institutional factors influencing the role of women in aquaculture value chain
3. Ascertain women's socio-economic benefits from aquaculture

Study area and methods

Fig. 1. Map of Uganda showing study districts

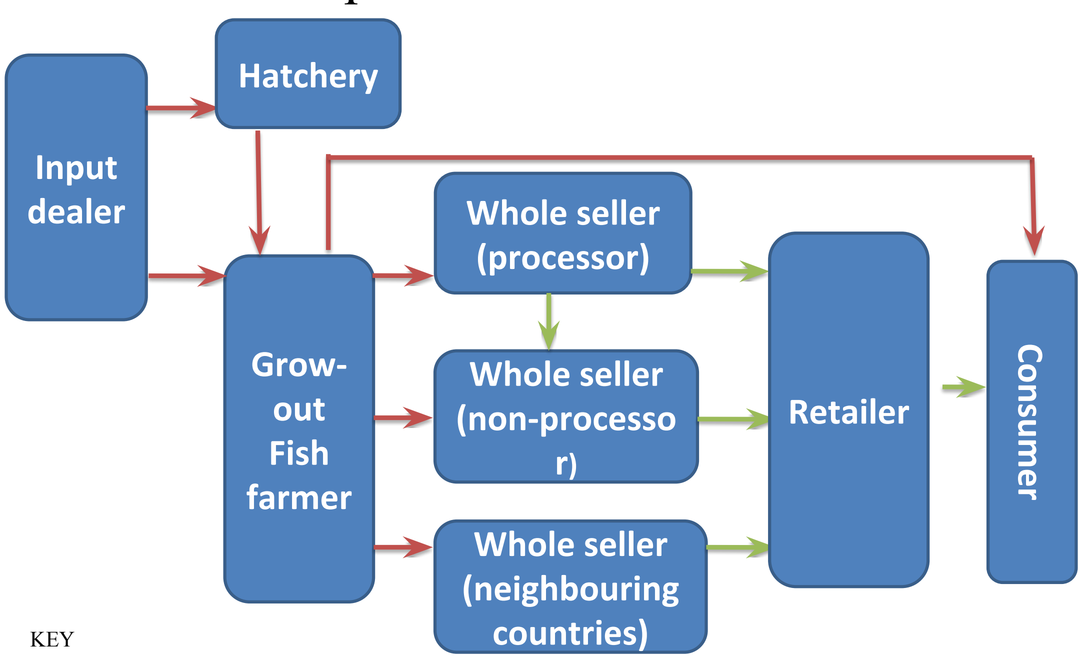
Selected characteristics

	Central	**North**
Pop'n (per Sq m)	176	65
Poverty levels (%)	6	47
Mean temp ∘C	21.0	24.6
Topography	hilly	lowland
Water sources	swamps	springs

Data collection methods

- Women Group discussions
- Men Group discussions
- Interviews with selected informants

Generic aquaculture value chain actors



KEY

= **Predominantly males**

= **Predominantly females**

Fig 2. Value chain actors by gender

Gender division of labour in pond aquaculture

	Actors	
Activity	Males	Females
Pond site section and construction	♂	♀
Stocking	♂	♀
Sampling	♂	♀
Pond maintenance	♂	♀
Sourcing in-puts	♂	♀
Supervising workers	♂	♀
Feeding fish	♂	♀
Harvesting	♂	♀
Selling fish	♂	♀
Keeping records	♂	♀

Aquaculture value chain activities by gender


Fig 3. Woman feeding fish


Fig 4. Men sampling fish

Factors influencing women's role in aquaculture

Household level factors

- Socio-cultural perceptions and practices regarding household resources particularly land
- Aquaculture viewed and undertaken primarily for income generation
- Membership to fish farmers groups (dominated by men); women expected to belong to women groups
- Limited access to capital

Factors outside the household sphere

- Extension advice often biased towards men
- Limited promotion and use of ICTs
- Training scheduling, targeting in favour of the extension worker

Women's socio-economic benefits from aquaculture

- Fish for home consumption
  - change of diet
  - Health/nutrition of children and mothers
- Income
- Employment
- Improved relations
- Social status
- Knowledge and skills

Emerging opportunities for women's participation in aquaculture value chain

- Increasing recognition of role of women in aquaculture by male counterparts
- Partnering with youths (the case of Kasooka Youth Fish Farmers)
- Emerging women groups inclusive of various actors at different nodes of the value chain

Conclusion and recommendations

- Individual and policy interventions seem to be positively addressing household level factors
  - Awareness creation on women's empowerment through women's fund
  - Savings groups
  - Free government inputs (though more of a distortion than promotion)
- Extension needs to recognise and build on the changing patterns in women's roles
- Training should also target women and provide complete information along the value chain

Acknowledgement

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NARO

Which author is which gender authorship position as a proxy for the status of gender in aquaculture literature

Morgan Chow*, Hillary Egna and Jevin West

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Examining authorship position in aquaculture facilitates an improved understanding of status of women in the discipline, as authorship is a critical factor in professional success in academia and beyond. In a review of more than eight million papers in the JSTOR Corpus across disciplines in natural and social sciences and humanities, West et al. 2013 found that men predominate in the first and last author positions and women are underrepresented in single-authored papers. Other studies have assessed women authorship in other disciplines such as law and medicine, and found that a gender gap in published literature still persists.

This study applies the large sample size and methodology of West et al. 2013 to the broad discipline of aquaculture, and compares these results to gender authorship in the International Aquaculture Curated Database (IACD) - a compilation of 543 peer-reviewed publications supported by four long-term international aquaculture programs headquartered at Oregon State University and a curated database of aquaculture journals in the Web of Science. Results reveal that the percentage of women authors (13.8%) was similar for the JSTOR aquaculture subsample and the IACD (15.7%), yet significantly lower for that of the Web of Science database (3.7%). Women are not well represented any of the databases, and remain underrepresented as authors in any position in aquaculture journals. To contextualize our findings with the percentage of women graduating in the field, we examined the number of women graduates in agricultural, biological, natural, and social sciences who earned Bachelor's, Master's, and PhD's in the U.S. from 1991-2015. Results from the U.S. Department of Education's National Center for Education Statistics shows that the percent of women graduates each year has increased with women representing more than 50% of graduates in 2015. While this does not represent international graduates, it still provides some contextualization for the proportion of women in the discipline. Learning how authorship has changed in the aquaculture discipline over the last few decades is critical for promoting gender equity for future aquaculture scholarship and the sustainability of the professional discipline.

WHICH AUTHOR IS WHICH?

Gender Authorship Position as a Proxy for the Status of Gender Integration in Aquaculture Literature

Morgan Chow[1], Jevin West[2], and Hillary Egna[1]
1. Oregon State University
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Aquaculture America
Las Vegas, Nevada
February 20, 2018

USAID FROM THE AMERICAN PEOPLE   AQUAFISH INNOVATION LAB   Oregon State University

WHY LOOK AT AUTHORSHIP IN AQUACULTURE?

Publications are an important factor for promotions, future funding, and tenure-tracked positions

The process is NOT always straightforward AND authors listed first or last generally receive the most credit (Laurance 2006; Tscharntke et al 2007)

Authorship order has intent, can be politically motivated, and is culturally embedded within a system

Research Question: Are women publishing in the field of aquaculture proportionate to their involvement in the field?

WHAT WE KNOW ABOUT GENDER AND AUTHORSHIP IN SCIENTIFIC LITERATURE

Women represent roughly 1/2 of all biological scientists, but their representation as full faculty and managers is much lower, suggesting the perpetuation of a **leaky pipeline**.

Women are less likely to be promoted, publish less, receive less grant funding, and fewer patents than their male colleagues

Fisheries Discipline	1665-1989	1990-2011
Ichthyology	5.5% Women	13.9% Women
	94.5% Men	86.1% Men
Aquatic Ecology	12.7% Women	24.6% Women
	87.3% Men	75.4% Men

OUR APPROACH

JSTOR Corpus → JSTOR aquaculture subsample

IACD → Web of Science

JSTOR Corpus: Expansive database of publications across multiple disciplines, dating back to 1665

JSTOR aquaculture subsample: Extracted articles from the Corpus from several aquaculture journals, dating back to 1913

IACD: ~500 articles whose research was supported by four international aquaculture programs developed by Dr. Hillary Egna, since 1983

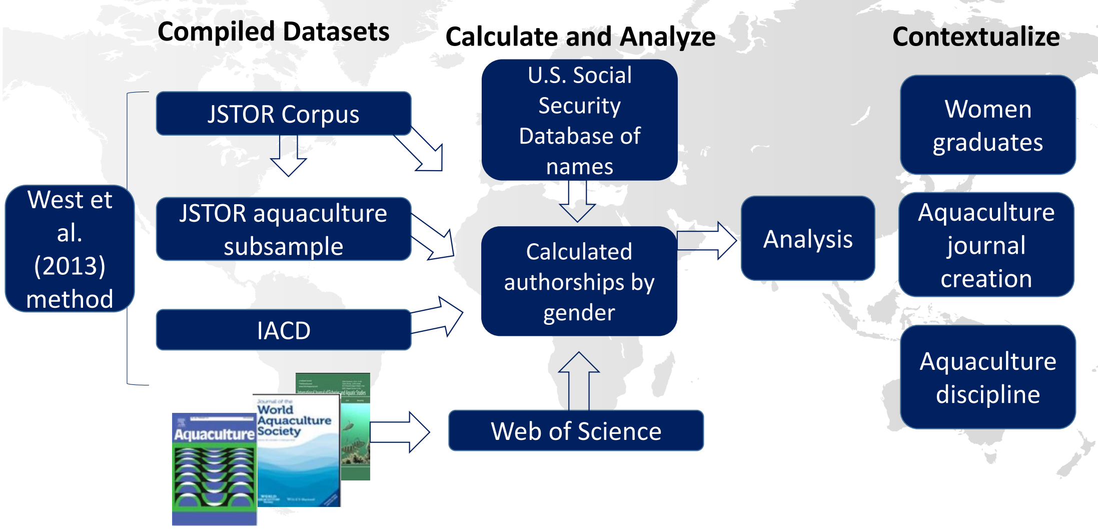
Web of Science: Extracted articles from the most reputable aquaculture journals since 1980 to compare to the IACD

OUR APPROACH

%WOMEN AUTHORS in four “datasets” of Peer-Reviewed AQUACULTURE Literature

Dataset	#Journals	#Articles	#Authorship	Time Period	% Genders Unknown
JSTOR	2227	1.8 million	2.8 million	1666-2011	26.7%
JSTOR Sub-sample	8	23,381	43,146	1913-2016	23.7%
IACD	121	543	1706	1983-2016	<1%
Web of Science	185		496,745	1980-2016	69%

OUR APPROACH



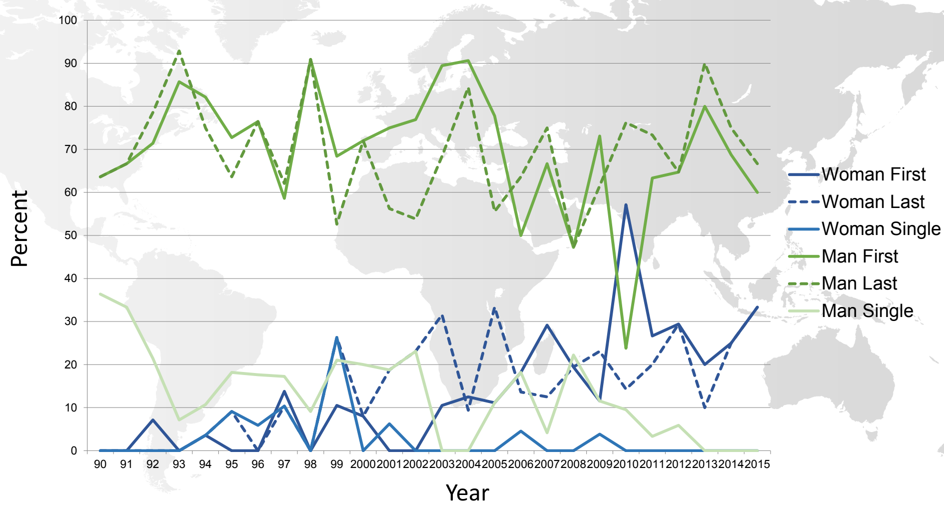
FINDINGS

%WOMEN AUTHORS in four “datasets” of Peer-Reviewed AQUACULTURE Literature

Authorship Position of women	International Aquaculture Curated Database (IACD)	JSTOR – Aquaculture subsample	JSTOR Corpus	Web of Science
Any position	15.7%	13.8%	16.1%	8.5%
Single Author	≥1990: 11.1%	11.0% (All years)	All years: 17.0% <1990: 12.0% ≥1990: 26.0%	17.7%
First Author	14.2%	15.8%	19.2%	5.1%
Last Author	14.0%	16.5%	19.6%	3.6%

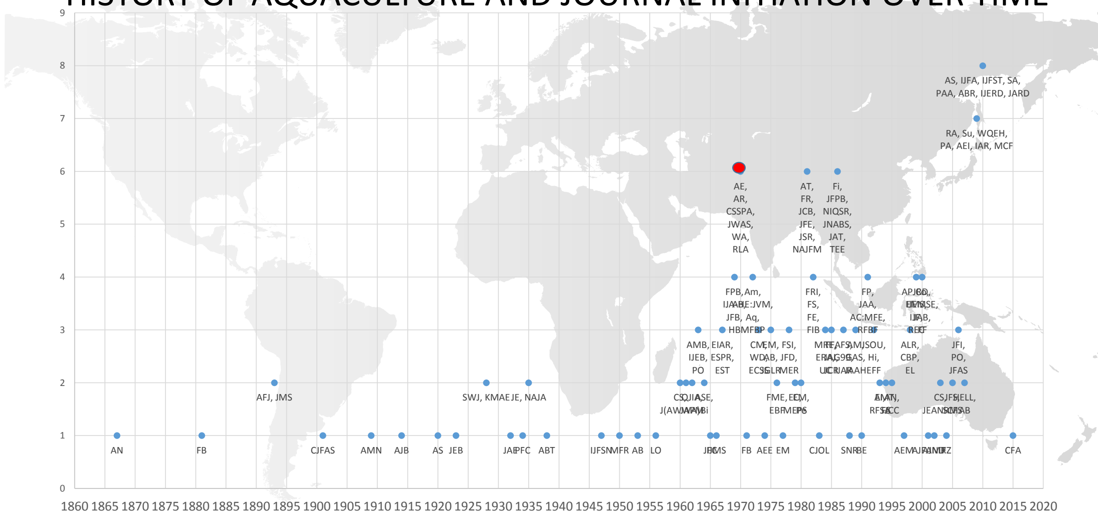
FINDINGS

WOMEN AUTHORSHIP BY POSITION OVER TIME IN IACD



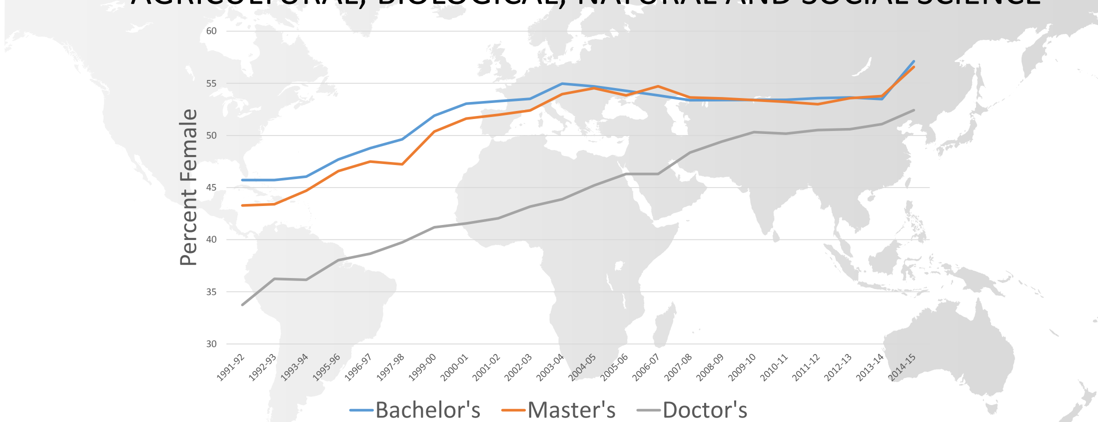
FINDINGS

HISTORY OF AQUACULTURE AND JOURNAL INITIATION OVER TIME



FINDINGS

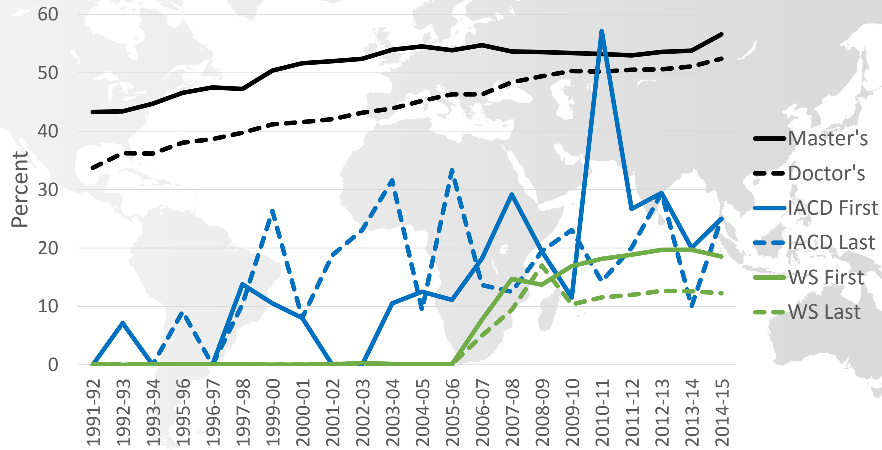
% WOMEN GRADUATES IN AGRICULTURAL, BIOLOGICAL, NATURAL AND SOCIAL SCIENCE



Data source: U.S. Department of Education, National Center for Education Statistics

PERCENT WOMEN GRADUATES IN SCIENCE ALONGSIDE PERCENT FIRST AND LAST AUTHORSHIP POSITIONS

In IACD and Web of Science Datasets



CONCLUSIONS

- Data shows that gap in women authorship is closing

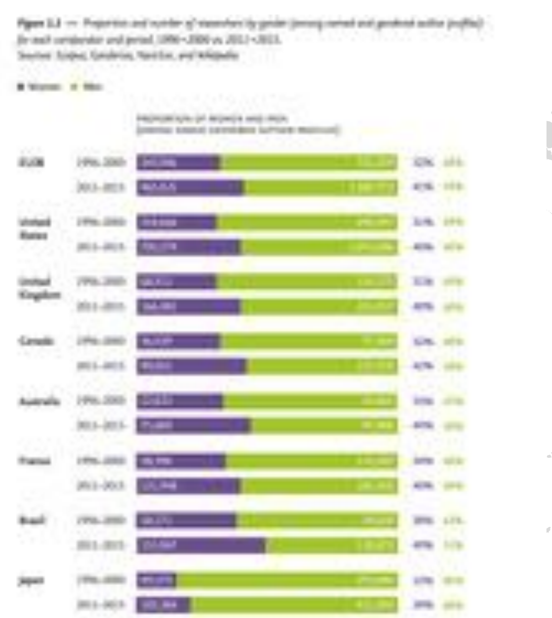
- However, women authorship is still low considering the increasing proportion of women graduates in the sciences

FUTURE CONSIDERATIONS

- Generate JSTOR authorship positions over time

- Calculate % women in aquaculture internationally

- Applications for IACD dataset on Data Verse



SO WHAT?

RECOMMENDATIONS

- Continue to track gender authorship in scholarly literature

- Promote standardized practices for assigning authorship position on peer-reviewed papers

- Provide atmosphere to encourages women scientists to remain in academia through mentoring, opportunities for promotion, reviewers on publications, etc.

- Encourage organizations and individuals to consider how structures that propagate gender inequities can be overturned to promote better outcomes

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Effect of consumption of complimentary traditional food on the growth and iron status of 6 to 15 months old Cambodian children in Preveng Province, Cambodia

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With prevalent malnutrition problems largely due to food and nutrition insecurity, locally available foods need to be maximized for increased consumption. The effect of two rice-based complementary foods prepared using edible spider (Winfood CF) and small fish (Winfood-Lite) vis-à-vis two corn soya blend products (CSB+ and CSB ++) was explored in this single-blind randomized intervention trial among 126 Cambodian infants aged 6 months without severe wasting (<-3 weight-for-length z-score), pitting edema, signs of vitamin A deficiency or anemia (Hb<80g/L). The samples were recruited and randomized from 7 communes in Pea Raing District, Prey Veng province, Cambodia. Intervention was daily supplementation with one of the four products for nine months: 50g/d form 6-8 months, 75g/d from 9-11 months and 125 g/d from 12-15 months of age.

Mean weight and height of infants significantly improved and remained within normal range at endline. The weight for age Z score (WAZ), length for age Z score (LAZ) and weight for height Z scores (WHZ) also increased. In contrast, there was a three-fold decrease in serum ferritin though it remained within normal range. Hemoglobin levels remained unchanged and indicated anemia. No difference in weight, length, WAZ, LAZ, WHZ, serum ferritin and hemoglobin was observed between the four groups of children indicating that the Winfoods had the same effect as the CSB products on iron status and growth. There is a weak but positive association between ferritin and weight, length and age, hemoglobin and vitamin C intake. Weight and gender were also correlated.

The study concludes that Winfood products (Windfood CF and Winfood Lite) are at par with CSB products (CSB^{+} and CSB^{++}). The promotion and utilization of nutritious and locally available foods should be sustained and enhanced to increase consumption either in their natural or processed state. The conduct of further studies on the nutritional impact of the edible spider and small fish, as well as reviews of their proportion in product formulation are likewise suggested.

EFFECT OF CONSUMPTION OF COMMLEMNTARY TRADITIONAL FOOD ON THE GROWTH AND IRON STAUTS OF 6 TO 15 MONTHS OLD CAMBODAIN CHIDREN IN PREVENG PROVINCE CAMBODIA

TOUCH BUNTHANG

Aquaculture America 2018

Las Vegas, Nevada

February 20, 2018

Outline

- INTRODUCTION
- METHODOLOGY
- RESULTS
- CONCLUSION
- RECOMMENDATION

INTRODCTION

- Malnutrition remains the world's most serious health problem and the biggest contributor to child mortality
- Cambodia with a population of 15 million, undernutrition rates are high and have changed little in the past 10 years with 40% of 1.5 million children under five stunted, 11% wasted and 28% underweight.
- Micronutrient deficiencies especially iron, vitamin A and iodine deficiencies are of critical concern in Cambodia.

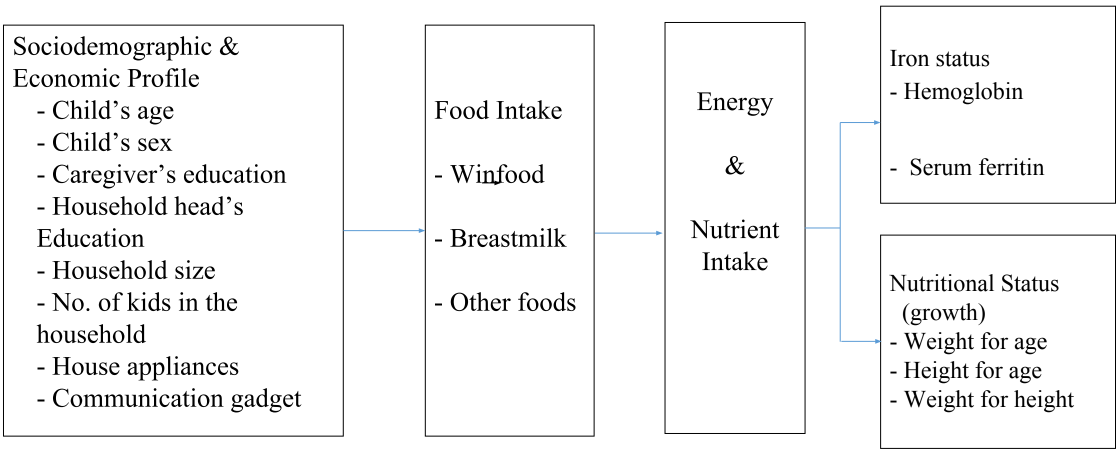
Objective the Study

In general, this study evaluated the effect on (Winfood CF and WinFood Lite) on the iron status and growth of children aged 6 to 15 months of age, comparison CSB+ and CBS++. The primary outcome is the iron status and the secondary outcome is growth.

The specific objective are:

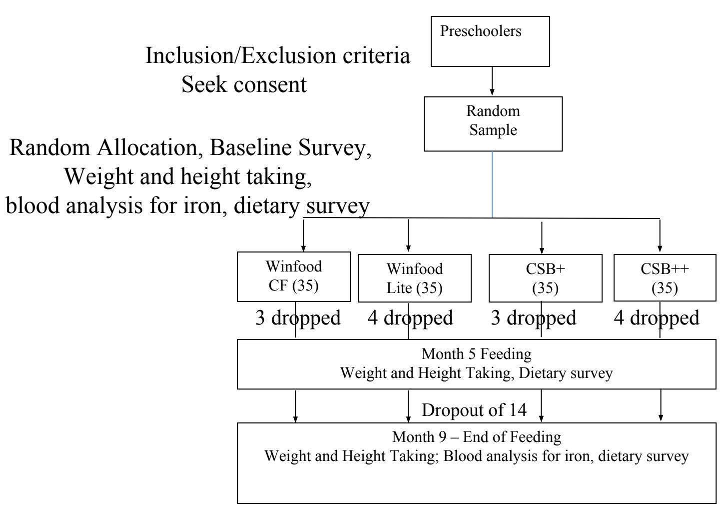
- To assess if there are significant differences between and within the study groups on growth and,
- To assess if there are significant differences between and within the study groups on iron

Conceptual Framework of the Study



METHODOLOGY

Design of the study



Seven selected communes in Prey Veng Province which identified as being food insecure by RACHA (Cambodian Non-Governmental Organisation).

Study Site

Population and Sampling

- The 140 infants (WinFood CF=35, WinFood Lite 35, CBS+=35 and CSB++=35)

- Drop outs however, the final sample was 126 children (95%) of the target sample.

Eligibility Criteria

Enrolment of the child was based on the following criteria:

- should be 6 (+ and – one months)
- not severely malnourished based on weight for length z-score (WLZ) (>-3)
- No clinical signs of vitamin A deficiency
- no severe anemia based on a hemoglobin level of <80ug/L
- mother planned to stay in the study area for the next 9 months
- mothers consented to participate in the study
- Children with weight-for-height z-score <-3 and/, anemia (Hb < 80ug/L), clinical signs of vitamin A deficiency were referred for treatment to hospitals.

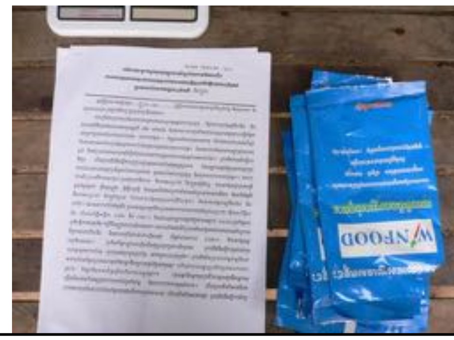
Winfood Complementary Foods

Contents of key nutrients in a portion of 100 g processed WinFood-FC

PROCESSED FOOD	DRIED PORTION (g)	ENERGY (kcal)	CONTENT (g)		E%		MINERAL (mg/100g)			DENSITY (mg/1000kcal)		
			Protein	Fat	Protein	Fat	Fe	Zn	Ca	Fe	Zn	Ca
Rice	84.5	308	7.1	1.2	9	3	1	1.4	42.3	3.3	4.7	137
Fish (Tray Changwa Phlieng)	6.3	35	5.6	1.4	64	36	28	1.3	209	8	38	6000
Fish (Trey Slouek Russey)	6.3	58	5	4.2	35	65	0.6	1	209	9.7	17	3623
Other animal foods												
Spider (aping)	2.1	9	1.5	0.3	71	29	0.2	1		27	118	494
Oil (1)	0.6											
WinFood Product	100	409	19.2	7	18.8	15.5	4.6	4.8	461	11	12	1127
To be added before processing												
Oil [1]	5	45	0	5	0	100	0	0	0	0	0	0
Sugar [2]	5	20	0	0	0	0	0	0	0	0	0	0
Total	110	474	19	12	16.2	22.9	4.6	4.8	461	10	10	972
Recommended					15	20-30				9	13	600

Contents of key nutrients in a portion of 100 g processed WinFood Lite

PROCESSED FOOD	DRIED PORTION (g)	ENERGY (kcal)	CONTENT(g)		E%		MINERAL (mg/100g)			DENSITY (mg/1000kcal)		
			Protein	Fat	Protein	Fat	Fe	Zn	Ca	Fe	Zn	Ca
Rice	84.8	309	7.1	1.2			1	1.4	42			
Mixed fish species	10	55	8.8	2.2			0.3	0.3	38			
Oil	5	45	0	5								
Premix	0.2						7	2.8				
Total WF Lite	100	409	15.39	8.4	14.9	17.6	8.3	4.5	350	19	11	857
Added sugar	5	20										
Total WF-Lite + sugar	105	429	15.9	8.4	14.9	17.6	8.3	4.5	350	19	11	817



Corn-Soy Blend Products

CSB+ formula (copied from WFP technical specification for CSB+, vers.1.6)

N°	Ingredients	Percentage (by weight)
1	Corn (maize white or yellow)	72.05-77.05
2	Whole soya beans	20-25
3	Vitamin/Mineral FBF-V-10	0.2
4	CaCO3 (calcium carbonate)	1.19
5	$Ca(H_2PO_4)_2$ H2O (mono calcium phosphate)	0.8
6	KCI (potassium chloride)	0.76

Micronutrient rate and chemical form for CSB++

N°	INGREDIENTS	PERCENTAGE (by weight)
1	Corn (maize white or yellow)	57.05-2.05
2	De-hulled soya beans	15-20
3	Dried skim milk powder	8
4	Sugar	9
5	Refined soya bean oil	3
6	Vitamin/Mineral FBF-V-10	0.2
7	CaCO3 (calcium carbonate)	1.19
8	$Ca(H_2PO_4)_2$ H2O (mono calcium phosphate)	0.8
9	KCI (potassium chloride)	0.76

Composition of the WinFoods, CSB++ and CSB+ nutrient composition

PORTION	WINFOOD CF	WINFOOD LITE	CSB++	CSB+ (OIL+SUGAR)
Total dried food, g/portion	100	100	100	100
Animal ASF (% of tot. dried)	14	10	8	0
Added oil	5	5	3	10
Added sugar	5	5	9	10
Total portion, g	110	105	112	120
Energy and macronutrients				
Energy, food+oil+sugar (kcal/portion)	474	428	420	510
Protein E%	16	15	15	11
Fat E%	23	18	19	27
Total protein, g/portion	19	16	16	14
Animal protein, g/portion	12	9	3	0
Fat, g/portion	12	8	9	16
Minerals				
Fe, total mg/portion	5.2	9	6.5	6.5
Fe, mg/ portion “high” bioavail. (from ASF or NaEDTA)	3.4		2.5	2.5
Fe, estimated mg absorbable/portion[(1)]	0.8		0.7	0.7
Fe, mg/1000 kcal	11	20	15	13
Zn, mg/portion	3.6	4.5	5.0	5.0
Zn, mg/1000 kcal	8	11	12	10

The Questionnaire

Data Collection

Anthropometric measurements

Blood collection

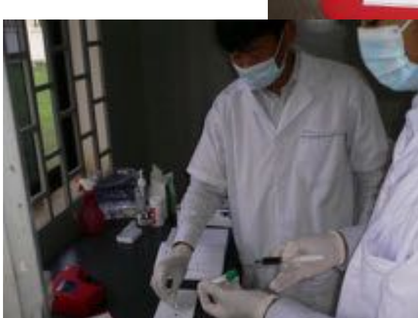
Food and Nutrient Consumption Survey


Electronic
Kitchen scale
WINFOOD
(WinFood)


Electronic
Kitchen scale

Iron analysis

Hemoglobin measurement

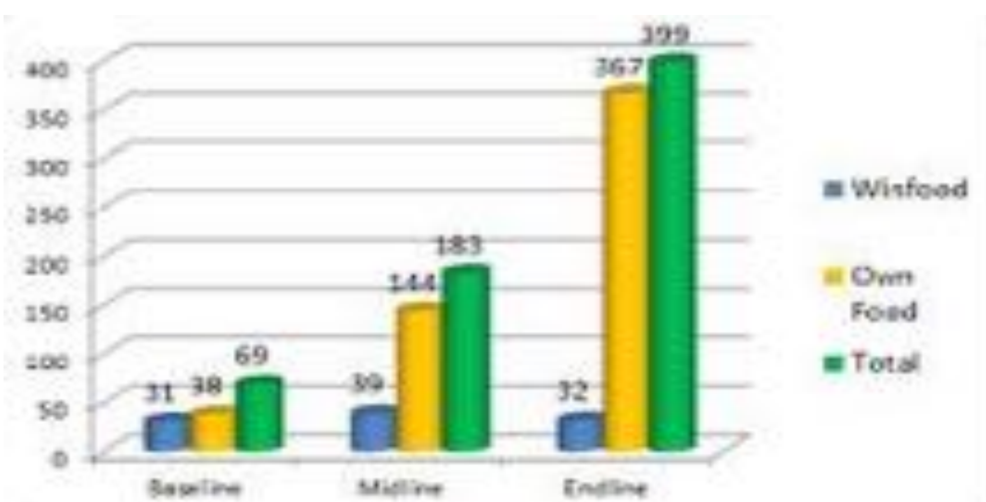


RESULTS

Mean food intake in grams

FOOD GROUP»»	STUDY GROUPS				ALL GROUPS
	WinFood C	WinFood Lite	CSB +	CSB2 ++	
Cereals & products					
Baseline	73.6	44.2	126.7	108.5	87
Endline	450	633.6	639.3	661.4	559
p value	0.00*	0.00*	0.00*	0.00*	0.00*
Starchy roots & tubers					
Baseline	0	0	0	0	0
Endline	33	17	5.4	5.7	25.7
p value	0.18 ^{ns}	0.13 ^{ns}	0.32 ^{ns}	0.05 ^{ns}	0.17 ^{ns}
Legumes & nuts					
Baseline	0	0	0	0	0
Endline	0.4	14.8	23.4	0	12.4
p values	0.67^{ns}	0.08 ^{ns}	0.32 ^{ns}	0.16 ^{ns}	0.09^{ns}
Vegetables & products					
Baseline	0	4.6	0.00	0.7	3.3
Endline	13	18.4	21.7	18.4	18.3
p values	0.00*	0.03*	0.00*	0.00*	0.02*
Fruits					
Baseline	49.7	44.5	28.1	45.4	40.6
Endline	85.2	97.3	59.9	111.2	77.6
p value	0.03*	0.06 ^{ns}	0.02*	0.29 ^{ns}	0.03*
Meat					
Baseline	0	4.6	0	13.3	10.1
Endline	39.6	31.4	31.4	31.4	28.9
p value	0.00*	0.01*	0.00*	0.02*	0.03*
Fish and products					
Baseline	0.0	0.0	0.0	0.0	0.0
Endline	28.5	92.4	94.9	83.9	74.8
p value	0.00*	0.00*	0.00*	0.00*	0.00*

Mean intake of WinFoods and other foods, in grams



Mean energy and nutrient intakes

ENERGY/ NUTRIENT	STUDY GROUPS				ALL GROUPS	P VALUES
	WinFood CF	WinFood Lite	CSB+	CSB++		
Energy, kcal						
Baseline	213	214	184	220	208	0.73 ns
Endline	517	575	572	639	576	0.54 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	
Protein, g						
Baseline	6.84	7.09	6.03	8.22	7.04	0.50 ns
Endline	19.12	22.13	22.03	22.32	21.38	0.66 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	
Carbohydrates, g						
Baseline	26.9	11.58	10.88	12.03	15.4	0.45 ns
Endline	87.06	77.48	80.38	86.06	82.76	0.94 ns
P value	0.01*	0.00*	0.00*	0.00*	0.00*	
Fats, g						
Baseline	4.15	4.26	7.72	5.03	5.3	0.15 ns
Endline	10.28	11.39	12.93	14.93	12.37	0.18 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	

Mean energy and nutrient intakes, cont…

ENERGY/ NUTRIENT	STUDY GROUPS				ALL GROUPS	P VALUES
	WinFood CF	WinFood Lite	CSB+	CSB++		
Vitamin A, ugRE						
Baseline	23	85	51	91	62	0.05 ns
Endline	104	179	135	158	144	0.20 ns
P value	0.00*	0.04*	0.00*	0.08 ns	0.00*	
Vitamin C, mg						
Baseline	1.19	37.08	29.31	36.29	25.79	0.00*
Endline	9.14	38.79	26.4	34.25	26.99	0.03*
P value	0.00*	0.88 ns	0.68 ns	0.82 ns	0.06 ns	
Vitamin B1						
Baseline	0.08	0.06	0.4	0.07	0.06	0.13 ns
Endline	0.3	29	0.55	0.55	0.42	0.63 ns
P value	0.00*	0.00*	0.08 ns	0.07 ns	0.00*	
Vitamin B2						
Baseline	0.06	0.21	0.16	0.2	0.16	0.13 ns
Endline	0.16	0.32	0.27	0.64	0.35	0.16 ns
P value	0.00*	0.06 ns	0.01*	0.16 ns	0.00*	

Mean energy and nutrient intakes, cont…

ENERGY/ NUTRIENT	STUDY GROUPS				ALL GROUPS	P VALUES
	WinFood CF	WinFood Lite	CSB+	CSB++		
Vitamin B3						
Baseline	1.2	2.11	1.68	2.06	1.96	0.49 ns
Endline	4.04	4.41	3.9	4.29	4.17	0.88 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	
Iron						
Baseline	1.75	2.64	4.47	4	3.21	0.05ns
Endline	5.3	4.89	5	7.92	5.77	0.36 ns
P value	0.01*	0.02*	0.71*	0.10*	0.00*	
Zinc						
Baseline	1.57	2.1	1.97	2.65	2.07	0.06ns
Endline	2.23	2.54	2.11	5.45	3.07	0.20 ns
P value	0.17*	0.00*	0.72*	0.00*	0.35*	
Calcium						
Baseline	193	239	61	134	156	0.00*
Endline	249	312	171	272	311	0.23 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	

Mean weight, length and z scores of the respondents

INDICATOR	STUDY GROUP				ALL GROUPS	P VALUE
	WinFood CF	WinFood Lite	CSB+	CSB++		
Weight, kg						
Baseline	7.1	7.4	7.3	7.1	7.2	0.43ns
Endline	8.6	8.9	8.7	8.5	8.7	0.28 ns
p value	0.00*	0.00*	0.00*	0.00*	0.00*	
Height, cm						
Baseline	66.0	66.1	66.6	66.7	66.4	0.63 ns
Endline	75.1	75.5	75.1	74.9	75.2	0.82 ns
p value	0.00*	0.00*	0.00*	0.00*	0.00*	
Weight for length , z score						
Baseline	-0.62	-0.29	-0.47	-0.54	-0.48	0.61 ns
Endline	-0.97	-0.72	-0.89	-1.14	-0.94	0.21 ns
p value	0.00*	0.00*	0.00*	0.00*	0.00*	
Weight for age, z score						
Baseline	-1.07	-0.71	-0.87	-1.02	-0.92	0.43 ns
Endline	-1.25	-1.05	-1.21	-1.44	-1.24	0.32 ns
p value	0.00*	0.00*	0.00*	0.00*	0.00*	
Length for age, z score						
Baseline	-0.91	-0.74	-0.78	-0.93	-0.84	0.82 ns
Endline	-1.16	-1.16	-1.23	-1.30	-1.21	0.90 ns
p value	0.00*	0.00*	0.00*	0.00*	0.00*	

Percent of malnourished children based on anthropometry

INDICATOR	STUDY GROUP WinFood CF	WinFood Lite	CSB +	CSB ++	ALL GROUPS	P Value
Wasted						
Baseline	15.63	6.45	3.23	15.63	10.32	0.03*
Endline	3.13	6.45	3.23	15.63	7.14	0.04*
P value	0.00*	1.00ns	1.00ns	1.00ns	0.43ns	
Underweight						
Baseline	6.25	12.9	3.23	34.38	14.29	0.03*
Endline	12.5	12.9	9.68	31.25	16.67	0.04*
P value	0.00*	1.00ns	0.00*	0.65ns	0.74ns	
Stunted						
Baseline	15.63	6.45	3.23	25	12.69	0.04*
Endline	25	19.35	29.03	37.5	27.78	0.04*
P value	0.00*	0.00*	0.00*	0.00*	0.00*	

Mean serum ferritin and hemoglobin

INDICATOR	STUDY GROUP WinFood CF	WinFood Lite	CSB +	CSB ++	ALL GROUPS	P Value
Serum Ferritin						
Baseline	44.77	34.47	61.56	34.13	44.37	0.17ns
Endline	11.11	16.52	12.27	16.38	14.03	0.33 ns
P value	0.00*	0.00*	0.00*	0.00*	0.00*	
Hemoglobin, mg						
Baseline	10.73	10.65	10.65	10.69	10.68	0.99 ns
Endline	10.19	10.85	10.76	10.71	10.62	0.05 ns
P value	0.53ns	0.61ns	0.72ns	0.98ns	0.91ns	

CONCLUSION

- Complementary WinFood and CSB products have the same effect on iron status and growth among children aged 6 to 15 months.
- No difference weight, height, WAZ, LAZ, WLZ, serum ferritin and hemoglobin, was found between the four groups of children given either WinFood CF, WinFood Lite, CSB+ or CSB++.
- The two WinFood products (CF and Lite) can thus substitute for the CSB products.

CONCLUSION, cont…

- Decreased iron levels at endline is attributed to several factors (such as non-consumption of recommended daily dose of the complementary food, low iron intake, limited overall food intake, possible poor food combinations like iron-rich foods being consumed with foods having iron inhibitors and possible use of a complementary food assigned to other groups as the mothers live in the same area yet the study design was not cluster sampling)
- This study contributed to enhanced knowledge and understanding of the role of access to improved complementary feeding practices thereby contributing to positive human capital in the future.
- Combined with continuing breastfeeding, the locally produced complementary food products can contribute to sustain healthy growth in children. This is if the proper protocol is followed all through the duration of feeding by all project stakeholders.

RECOMMENDATION

- Promotion of nutritious, edible and locally available foods should be enhanced towards maximizing their consumption in their natural state or in processed products towards improving food and nutrition security;
- Research and development efforts on natural and bio-fortified products should be beefed up by the national government;
- Further studies on the role of the edible spider and small fishes in other aspects of nutrition should be conducted;

RECOMMENDATION, cont…

- Concerned agencies who develop and give out food rations should consider being country-specific in the products they make and distribute. That is, any locally available food should be used as an ingredient in processed food products; and
- The government of Cambodia can work towards making laboratory analysis possible within the country to minimize transportation costs and other challenges

Supply chain analysis of carp in Terai, Nepal

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In order to examine the supply chain of carp (Rohu *Labeo rohita*, Naini *Cirrhinus mrigala*, Bhakur *Catla catla*, Silver carp *Hypophthalmichthys molitrix*, Bighead carp *Aristichthys nobilis,* Grass carp *Ctenopharyngodon idella* and Common carp *Cyprinus carpio*) from farm to plate, a study was carried out in three districts of Terai, Nepal namely Makwanpur, Chitwan and Nawalparasi districts. Altogether 102 respondents (20 grow out farmers, 9 fish traders and 5 consumers in each district) were selected randomly for survey from three districts. The survey was carried out from May to September 2016. Data were collected by using semi-structured questionnaire interview of respondents, key informants and field observation. Data were analysed by using One Way Anova followed by Duncan's Multiple Range Test. Market survey showed that carp is sold in two forms, live and fresh forms. Four types of supply chains in live carp and seven types of supply chains in fresh carp were identified. The longest chain included middleman, wholesaler and retailer as intermediaries between farmer to consumer whereas shortest chain was directly from farmer to consumer without intermediaries. Supply chain of live carp was comparatively shorter than fresh carp to minimize fish loss due to handling stress. Grow out farmers in Nawalparasi earned significantly ($P<0.05$) higher profit of 156±1 Rs/kg than Chitwan and Makwanpur due to higher selling price and low variable costs incurred. In live carp supply chain, middleman received higher margin (34-36%) in three districts whereas in fresh carp supply chain, retailers earned higher profit in Makwanpur (50%) and Nawalparasi (56%), and middleman in Chitwan (50%). Unless infrastructure is well developed for fish marketing, unnecessary intermediaries should be eliminated to reduce post harvest loss.

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SUPPLY CHAIN ANALYSIS OF CARP IN TERAI, NEPAL

Sunila Rai*, Kamala Adhikari, Dilip K. Jha, and Ram B. Mandal
Agriculture and Forestry University
Rampur, Nepal

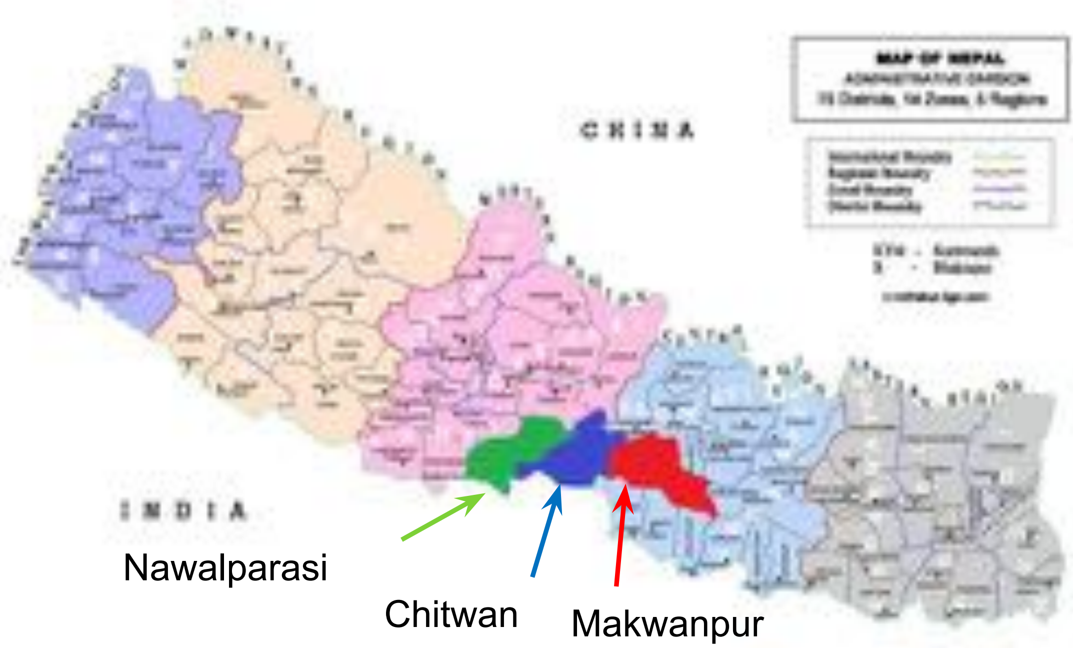
Introduction

- Nepal imports over 60% fish from India (Bhujel, 2015) indicating there is a huge potential for aquaculture development.
- Carp is the major fish produced and imported in Nepal.
- Carp is sold in fresh, live and dry states.
- Live fish marketing is recently emerging in cities despite higher risks. There is a need of in-depth study on supply chain of carp.

Objectives

❖ To examine overall carp supply chain from grow out farmers to traders to consumers and marketing margins of the intermediaries in Makwanpur, Chitwan and Nawalparasi districts.

Research Location



Number of Respondents

Level	Makwanpur	Chitwan	Nawalparasi
Fish farmers	20	20	20
Middlemen	3	3	3
Wholesaler	3	3	3
Retailer	3	3	3
Consumer	5	5	5
Total	**39**	**39**	**39**

Research Methodology

❖ Household survey was done by interviewing respondents using semi structured questionnaire.

❖ Data were analysed using oneway anova followed by DMRT.

❖ Means were given with standard deviation

Results: Supply chain of Fresh Carp

Chain I Farmer → Middlemen → Retailer → Consumer

Chain II Farmer → Retailer → Consumer

Chain III Farmer → Wholesaler → Consumer

Chain IV Farmer → Middlemen → Consumer

Chain V Farmer → Middlemen → Wholesaler → Consumer

Chain VI Farmer → Middlemen → Wholesaler → Retailer → Consumer

Chain VII Farmer → Consumer

Supply chain for Live Carp

Chain I Farmer → Middlemen → Consumer

Chain II Farmer → Retailer → Consumer

Chain III Farmer → Wholesaler → Consumer

Chain I V Farmer → Consumer

Profit earned by Grow-out Farmers

Grow-out Farmer			
District	Selling price (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	200 ± 2^{b}	74 ± 1^{b}	126 ± 1^{b}
Chitwan	200 ± 3^{b}	99 ± 1^{a}	101 ± 1^{c}
Nawalparasi	226 ± 4^{a}	70 ± 1^{c}	156 ± 2^{a}

Profit earned by Middlemen

For Fresh Carp

Middlemen					
District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	220 ± 10^{b}	200 ± 2^{b}	20 ± 0^{b}	3 ± 0^{a}	17 ± 0^{b}
Chitwan	260 ± 1^{a}	200 ± 3^{b}	60 ± 10^{a}	1 ± 0^{b}	59 ± 10^{a}
Nawalparasi	229 ± 0^{b}	226 ± 4^{a}	3 ± 0^{b}	1 ± 0^{b}	2 ± 0^{b}

Profit earned by Middlemen

For Live Carp

Middlemen					
District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	350 ± 0^{a}	200 ± 2^{b}	150 ± 12^{a}	3 ± 0^{a}	147 ± 12^{a}
Chitwan	350 ± 0^{a}	200 ± 3^{b}	150 ± 0^{a}	3 ± 0^{a}	147 ± 0^{a}
Nawalparasi	350 ± 0^{a}	226 ± 4^{a}	124 ± 1^{a}	3 ± 0^{a}	121 ± 1^{a}

Profit earned by Wholesalers

For Fresh Carp

District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	283±5[a]	225±25[a]	58±30[a]	18±0[a]	40±26[a]
Chitwan	265±5[a]	230±26[a]	35±25[a]	14±0[ab]	21±26[a]
Nawalparasi	253±5[a]	223±3[a]	30±8[a]	11±2[b]	19±6[a]

Profit earned by Wholesalers

For Live Carp

District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	350±0[a]	200±20[a]	150±20[a]	18±0[a]	132±19[a]
Chitwan	350±0[a]	200±20[a]	150±20[a]	14±0[ab]	136±22[a]
Nawalparasi	350±0[a]	226±0[a]	124±0[a]	11±0[b]	113±16[a]

Profit earned by Retailers

For Fresh Carp

District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	333 ± 04^{a}	260 ± 20^{a}	73 ± 21^{a}	17 ± 01^{a}	56 ± 22^{a}
Chitwan	283 ± 26^{ab}	238 ± 12^{a}	45 ± 14^{a}	8 ± 01^{b}	37 ± 14^{a}
Nawalparasi	263 ± 05^{b}	233 ± 08^{a}	30 ± 06^{a}	3 ± 01^{c}	27 ± 07^{a}

Profit earned by Retailers

For Live Carp

District	Selling price (Rs/kg)	Buying price (Rs/kg)	Income (Rs/kg)	Variable cost (Rs/kg)	Profit (Rs/kg)
Makwanpur	350 ± 0^{a}	200 ± 20^{a}	150 ± 20^{a}	17 ± 0^{a}	133 ± 19^{a}
Chitwan	350 ± 0^{a}	200 ± 20^{a}	150 ± 20^{a}	8 ± 0^{b}	142 ± 19^{a}
Nawalparasi	350 ± 0^{a}	226 ± 0^{a}	124 ± 0^{a}	3 ± 0^{c}	121 ± 01^{a}

Percentage (%) distribution in profit of Fish Traders

For Fresh Carp

District	Makwanpur	Chitwan	Nawalparasi
	% of total profit	% of total profit	% of total profit
Middlemen	15	50	4
Wholesaler	35	18	40
Retailer	50	32	56

Percentage (%) distribution in profit of Fish Traders

For Live Carp

District	Makwanpur	Chitwan	Nawalparasi
	% of total profit	% of total profit	% of total profit
Middlemen	36	35	34
Wholesaler	32	32	32
Retailer	32	33	34

Conclusion

- ❖ There was no difference in profit earned by farmers from fresh and live carp marketing.
- ❖ Fish traders earned higher profit from live carp than fresh carp due to higher selling price and shorter supply chain.
- ❖ Live carp marketing benefit both consumers and traders. So, it is gaining popularity among consumers and traders.

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Forecasting farm-gate catfish prices in Uganda using SARIMA model

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Over the last ten years, the aquaculture subsector has emerged as a vibrant sector in Uganda and is being considered as a strategic sub-sector for promoting agricultural diversification. With improved market prices, government intervention for increased production, and stagnating supply from capture fisheries, aquaculture has attracted entrepreneur farmers seeking to exploit the business opportunity provided by the prevailing demand. As production has adjusted over time so have prices. Farm-gate prices have been highly volatile and are potentially a major factor in explaining why catfish farmers and processors are operating at narrow net margins. Price fluctuations translate into significant price risk, since the magnitude and the direction of the month-to-month changes are often unknown to producers. The farmer has to frequently assess whether to harvest now to capture a known price, or to continue to feed to deliver a larger catfish at an unknown future price. Thus, the knowledge of future prices and factors influencing prices would be helpful to fish producers in decision making. It is against this background that a seasonal ARIMA forecasting model was developed to improve the prediction of catfish prices in Uganda.

Monthly farm-gate prices for African catfish covering the period 2006-2013 were obtained from Aquaculture Management Consultants in Uganda. Catfish prices, expressed in Uganda Shillings per kilogram, were deflated using a consumer price index. Stationarity of the series was examined using the ADF and PP test statistics. The optimal number of lags was determined using the Schwarz information criteria. Investigation was also done by examining the ACF and PACF functions. Using the AIC and BIC, six tentative SARIMA models were tested and the best model SARIMA (1,1,1) (0, 1,1)12 was selected by picking the model with the least values.

The estimates parameters are 0.6532 for the non-seasonal AR term and 0.9012 and 0.8095 for the non-seasonal and seasonal MA terms, respectively (Table 1). Based on 95% confidence level, we conclude that all estimated coefficients are significantly different from zero, and thus the model is ideal for forecasting catfish prices.

The forecasted in-sample results are reported in Table 2. It can be noticed from the results that forecasted catfish real prices are close to their actual values. Moreover, all the actual prices fall within the 95% Confidence Intervals of the forecasts, which further confirmed the reliability of the fitted model.

Table 1 Estimated Parameters of SARIMA Model [illegible]			
Parameter	Estimate	Standard Errors	t-Value
Nonseasonal AR			
Lag 1	[illegible]	[illegible]	[illegible]
Nonseasonal MA			
Lag 1	[illegible]	[illegible]	[illegible]
Seasonal MA			
Lag 12	[illegible]	[illegible]	[illegible]
Variance	[illegible]		
Likelihood Statistics			
Effective number of observations [illegible]			[illegible]
Log likelihood (L)			[illegible]
AIC			[illegible]
AICC (F-corrected AIC)			[illegible]
Hannan-Quinn			[illegible]
BIC			[illegible]
Number of parameters estimated (np)			[illegible]

Table 2 Actual and In-sample Predicted Prices [illegible]				
Month	Actual [illegible]	Forecast [illegible]	LCL	UCL
2013 Jan	[illegible]	[illegible]	[illegible]	[illegible]
2013 Feb	[illegible]	[illegible]	[illegible]	[illegible]
2013 Mar	[illegible]	[illegible]	[illegible]	[illegible]
2013 Apr	[illegible]	[illegible]	[illegible]	[illegible]
2013 May	[illegible]	[illegible]	[illegible]	[illegible]
2013 Jun	[illegible]	[illegible]	[illegible]	[illegible]
2013 Jul	[illegible]	[illegible]	[illegible]	[illegible]
2013 Aug	[illegible]	[illegible]	[illegible]	[illegible]
2013 Sep	[illegible]	[illegible]	[illegible]	[illegible]
2013 Oct	[illegible]	[illegible]	[illegible]	[illegible]
2013 Nov	[illegible]	[illegible]	[illegible]	[illegible]
2013 Dec	[illegible]	[illegible]	[illegible]	[illegible]

FORECASTING FARM-GATE FISH PRICES IN UGANDA USING SARIMA MODEL

James O. Bukenya, Kelvin Lule, Moureen Matuha, Theodora Hyuha and Joseph Molnar

Presented at the Aquaculture America 2018, Las Vegas, Nevada

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Why undertake price analysis?

Market Examples: 2009 and 2017

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In 2009..

fish prices in uganda

ALL SHOPPING NEWS IMAGES VIDEOS

"Price of Fresh Tilapia Soars High in Jinja. The price of Fresh Tilapia Fish in Jinja has increased significantly over the past three weeks. Whole sale buyers have to pay **3,900 shillings** per fish up from **2900 shillings**." Nov 26, 2009

New Vision Newspaper

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In 2017..


Tilapia on demand as prices shoot

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Why undertake price analyses?

- Fish prices vary through the course of a calendar year due to seasonal supply and demand factors.
  - ✓ Understanding seasonal price patterns can assist fish producers with their marketing and production management decisions.

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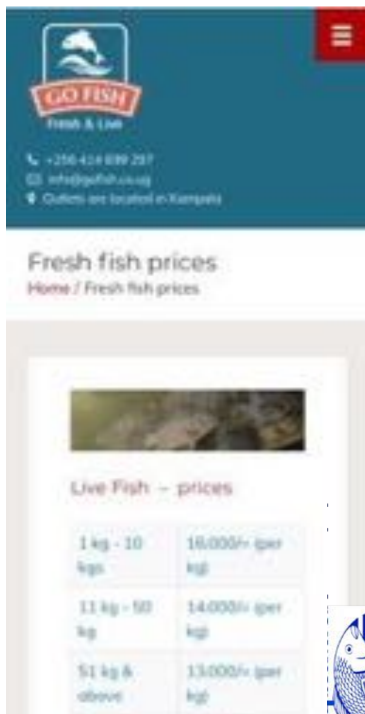
INFOTRADE
AGRICULTURAL MARKET INFORMATION SYSTEM



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Objectives

1. **Understand the historical variations in catfish farm-gate prices, and**
2. **Develop models for forecasting catfish farm-gate prices.**
   - **The motivation is to allow aquaculture producers to plan in advance and manage price risk.**

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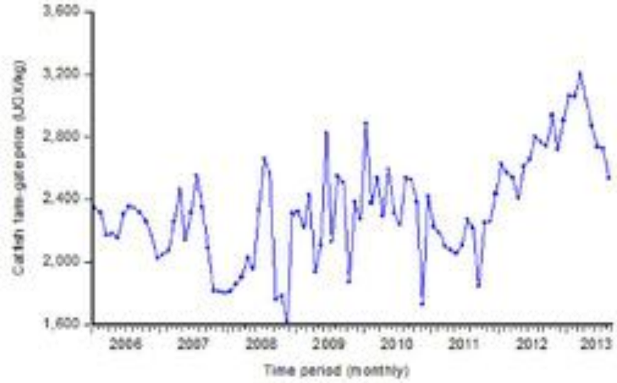
Data

- Price data by the Aquaculture Management Consultants.
- Catfish farm-gate prices analyzed based on historical monthly data fr



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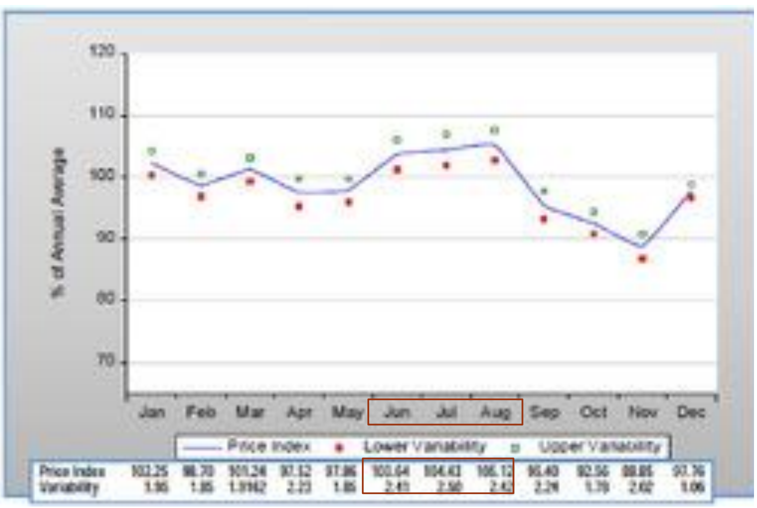
Catfish Monthly Price Index and Variability



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Obj. 1: Understand the historical seasonal variations in prices

- **What is the take home message:**
  - ✓ **The seasonal index show clusters of low (Sept. Oct. Nov.) and high (June, July Aug.) farm-gate monthly prices.**
  - ✓ **The message to stakeholders (farmers, traders, policy makers) is that understanding price behavior across seasons and over space is essential as fish demand varies over species, season and market.**
  - ✓ **Farmers can use the results to develop market specific strategies to gain further market share.**

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Obj. 2: Developing forecasting models.

- **The Box-Jenkins methodology was used:**

1) ***Identification*—Checking for stationary and select order of AR and MA parameters.**
2) ***Estimation of selected model*—Seasonal and non-seasonal parameters.**
3) ***Diagnostic checking and model validation*—Checking ACF and Normal probability plot of the residuals.**
4) ***Forecasting* – In-sample and out-sample using selected model.**

Seasonal Autoregressive Integrated Moving Average

SARIMA (p,d,q)(P,D,Q)s

Where,

p = order of autoregressive component (AR),
d = order of differencing to achieve stationarity,
q = order of the moving average component (MA
P = order of seasonal AR,
D = order of seasonal difference,
Q = order of seasonal MA,
s = the length of seasonal period

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SARIMA (p,1,q) (P,0,Q)12 Model Selection

Table 1
Postulated SARIMA Models and Performance Evaluation

SARIMA Model	# of estimated parameters	AIC	AICC (F-corrected-AIC)	BIC
(0,1,0) (0,1,1)	2	1182.57	1182.72	1187.41
(0,1,0) (1,1,0)	2	1199.47	1199.62	1204.31
(0,1,1) (0,1,1)	3	1180.70	1181.01	1187.96
(0,1,1) (1,1,0)	3	1192.63	1192.93	1199.89
(1,1,0) (0,1,1)	3	1181.97	1182.28	1189.23
(1,1,0) (1,1,0)	3	1195.13	1195.43	1202.39
(1,1,1) (0,1,1)	**4**	**1178.74**	**1179.26**	**1187.42**
(1,1,1) (1,1,0)	4	1192.72	1193.23	1202.39

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Table 2
Estimated Parameters of SARIMA (1, 1, 1)(0, 1, 1)12 Model

Parameter	Estimate	Standard Errors	t-Value
Nonseasonal AR			
Lag 1	0.6532*	0.12170	5.3767
Nonseasonal MA			
Lag 1	0.9012*	0.07270	12.3962
Seasonal MA			
Lag 12	0.8095*	0.07984	10.1390
Variance	0.66652E+05		
Likelihood Statistics			
Effective number of observations (nofobs)			83
Log likelihood (L)			-585.3719
AIC			1178.7438
AICC (F-corrected-AIC)			1179.2566
Hannan Quinn			1182.6308
BIC			1187.4192
Number of parameters estimated (np)			4

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Table 3
In-sample Forecast Prices (UGX/kg)
SARIMA (1, 1, 1) (0, 1, 1)$_{12}$ Model

Month	Actual (UGX/kg)	Forecast (UGX/kg)	LCL	UCL
2013.Jan	7100	6941	6361	7521
2013.Feb	6900	6965	6371	7560
2013.Mar	7200	7000	6404	7595
2013.Apr	7500	7211	6635	7788
2013.May	7500	7446	6872	8019
2013.Jun	7400	7471	6899	8043
2013.Jul	7450	7426	6854	7997
2013.Aug	7350	7435	6867	8002
2013.Sep	7352	7369	6802	7936
2013.Oct	7614	7386	6819	7953
2013.Nov	7871	7660	7075	8245
2013.Dec	7827	7840	7270	8410

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Table 4
Forecast Perfomance for SARIMA (1, 1, 1) (0, 1, 1)$_{12}$

Root Mean Square Error	264.02
Mean Absolute Error	180.55
Mean Absolute Percent Error	4.909
Theil Inequality Coefficient	0.029
Bias Proportion	0.076
Variance Proportion	0.003
Covariance Proportion	0.922

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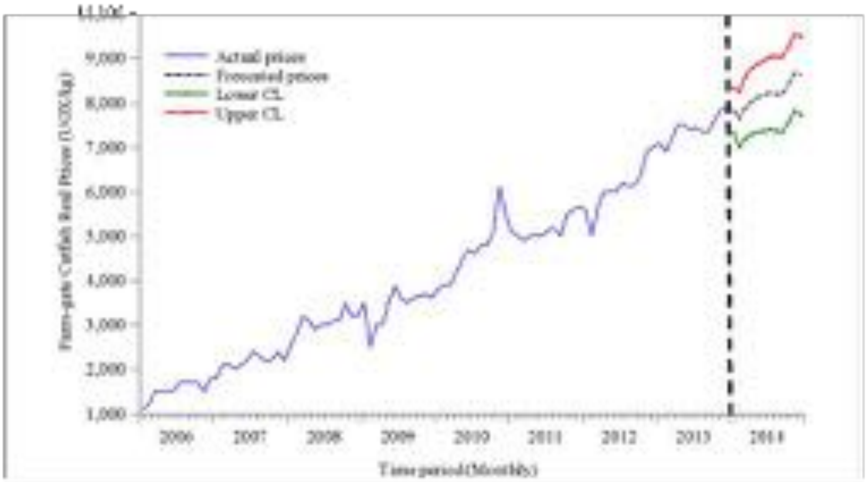
Out-Sample Forecast for Catfish Prices in Uganda



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Conclusions

- **The seasonal index show clusters of low (Sept. Oct. Nov.) and high (June, July Aug.) farm-gate prices.**
- **The forecast of SARIMA model show an increasing trend for the 12-month ahead period.**
- **The message to stakeholders (fish farmers, traders, policy makers) is that understanding price behavior across seasons and over space is essential as fish demand varies over species, season and market.**
- **Farmers can use the results to develop market specific strategies to gain further market share.**
- **One of the major limitation of the study is data: *sample size and dates covered.***

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Acknowledgments:

This research is a component of AquaFish Innovation Lab, supported by USAID CA/LWA No. EPP-A-00-06-00012-00 and by contributions from the participating institutions.

The opinions expressed herein are those of the author) and do not necessarily reflect the views of AquaFish or the U.S. Agency for International Development.

AquaFish Innovation Lab

USAID
FROM THE AMERICAN PEOPLE

Investigating the effects of different feed and probiotics on the survival and growth of goby *Oxyeleotris marmorata* (Bleeker, 1852) from 3-45 days old

Nguyen Phu Hoa*, Vo Phuong Tung, Nguyen Van Bao, Nguyen Van Tu

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This study was conducted to increase survival and growth in the period from 3 to 45 days old. The results showed that supplemented probiotic combining with enriched rotifers accelerated the growth of goby fry period 3 - 15 days old. At 15 to 30 days of age, the use of enriched Artemia at the beginning of the experiment (15 dph) combined with the addition of Moina on 25 dph (NT5) significantly increased the survival rate of marble goby. Moina and Tubifex as food gave the best performance of marble goby at 30-45 days of age.

TABLE 1. Growth of marble goby at 15 days old

Treatment	Average length (mm)	Average weight (mg)
Control	[illegible]	[illegible]
T1	[illegible]	[illegible]
T2	[illegible]	[illegible]
T3	[illegible]	[illegible]

TABLE 2. Growth of marble goby at 30 days old

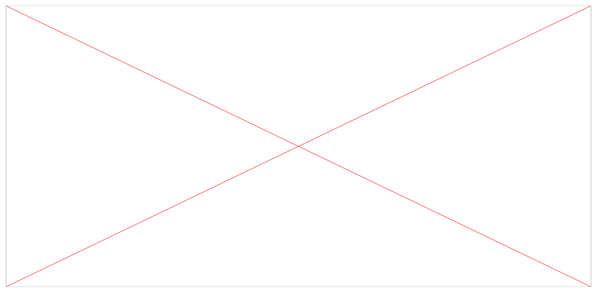
Treatment	Average length (mm)	Average weight (mg)
Control	[illegible]	[illegible]
T1	[illegible]	[illegible]
T2	[illegible]	[illegible]
T3	[illegible]	[illegible]
T4	[illegible]	[illegible]

TABLE 3. Growth of marble goby at 45 days old

	Treatment					
	T1 Moina	T2 Tubifex	T3 Moina+ Tubifex	T4 Pelleted feed	T5 Pelleted feed+ Moina	T6 Pelleted feed+ Tubifex
Average length (mm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average weight (mg)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SGR_L (%/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SGR_W (%/day)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Aquaculture America 2018

Investigating the effects of different feed and probiotics on the survival and growth of marble goby (*Oxyeleotris marmorata* Bleeker 1852) 3-45 days old



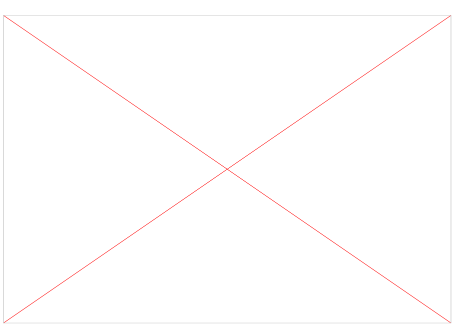
Nguyen Phu Hoa, Vo Phuong Tung,Nguyen Van Bao, Nguyen Van Tu

NONG LAM UNIVERSITY, HO CHI MINH CITY

INTRODUCTION

Marble goby

Oxyelotris marmorata Bleeker 1852



Nutritous and high value

Distribute in all freshwater body in South East Asia (Dương Nhựt Long, 2003).

In Viet Nam, nursing fingerling has low survival rate (Nguyễn Phú Hòa và Dương Hữu Tâm, 2007).

INTRODUCTION

Phạm Văn Khánh (1999), Võ Đình Tâm (2010) nursing fingerling gave survival rate of less than < 50 %.

Fry of 30 day old change their living habit: from column dwelling to bottom. They also change their feeding habit and chasing prey (Dương Nhựt Long, 2003).

Objective

To evaluate the survival and growth of mable goby 3-45 days-old using different feeds and probiotic

RESULTS

1. Survival rate and growth of 3-15 days-old marble goby

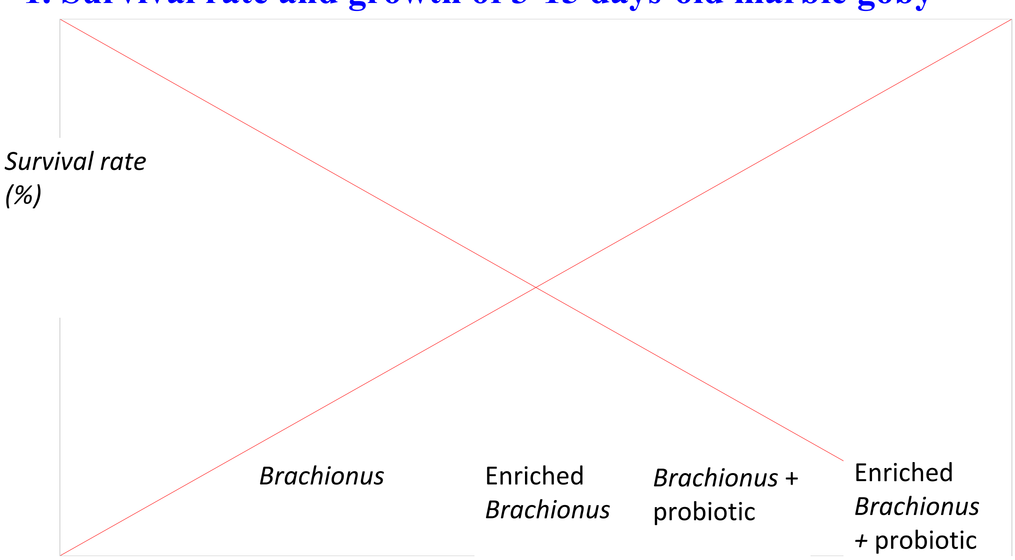


Fig. 1. Average survival rate of mable goby fry at 15 days-old

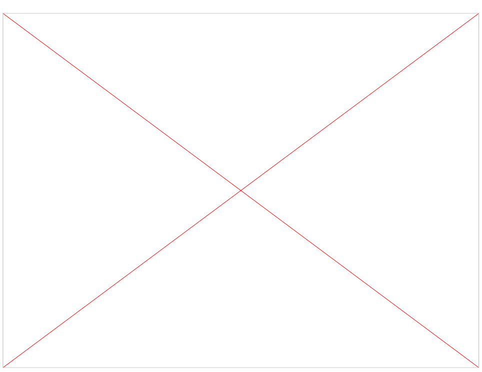
RESULTS

Table 1: Growth of marble goby at 15 days old

Treatment	Average length (mm)	Average weight (mg)
Brachionus	$5{,}22^{a} \pm 0{,}16$	$0{,}82^{a} \pm 0{,}07$
Enriched *Brachionus*	$5{,}25^{a} \pm 0{,}18$	$0{,}96^{b} \pm 0{,}03$
Brachionus + Probiotic	$5{,}22^{a} \pm 0{,}13$	$0{,}82^{a} \pm 0{,}02$
Enriched *Brachionus* + Probiotic	$5{,}55^{b} \pm 0{,}18$	$1{,}05^{c} \pm 0{,}04$

Enriched *Brachionus angularis* with (n–3) HUFA (0,6 g A1DHA in 1 L of water with 500,000 *Brachionus*)
Probiotic: *Bacillus licheniformis* 1,6 x 10^{10} CFU, *Bacillus megaterium* 1,6 x 10^{10} CFU, *Bacillus mensentericus* 1,6 x 10^{10} CFU, *Nitrosomonas* sp 1,6 x 10^{10} CFU, *Nitrobacter* sp 1,6 x 10^{10} CFU

RESULTS



Picture 1. 3 days-old marble goby (4X)

Picture 2. 15 days-old marble goby (4X)

3 days old marble goby were nursed in green water of *Chlorella* sp. adding probiotic and fed with enriched *Brachious angularis* got the highest survival rate and better growth performance compared to other treatments.

RESULTS

2. Survival rate and growth of 15 – 30 days-old marble goby

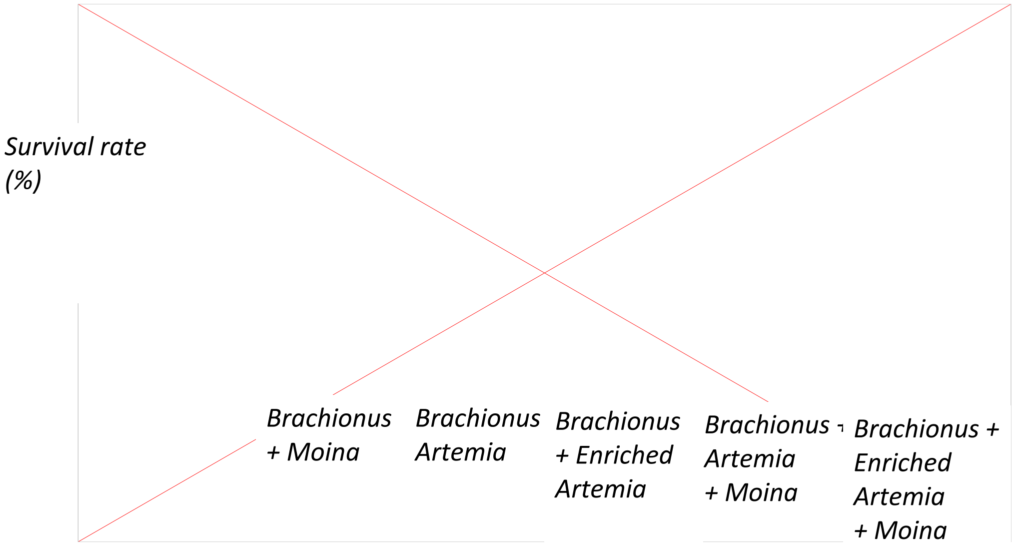


Fig. 2. Average survival rate of mable goby fry at 30 days-old

RESULTS

Table 2: Growth of marble goby at 30 days old

Treatment	Average length (mm)	Average weight (mg)
Brachionus + Moina	$6{,}61^{a} \pm 0{,}23$	$3{,}57^{a} \pm 0{,}47$
Brachionus + Artemia	$7{,}20^{b} \pm 0{,}23$	$3{,}88^{b} \pm 0{,}50$
Brachionus + Enriched Artemia	$7{,}70^{c} \pm 0{,}16$	$4{,}66^{c} \pm 0{,}32$
Brachionus + Artemia + Moina	$7{,}81^{d} \pm 0{,}14$	$4{,}66^{c} \pm 0{,}38$
Brachionus + Enriched Artemia + Moina	$8{,}02^{e} \pm 0{,}15$	$5{,}20^{d} \pm 0{,}44$

⇒ Results showed that feeding marble goby fry with artemia, especially enriched artemia gave their best performance

RESULTS

3. Survival rate and growth of 30 – 45 days-old marble goby

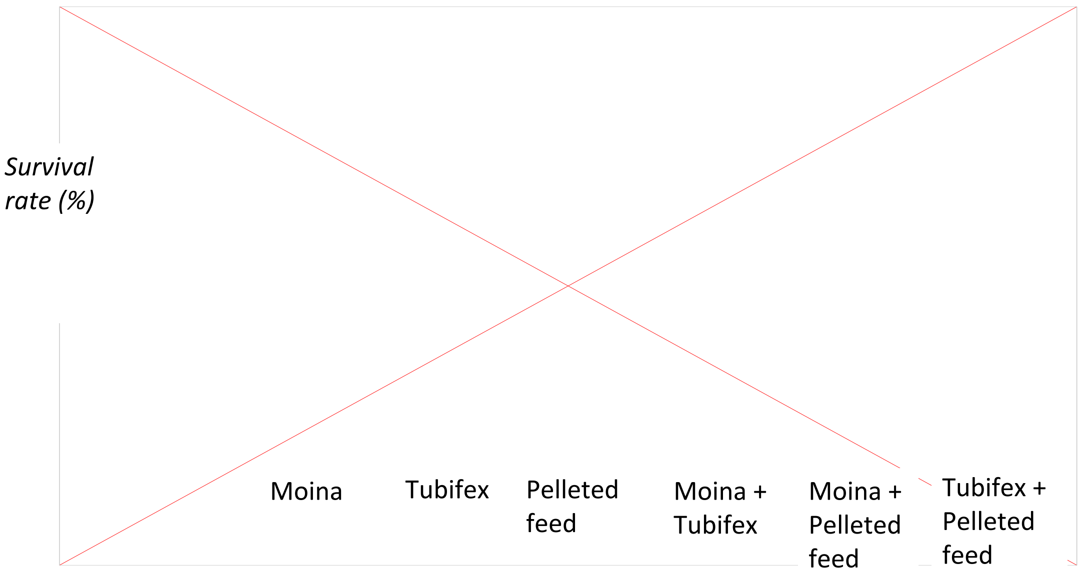


Fig. 3. Average survival rate of mable goby fry at 45 days-old

RESULTS

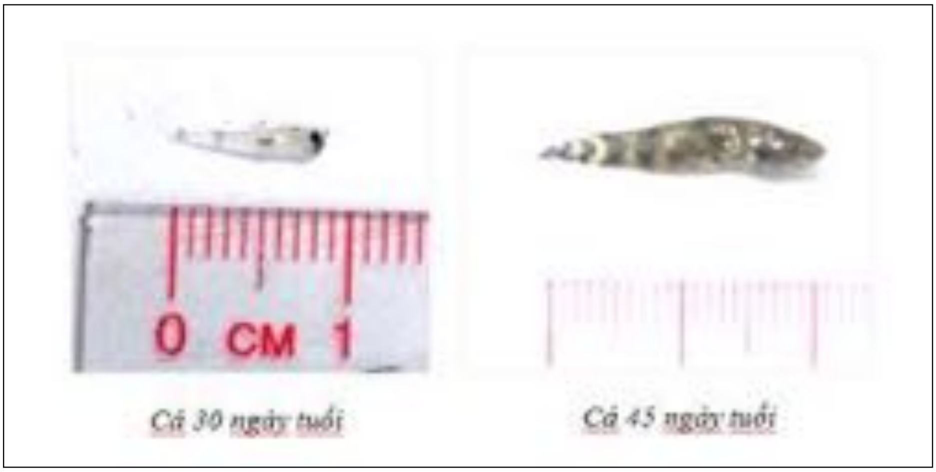
Table 3: Growth of marble goby at 45 days-old

	Treatment					
	T1	T2	T3	T4	T5	T6
	Moina	Tubifex	Moina+ Tubifex	Pelleted feed	Pelleted feed+ Moina	Pelleted feed+ Tubifex
Avergage length (mm)	$22,1\pm0,3^{a}$	$19,7\pm0,3^{b}$	**$22,1\pm0,4^{a}$**	$17,6\pm0,4^{c}$	$21,0\pm0,3^{ab}$	$20,1\pm0,3^{b}$
Average weight (mg)	$191,8\pm3,2^{bc}$	$186,8\pm4,5^{c}$	**$207,3\pm4,0^{a}$**	$168,2\pm2,4^{d}$	$200,8\pm3,0^{ab}$	$182,5\pm3,0^{c}$
SGR_L (%/ngày)	$5,6\pm0,1^{a}$	$4,8\pm0,1^{c}$	$5,6\pm0,1^{a}$	$4,1\pm0,1^{d}$	$5,3\pm0,1^{ab}$	$5,0\pm0,1^{bc}$
SGR_W (%/ngày)	$17,8\pm0,1^{bc}$	$17,6\pm0,2^{c}$	$18,3\pm0,1^{a}$	$17,0\pm0,1^{d}$	$18,1\pm0,1^{ab}$	$17,5\pm0,1^{c}$

Pelleted feed: Cargill feed, no.7404

RESULTS

Moina + Tubifex gave the best survival rate and growth of marble goby fry



RESULTS

4. Effects of PROBIOTIC on survial rate and growth of marble goby fry

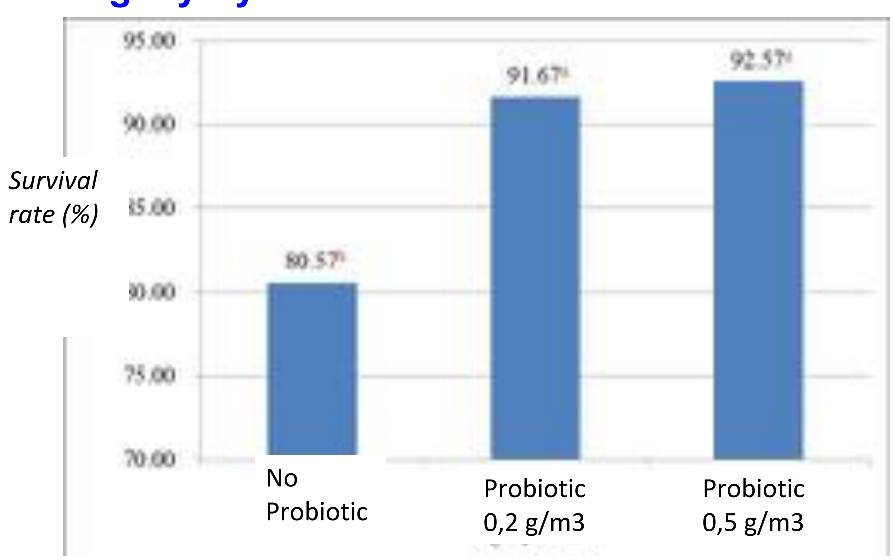


Fig. 4. Average survival rate of mable goby fr... ys-old

RESULTS

Table 4: Growth of marble goby at 45 days-old

	Treatment		
	No Probiotic	Probiotic (0,2 g/m3)	Probiotic (0,5 g/m3)
Avergage length (mm)	22,4±0,3^{b}	**23,8±0,4^{a}**	**24,1±0,3^{a}**
Average weight (mg)	204,7±3,4^{b}	**244,0±3,1^{a}**	**249,3±2,5^{a}**
SGR_L (%/ngày)	5,7±0,1^{b}	6,0±0,1^{a}	6,1±0,1^{a}
SGR_W (%/ngày)	18,2±0,1^{b}	19,1±0,1^{a}	19,4±0,1^{a}

CONCLUSION

In nursing marble goby,

from 3 – 15 days: feed them with enriched Brachionus,

from 15 – 30 days: feed them with enriched Brachionus + enriched artemia + Moina

from 30 – 45 days: using Moina + Tubifex

Using Probiotic at 0,2 g/m^3

Acknowlegements

- **This research is funded by Vietnamese Ministry of Education and Training**
- **Attending *Aquaculture America 2018* is sponsored by AquaFish Innovation Lab (Oregon State University)**

THANK YOU VERY MUCH

Recent advances in the culture of native marine species from the coast of Tabasco, Mexico

Contreras-García María J.*, Contreras-Sánchez Wilfrido, Mcdonal-Vera Alejandro, Cruz-Rosado Leonardo, Hernández-Franyutti Arlette, Hernández-Vidal Ulises, Martínez-García Rafael, González-González Guillermo, Heredia-Álvarez Rama K. Q., Ramón-Zapata Felipe, and Vázquez-Gómez Jenny

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Marine fishes represent an important source of food for inhabitants of the coastal region of Tabasco. Their fisheries are the only source of income for several communities and aquaculture is seen as the future for sustained resource management since catch volumes are decreasing at a constant rate. At the Marine Aquaculture Station located in Jalapita Tabasco, we continue our efforts for domesticating native marine species of fish. Broodstocks originated from wild populations are currently been assessed from three species of snooks: *Centropomus undecimalis*, *C. poeyi* and *C. parallelus*. The protocol for induced reproduction is complete including hormone type, dose and spawning timing. Spawning is achieved either with wild broodstock or sex-reversed females. We are currently working on larviculture and feeding regimes. Live food include phytoplankton (*Tetraselmis chuii* and *Nannochloropsis oculata*); zooplankton (*Brachionus rotundiformis, Brachionus plicatilis* and *Artemia* spp). In recent years, some species of the family Lutjanidae were incorporated (*Lutjanus griseus*, *Lutjanus analis*, *Lutjanus cyanopterus*), as well as, the sparid *Archosargus probatocephalus.* We have developed strong ties with the aquaculture and fisheries sectors, workshops and seminars have been conducted, particularly oriented towards Centropomid aquaculture, restocking and good fishing practices. Our next challenges are consolidating larviculture, evaluation of growth under culture conditions and massive release of juveniles in the neighboring coastal lagoons.

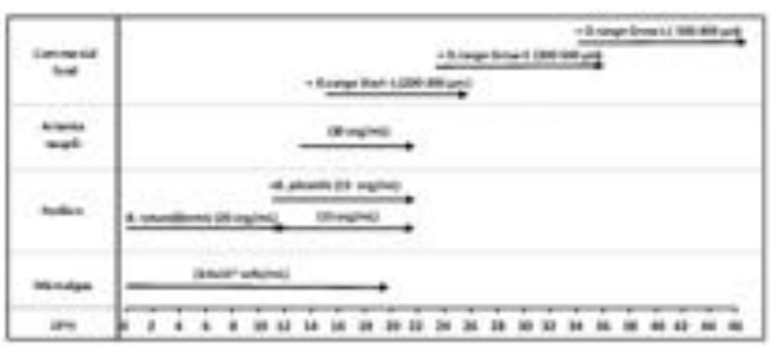


Figure 1. Feeding regime proposed for *C. poeyi*

UNIVERSIDAD JUÁREZ AUTÓNOMA DE TABASCO
División Académica de Ciencias Biológicas
Laboratorio de Acuicultura Tropical

RECENT ADVANCES IN THE CULTURE OF NATIVE MARINE SPECIES FROM THE COAST OF TABASCO, MEXICO

Snook species cultured at the Marine Aquaculture Station

Distributed in the Atlantic coast from Florida to Brasil

C. undecimalis

C. parallelus

The Mexican snook is endemic to the Gulf of México

C. poeyi

Good candidate for aquaculture

In Mexico snooks constitutes one of the most important fisheries in Mexico

- High commercial value
- Good flavor
- Good size
- Nice meat color

However the resource is OVERXPLOITED

MARINE AQUACULTURE STATION
TROPICAL AQUACULTURE LABORATORY

Built as an option to attend the problem

DACBiol-UJAT

Objective

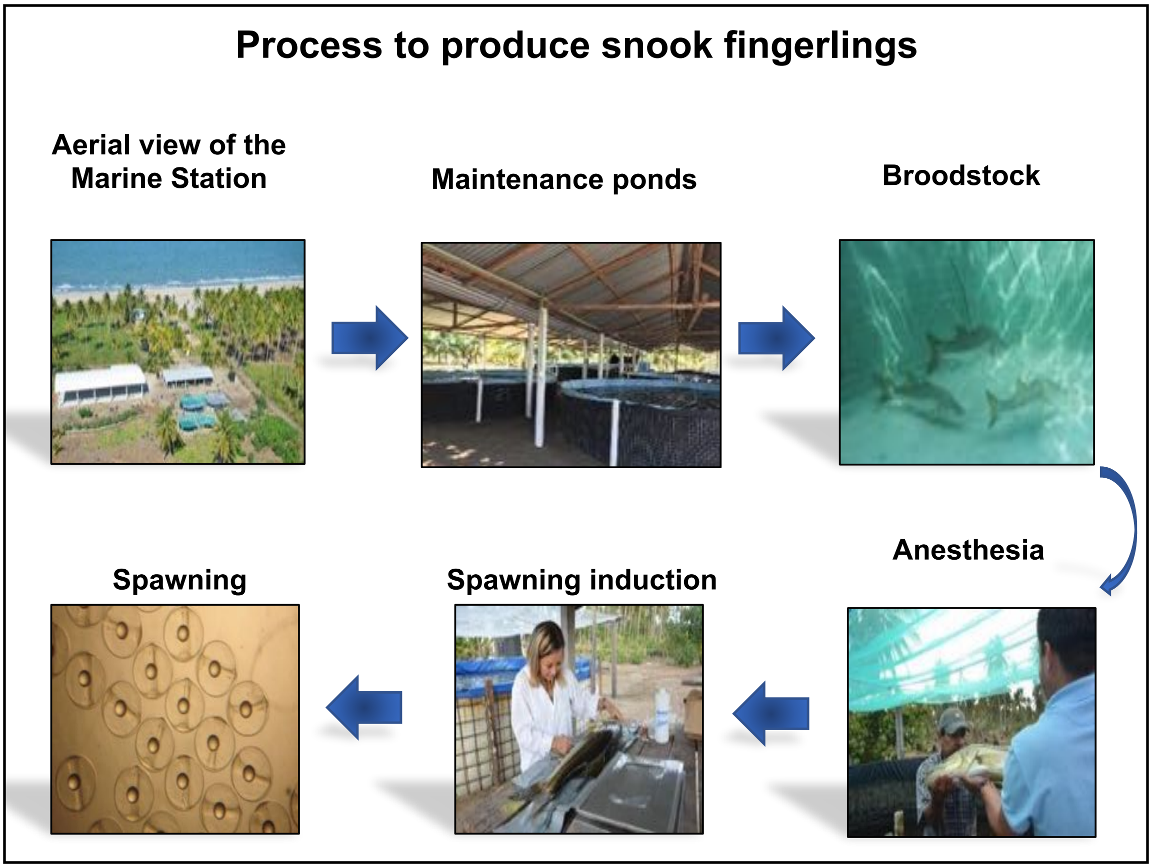
To Generate capacity to produce marine species fingerlings particularly snooks (*Centropomus* spp.) In order to contribute to the recovery of overexploited wild populations.

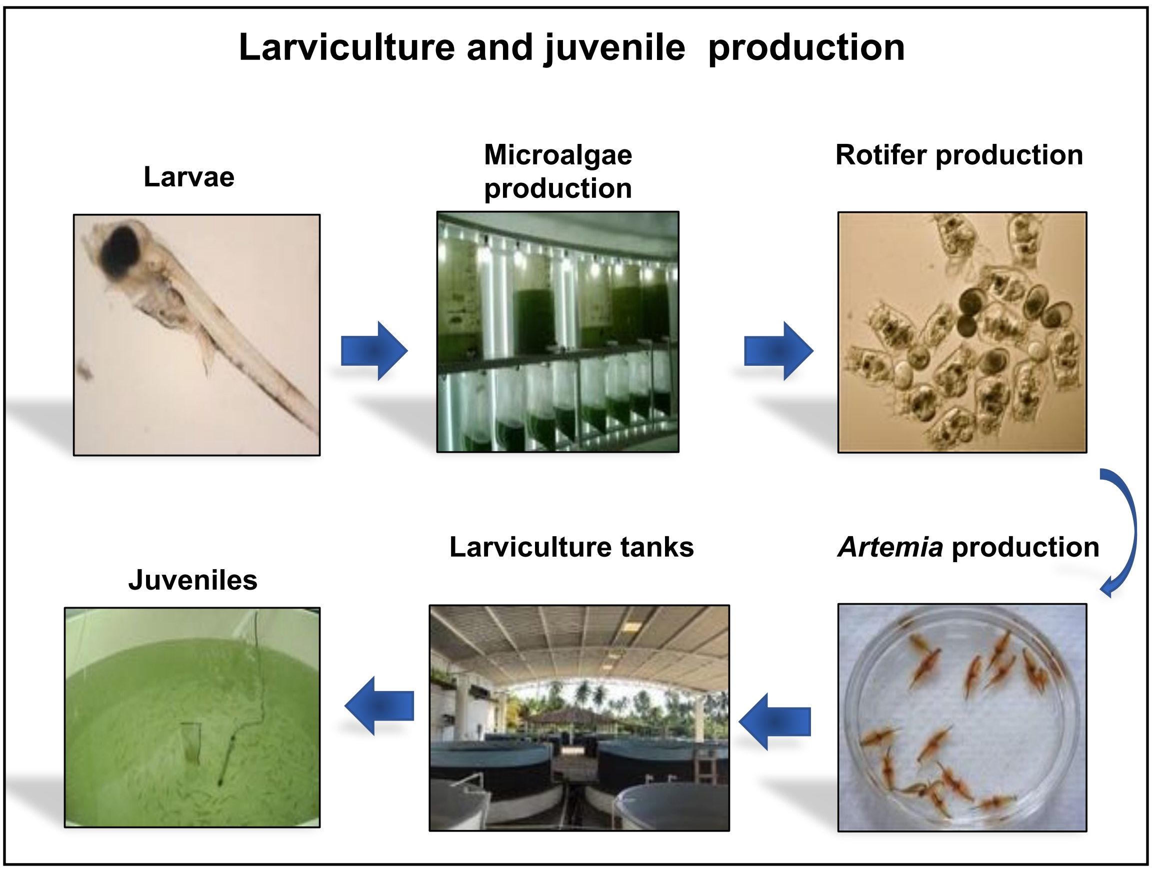
To develop technological packages to include these species into aquaculture

Mexican snook (prieto)

Fat snook

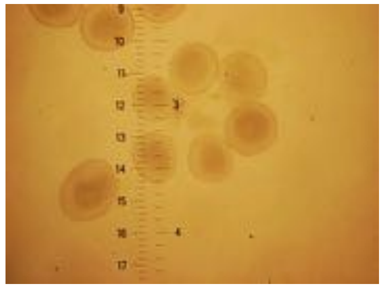
Common snook


Process to produce snook fingerlings
Aerial view of the Marine Station
Maintenance ponds
Broodstock
Anesthesia
Spawning induction
Spawning


Larviculture and juvenile production
Larvae
Microalgae production
Rotifer production
Artemia production
Larviculture tanks
Juveniles

Spawning induction

Females are anesthetized and checked



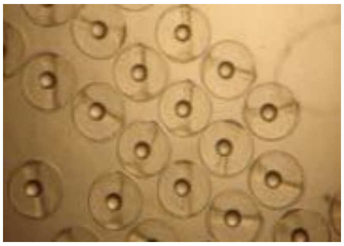
If eggs are > 150 µ, females are implanted

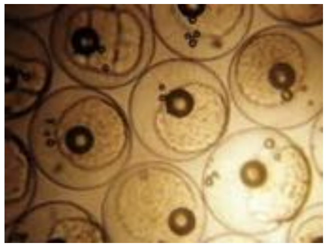
Home-made implants with 200 µg of LHrHa/kg of fish

•Depending on the species spawning takes place in small (fat snook) or large (common and Mexican) tanks.

• eggs are collected and taken into larviculture tanks

28-34 hours after implantation, spawning occurs

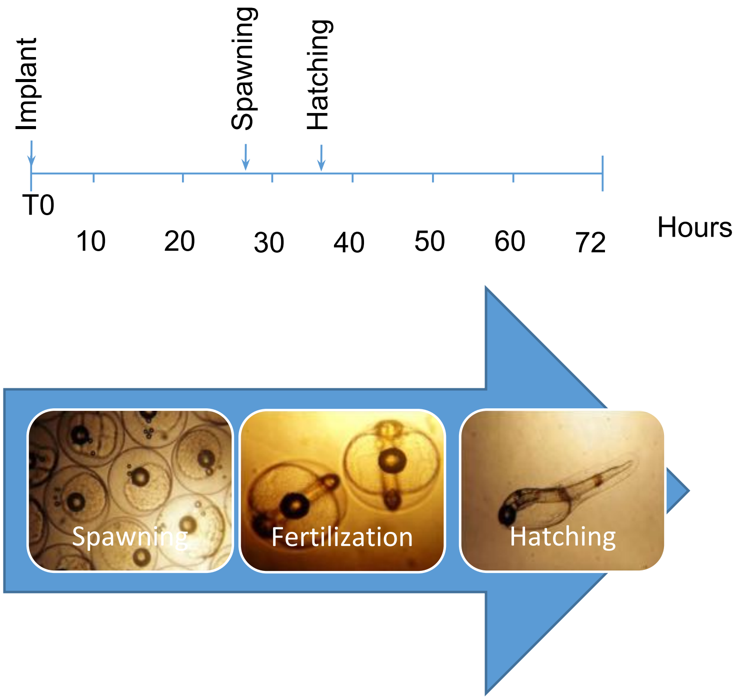




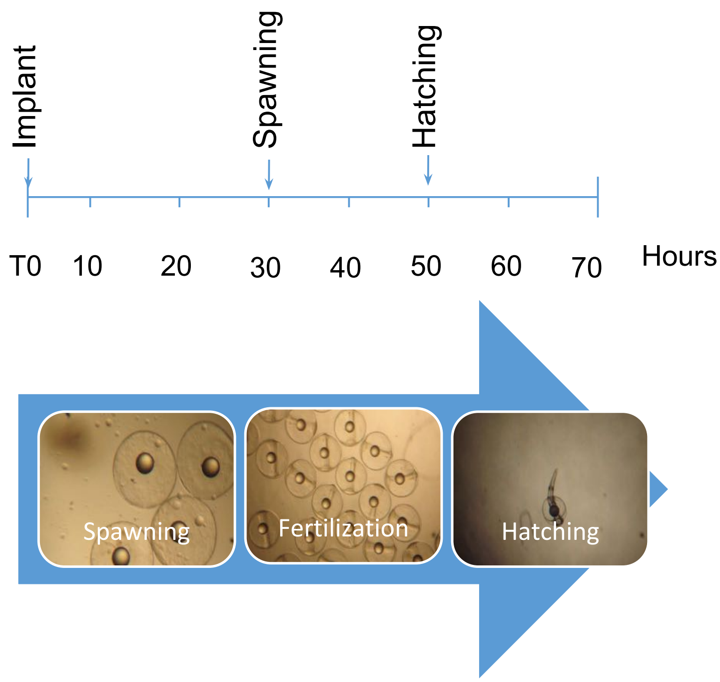
If spawning occurs, quality of the eggs is determined

Larvae hatch in a short period of time (18-26 hours)

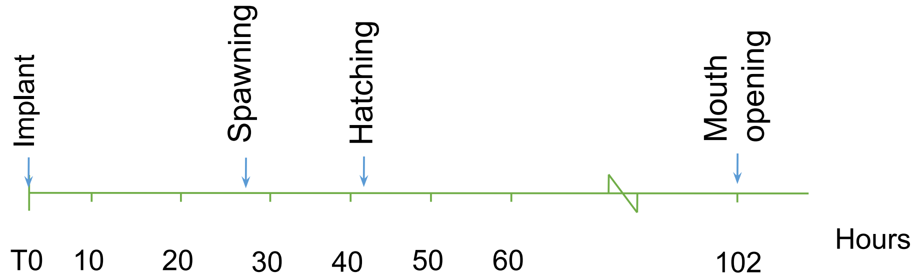
Spawning information for common snook *C. undecimalis*



Spawning information for fat snook, *C. parallelus*



Spawning information for Mexican snook, *C. poeyi*



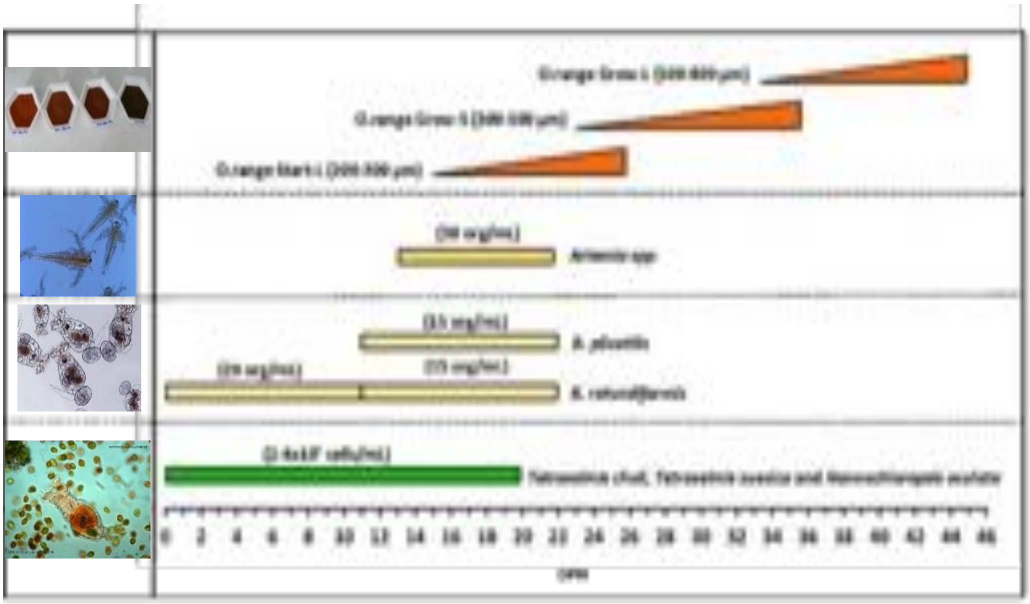
Live Food Production

Nannochloropsis oculata and *Tetraselmis chuii*

Brachionus rotundiformes and *Brachionus plicatilis*

Sampling for algae and rotifer counting is performed daily. Artemia nauplii are also produced

Feeding scheme includes *Brachionus rotundiformis* and *B. plicatilis*, *Artemia* nauplii and artificial feeds.



Daily countings for estimations

Results

Several lots of snook juveniles have been produced. They are used for research purposes and releasing.

Larvae production systems

Tanks used for larval culture

C. poeyi juveniles

Restocking in selected protected areas

Primera liberación a nivel nacional de 1500 juveniles de *C. undecimalis* en Tabasquillo, Centla, Tabasco

Tabasquillo, Centla, Tabasco

Mangrove area for release

Released juveniles

Synergies with the private sector

1500 juveniles of *C. undecimalis* were donated to the farm El Pucté del Usumacinta to perform grow out trials

Bagging and Oxigenation for transportation to El Pucté del Usumacinta

Producer with snook juveniles

Transportation in bags

Restocking of Mexican snook

First time release at the national level,
2,400 juveniles of *C. poeyi*
González river, Jalapita, Centla, Tabasco

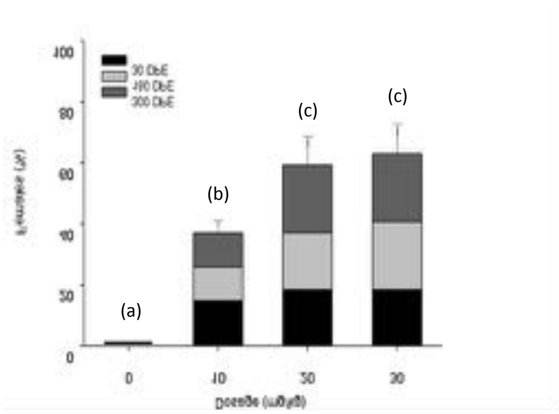
Snook transportation for realease

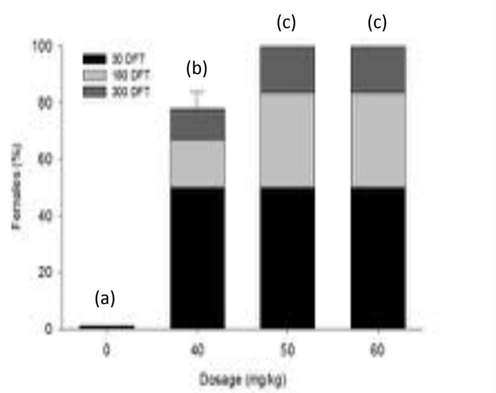
Preparation in the river

Release in the González river,
Jalapita, Centla, Tabasco.

1,000 juveniles of *C. poeyi*
used for research at
DACBiol-UJAT

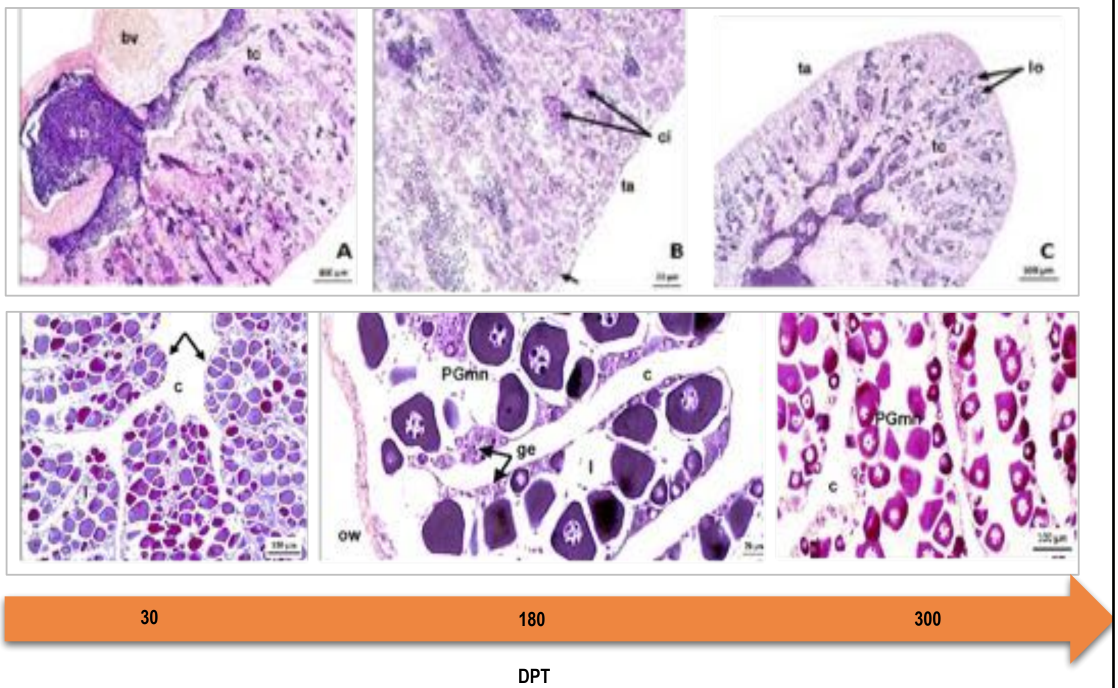
Feminization





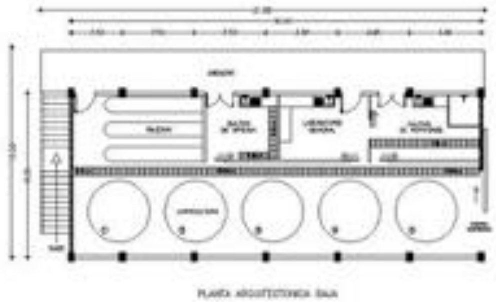
- Significant feminization in all treatments $p < 0.001$
- 100% females when fish were fed 50 and 60 mg per kg of food for 60 days.
- Higher feminization than Vidal *et al.* (2012) and Passini *et al.* (2016) for *C. undecimalis* using E2 in food and implants, respectively.
- In *C. parallelus* up to 100 % females were obtained when 25 mg E2 kg^{-1} were used for 45 days (De Carvalho *et al.*, 2014).

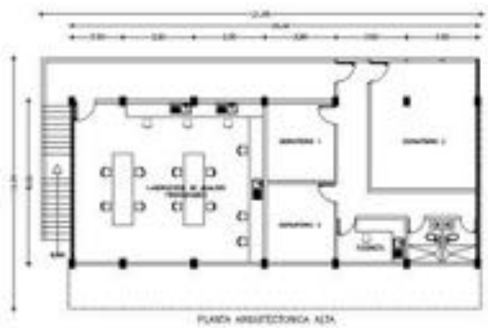
Hystological analysis of ovaries and testis



It is not the same

CONSERVATION OF SNOOKS AS INDICATOR SPECIES OF CONECTIVITY IN BIOLOGICAL CORRIDORS IN COASTAL AND RIVERINE SYSTEMS





INFRAESTRUCTURE

Larviculture laboratory

Multiple uses room

Facilities for personeel

Dormitories

Spawning and Larviculture areas

Spawning Area

Larviculture Area

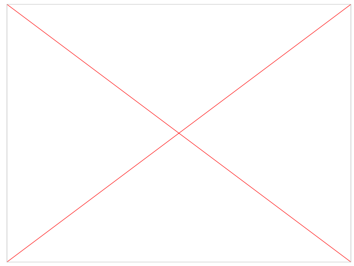
Juvenile
Grow/out

Broodstock management area

Training workshops for live food production, snook larviculture and juvenile grow/out

Snook larviculture workshop

Live feed workshop



Implant elaboration practice

Live food production practice

Responsible fishery workshop in fishermen comunities

Workshops and manuals

- Larviculture and juvenile production manual.
- Live Food production Manual
- Workshop on snook juvenile production.
- Workshop on Aquaculture as an alternative to fishing.
- Environmental education campaign in fishermen communities
- Scientific papers on snook biology and aquaculture.

Limitatons to this point at the Marine Station

- Infrastructure
- Pumping station
- Large scale filtration and UV treatment
- Water reservoirs
- Ponds for grow/out trials
- Maintenance

Snook research and production

- **Investment in research and facilities**
- **Studies on diseases and parasites in captivity**
- **Studies on feeds and ingredients**
- **System evaluation**
- **Extension projects with private sector (win/win)**
- **Public policies that impact the sector**

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- *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.*
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A review of over a decade of global investment in aquaculture feed technologies

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Investment in science and innovation is fundamental to developing effective solutions to global food security challenges, and transferring information and technologies to farmers and industry is essential for scaling up farming technologies and best practices for broad adoption. Capturing the quantitative impacts of investment in research and capacity building requires identifying relevant indicators and metrics, setting targets and benchmarks, and regular monitoring and evaluation of progress. Qualitative impacts, however, are much more challenging to capture and yet of equal importance.
The authors undertook an internal evaluation of the impacts of USAID's investment in a research program that has been funded since late 2006, The Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries (AquaFish Innovation Lab, previously AquaFish Collaborative Research Support Program). For a decade, AquaFish has partnered with US and host country individuals and institutions to undertake innovative aquaculture research; develop new and improved technologies that are relevant to local conditions and on-the ground needs; transfer information and technologies to fish farmers, industry, academics, government agencies, and others; and enhance individual and institutional capacity so that host countries can build upon successes and lead new lines of research once the program ends.

This review capture both qualitative and quantitative outputs and impacts of AquaFish work in aquaculture feed technologies in Africa, Asia, and Latin America and the Caribbean. With feeds comprising the greatest production cost for fish farmers (about 60-80%), the development and transfer of sustainable and affordable feeds and feed strategies for small- and medium-scale aquaculture has been a significant portion of the AquaFish research portfolio. AquaFish has successfully developed solutions on alternative feeding strategies and feed ingredients that decrease production costs, reduce reliance on animal protein content in feeds, increase overall fish yield, and decrease environmental impacts associated with aquaculture effluents. The review considered innovativeness of the technology, stage of development, technology transfer, impacts, and scalability. Some highlighted feed technologies include: alternate day feeding in the Philippines and Bangladesh that improves farmer profits and reduces effluents, feed formulations for snakehead in Cambodia and Vietnam that utilizes soy protein, and feed development for tilapia in Tanzania that replaces fish meal with earthworm and maggot meal. AquaFish has advanced sustainable aquaculture globally by developing and transferring these technologies and best management practices to small- and medium-scale producers and other stakeholders. Finding ways to reduce feed costs and responsibly include locally sourced ingredients will continue to have significant and long-lasting benefits for the fish farming sector and more broadly.

A Review of Over a Decade of Global Investment in Aquaculture Feed Technologies

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Amanda Hyman, and Hillary Egna

Aquaculture America
22 February 2018
Las Vegas, Nevada, USA

USAID FROM THE AMERICAN PEOPLE

Oregon State University

AQUAFISH INNOVATION LAB

Background and Overview

- The AquaFish Innovation Lab (formerly AquaFish CRSP) has been funded by USAID since 2006 to lead research and capacity building for small- and medium-scale aquaculture development in Africa, Asia, and Latin America and the Caribbean.
- With feeds comprising the greatest production cost for fish farmers (about 60-80%), the development of sustainable and affordable feeds and feed strategies has been a significant portion of the AquaFish research portfolio.
- This review highlights examples of the most impactful feed technologies developed by AquaFish, capturing over a decade of global research investment in aquaculture feed technologies.

Methods

Evaluation Questions: Identified the most impactful feed technologies developed by AquaFish, considering the following:

1. How innovative is the technology?
2. At what stage of development is the technology?
3. What are the major outputs and impacts?
4. Has the technology been transferred? To whom?
5. Is the technology scalable?

Timeframe: 2006-2018

Methods

Geographic Focus: 18 countries in which AquaFish has conducted research were considered.

Results: AquaFish Feed Technologies

Asia Region

- Bangladesh: *Enhanced Biodiversity of Gut Flora and Feed Efficiency of Pond Cultured Nile tilapia Under Pulsed Feeding Strategies*
- Cambodia and Vietnam: *Feeding Strategies and Feed Ingredients for Sustainable Snakehead Culture*
- China: *Bioflocs in an Integrated Shrimp Culture System*
- Nepal: *Periphyton Enhancement and Reduced Feeding Rates for Polyculture Ponds*
- Philippines: *Fishmeal-Free and Lower Protein Diets Improve the Cost Effectiveness of Culturing Nile Tilapia in Ponds*

Africa Region

- Ghana: *Evaluation of Two Feed Types on the Growth Performance and Cost Effectiveness of Nile tilapia (Oreochromis niloticus) Cultured in Ponds*
- Kenya: *Feed Formulations for Tilapia using Locally Available Agricultural By-Products*
- Tanzania: *Moringa Leaf Meal, Housefly Maggot Meal, and Earthworm Meal as Protein Supplements in Fish Diets*

Latin America Region

- Mexico: *Elimination of a Feed Steroid (17α-methyltestosterone) Using Bacterial Degradation in Nile tilapia Masculinization Systems*

Results: AquaFish Feed Technologies

Asia Region

- Bangladesh: *Enhanced Biodiversity of Gut Flora and Feed Efficiency of Pond Cultured Nile tilapia Under Pulsed Feeding Strategies*
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Latin America Region

- Mexico: *Elimination of a Feed Steroid (17α-methyltestosterone) Using Bacterial Degradation in Nile tilapia Masculinization Systems*

Results: AquaFish Feed Technologies

AquaFish has focused on two primary areas of feeds research:

1. **Feed Reduction Strategies** - The high cost of commercial fish feeds remains a barrier to the profitability of aquaculture operations, and is exacerbated by overfeeding and poor feed utilization.

2. **Alternative Feed Ingredients** - Commercial fish feeds are often expensive, lack reliable ingredients, and typically are not environmentally sustainable.

Results: Feed Reduction Strategies

Feed Reduction Strategies – By utilizing primary productivity in ponds and enhancing its growth through fertilization, AquaFish has enabled fish producers to significantly reduce the quantity of feeds used without compromising production.

Highlighted technologies:

- Alternate-day feeding for tilapia in the Philippines and Bangladesh
- Periphyton enhancement in a carp polyculture system in Nepal

Results: Feed Reduction Strategies

Objective: Reduce feeds for Nile tilapia through alternate-day feeding in the Philippines and Bangladesh


Methods: (1) Conducted trials to replicate alternate-day feeding successes in other areas of the world, and (2) Examined gastrointestinal microbiome and feed efficiencies.

Results: Feed Reduction Strategies

Objective: Reduce feeds for Nile tilapia through alternate-day feeding in the Philippines and Bangladesh

Results:

- Feed rations can be reduced by up to 50% through alternate-day feeding and pond fertilization, improving economic returns with little impact on yield.
- Experiments in Bangladesh replicated results, proving that alternate-day feeding for grow-out of tilapia reduces costs by 50%.
- Fish fed on an alternate-day feeding strategy had higher diversity of intestinal microbiota and feed efficiency increased by almost 140%.


Results: Feed Reduction Strategies

Objective: Improve upon reduced feeding strategies through periphyton enhancement in a carp polyculture system in Nepal

Methods: Tested 4 treatments comparing production for carp monoculture and carp polyculture systems under reduced feed conditions and with periphyhton enhancement.

Results: Feed Reduction Strategies

Objective: Improve upon reduced feeding strategies through periphyton enhancement in a carp polyculture system in Nepal

Results:

- 50% feed reduction paired with periphyton enhancement in a carp polyculture system resulted in the highest net fish yield.
- Researchers in Nepal are building on this initial success by collaborating with women's fish farmer groups to identify the best substrates for periphyton growth. The top four substrates being tested include: split bamboo mat, whole bamboo, plastic bottles, and banana leaf's midrib.

Results: Alternative Feed Ingredients

Alternative Feed Ingredients - AquaFish research on alternative and local protein sources in feeds is resulting in more sustainable and lower-cost feeds that are reducing reliance on fish and fish meal.

Highlighted technologies:

- Developing more affordable feeds using invertebrates and Moringa leaf for tilapia diet in Tanzania
- Including soy protein in place of small-sized fish for snakehead diet in Vietnam and Cambodia

Results: Alternative Feed Ingredients

Objective: Develop more affordable feeds using local ingredients as alternative protein sources for Nile tilapia in Tanzania

Methods: (1) Evaluated the chemical composition of earthworm meal and housefly maggot meal as potential feed ingredients, (2) Developed 9 feeds and tested growth performance, feed utilization, and cost effectiveness.

Results: Alternative Feed Ingredients

Objective: Develop more affordable feeds using local ingredients as alternative protein sources for Nile tilapia in Tanzania

Results:

- More expensive protein sources can be replaced by up to 35% housefly larvae or earthworm meal.
- Researchers are further exploring ideal protein levels of housefly larvae and earthworm meal in combination with *Moringa*.
- Using local ingredients for tilapia diet in Tanzania can reduce reliance on costly feeds.

Results: Alternative Feed Ingredients

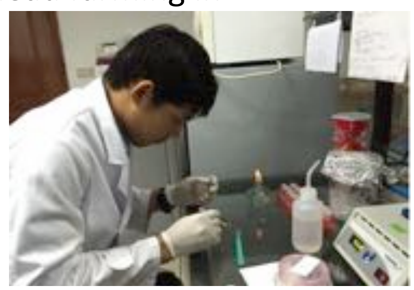
Objective: Reduce the reliance of small-sized fish for snakehead diet in Vietnam and Cambodia

Methods: (1) Develop and test a pelleted feed for snakehead consumption, (2) Conduct feed experiments to determine if soy protein can effectively replace fishmeal in snakehead diet.

Results: Alternative Feed Ingredients

Objective: Reduce the reliance of small-sized fish for snakehead diet in Vietnam and Cambodia

Results:
- Developed a pelleted feed that showed greater profits than for fish raised using chopped small fish.
- Soy protein concentrate can replace up to 40% of fishmeal in snakehead diet, while retaining production levels and fish health.
- Transfer of the feed technology from Vietnam to Cambodia helped lift the ban on snakehead farming in Cambodia in 2016.
- Nearly 2,000 stakeholders have been trained through 75 workshops.
- The technologies have been scaled up and commercialized in Vietnam.



Summary of Findings

- AquaFish feeds research is reducing the quantity of feeds used and the reliance on fish meal and other costly and unsustainable ingredients.
- Alternate-day feeding with pond fertilization can reduce production costs by up to 50% for tilapia and carp.
- Enhancing periphyton in ponds in polyculture systems has the potential to further improve production under reduced feed conditions.
- Soy protein can replace up to 40% of fishmeal in snakehead diet, enabling Cambodian farmers to legally and sustainably culture snakehead.
- Local ingredients, including invertebrates and *Moringa* leaf, show promise as viable protein replacements for tilapia feeds.

Significance and Future Directions

- AquaFish partners are continuing to build upon these successes through innovative research and training farmers on new feed technologies and best practices.
- This body of work can help inform future aquaculture feeds research and technology development beyond the life of the AquaFish program.
- Finding ways to reduce feed costs and responsibly include locally sourced ingredients will continue to have significant and long-lasting benefits for the fish farming sector and more broadly.

Acknowledgements

Many thanks and acknowledgements are due to AquaFish partners in the US and abroad who have been instrumental in the development of successful feed technologies from 2006 to present. Below is a subset of contributors based on the technologies included in this presentation.

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Tilapia aquaculture in Nepal: History from introductions to farmers ponds

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The government of Nepal introduced Nile tilapia (*Oreochromis niloticus* "Chitralada" strain) in 1985 from Thailand, yet tilapia remained inside the fence of government farms until 1996 when research on tilapia began at the Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, Nepal. In 2004, a new strain of Nile tilapia (GIFT - genetically improved farm tilapia developed by ICLARM and WorldFish) was introduced from the Asian Institute of Technology, Thailand to the Fisheries Research Center, Tarahara, part of the Nepal Agricultural Research Council (NARC). NARC subsequently initiated research in its Tarahara and Begnas Research Stations. Then in 2009, IAAS Rampur imported GIFT tilapia from WorldFish, Bangladesh. Lately in 2012, Himalayan Aqua Agritech introduced red tilapia from Nam-Sai farm Thailand and are maintained at AFU farm Chitwan and NARC farm Parwanipur.

Involvement of IAAS Aquaculture Program with the USAID-supported Aquaculture CRSP began in 2001 and has continued under the AquaFish Innovation Lab (also partly funded by USAID) through the present time. In 2010, IAAS transitioned to a new university structure with the establishment of Nepal's Agriculture and Forestry University (AFU) in Chitwan. At AFU, increasing public and private interest in tilapia, has resulted in increased emphasis on tilapia research. AFU has conducted a number of projects both at university and farmers' ponds, largely through AquaFish support, and shared the outcome of this research during workshops with government development and extension officials as well as NARC research scientists. The AFU-AquaFish collaboration has so far succeeded in farm trials at government farms and in farmer's ponds at Dayanagar Rupendehi, the fish farming pocket area in collaboration with the Directorate of Fisheries Development (DoFD), Nepal. This has led DoFD to include verification trials using tilapia in government farms along with a program for private hatchery development of mono-sex fry production, as part of their annual plan. The AFU fish hatchery and a private hatchery have started production of mono-sex fry to distribute to private farms.

Small-scale famers of AFU's on-farm research sites in Kathar, Chitwan and Kawasoti, Nawalparasi have begun farming tilapia and selling them in local markets. The AFU aquaculture farm produces tilapia for local sale. Some bigger farmers in Chitwan are producing tilapia with carps, which have a long history of cultivation in Nepal. Farmers in the Morang District of eastern Nepal are culturing tilapia. Danger of unwanted introduction of mixed-sex tilapia in natural waters has been the concerns for government and aquatic diversity conservationist. Currently, tilapia represents a major portion of the wild catch in Phewa and Begnas lakes of Pokhara though it was not intentionally introduced. Four percent of fish farmers are reported to be involved in tilapia farming, and tilapia contributed 1.5% of total aquaculture production in 2014-2015. Controlled culture of mono-sex tilapia in ponds has been the emphasis of AFU. We believe that incorporation of Nile tilapia in polyculture with carps, and tilapia monoculture will increase in future Nepalese aquaculture.

A F U

TILAPIA AQUACULTURE IN NEPAL: HISTORY FROM INTRODUCTIONS TO FARMERS PONDS

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[2]University of Michigan, USA
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Aquaculture America 2018, 19-22 Feb 2018, Las Vegas, Nevada, USA

Introduction

- Tilapia is the second ranked fish produced in world after carps and has reached more than 5.57 million tons production in 2016.
- China, Egypt, Indonesia, Brazil, Philippines, Thailand, Bangladesh, Mexico, Vietnam, and Taiwan are the top tilapia producing countries.
- There is growing interest on tilapia aquaculture in South-Asian countries: Bangladesh, Sri Lanka, India, Pakistan, and Nepal.

Introduction Cont'd …….

- The major attributes of tilapia for farming is: it fits for small-scale to commercial scale, and for semi-intensive to intensive culture.
- Though government introduced tilapia in Nepal for first time in 1985, it never included in government program .
- Recently, government has included tilapia in annual program and has emphasized in hatchery development for seed availability.
- Though university and research institutions are involved in tilapia aquaculture researches for several years, it is still in initial stage with limited farmers and production in Nepal.

History of tilapia introduction in Nepal

Nile tilapia - Chitralada strain

- 1st introduction in 1985 by government as gift from King of Thailand to King of Nepal at stocked at one of the Government Farm - Janakpur
- 2nd introduction in 2001 by Government Fisheries Research station, Tarahara, NARC from AIT Thailand.
- 3rd introduction in 2012 by private company - Himalayan Aqua Agritech Rupandehi from Nam-Sai farm Thailand .

Nile tilapia – GIFT strain

- In 2001 by FRC Tarahara, NARC from AIT Thailand.
- In 2003 by FRC Tarahara, NARC from AIT Thailand.
- In 2009 by WorldFish Bangladesh to IAAS Rampur Chitwan.

Red tilapia

- In 2012 by Himalayan Aqua Agritech Rupendehi from Nam-Sai farm Thailand
- Now it has been maintained at AFU Rampur, NARC Parwanipur, and private farm Kathar Chitwan

Role of University in Tilapia Aquaculture

- Aquaculture Department of Institute of Agriculture and Animal Science (IAAS) was the first to get tilapia fries from the government farm in 1996 for research.
- Initiated tilapia research with small university research grant during 1996 – 2002.
- With the start of Master in Aquaculture program at IAAS in 1999, tilapia has been one of the species for master thesis research.
- With the involvement of IAAS Aquaculture Program with the USAID-supported Aquaculture in began in 2001, tilapia was one of the focused species again for research.

Role of University…..

- In 2010, IAAS transitioned to a new university Agriculture and Forestry University (AFU) in Chitwan.
- At AFU, increasing public and private interest in tilapia, has resulted in increased emphasis on tilapia research.
- AFU has conducted a number of projects both at university and farmers' ponds, largely through AquaFish support.
- Research outcomes are shared during workshops with government development and extension officials as well as NARC research scientists.

Role of University…..

- The AFU-AquaFish collaboration has so far succeeded in farm trials at government farms and in farmer's ponds in the fish farming pocket area in collaboration with the Directorate of Fisheries Development (DoFD), Nepal.
- This has led DoFD to include verification trials using tilapia in government farms along with a program for private hatchery development of mono-sex fry production, as part of their annual plan.
- The AFU fish hatchery and a private hatchery have started production of mono-sex fry to distribute to private farms.

Highlights of Research Outcomes

Cage–pond integration system

Conducted series of experiments at University farm and farmers ponds in different models.

- Tilapia – tilapia
- Tilapia – tilapia with sahar
- Catfish – tilapia

Carps-tilapia-sahar polyculture

- Conducted experiments at university farm, government farm, private farm and in farmers pond

Tilapia – Sahar

- experiments were conducted on-station at university farms and on-farm n farmers ponds

Tilapia – Pangasius

- Conducted at private farm with support of private company

Research findings: Grow-out and Production

S.N.	Production model	Production (t/ha/yr)
1	Cage cum pond integrated system of mixed-sex tilapia	8.0
2	Polyculture of grass carp and Nile tilapia	4.8
3	Cage-pond integration of African catfish, Nile tilapia and carps	7.1
4	Tilapia-pangas polyculture	7.2
5	Carps-Tilapia-Sahar polyculture	6.0

Farming and Production

- Small-scale famers of Chitwan and Nawalparasi.
- Some bigger farmers in Chitwan
- Private CARP farm, Chitwan
- The AFU aquaculture farm
- Tarahara farm, NARC
- Farmers in the Morang District



Market approach

- Fresh tilapias in fish exhibition in Kathmandu
- Tilapia in weekly organic market in Kathmandu


Tilapia from Phewa lake Pokhara

- Currently, tilapia represents the major portion of the wild catch in Phewa and Begnas lake



Aquaponics

- Tilapia in Aquaponics system in Bhaisepati Lalitpur, Kathmandu

Tilapia Seed

- Government research station at NARC Tarahara developed tilapia hatchery in 2004 for research and seed production.

- IAAS developed tilapia hatchery on 2008
- AFU upgraded it in 2013
- AFU has started mon-sex fry production to distribute to private farms

Tilapia Seed ……

- Recently, a private tilapia hatchery has been established at Chitwan with the partial support of government.
- Started mono-sex seed production since last year.

Feed

- Tilapia are cultured in green water with natural food and supplemental feed.
- Tilapia farmers are also use carps feed.
- Locally made mass feed with the ingredient of rice bran and mustard oil cake is common to small-scale farmer.

Feed…..

- Locally made sinking pellet are mostly used by semi-commercial and commercial farmers.

- Recently, few commercial farmers started to use floating pellet feeds. Protein content of ranges 22-28%.

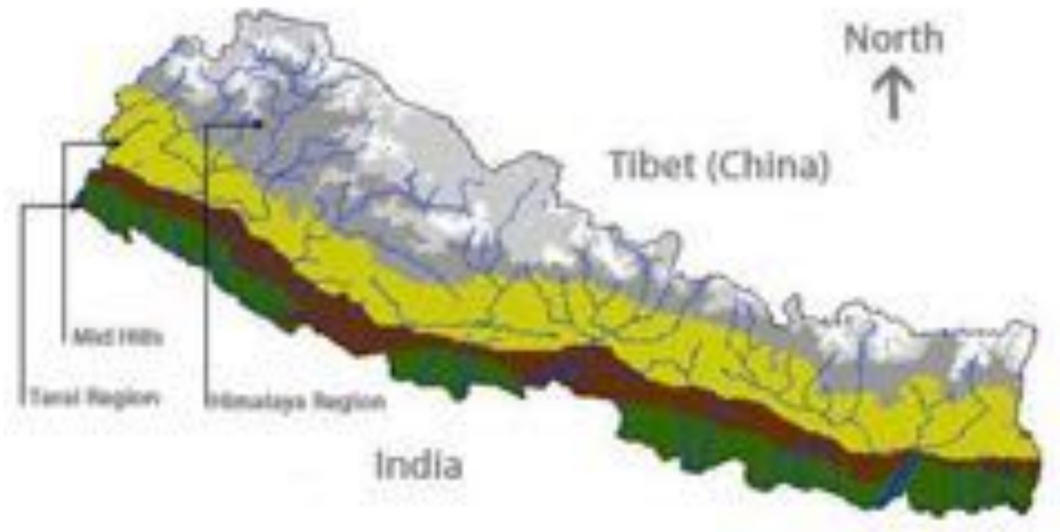
Tilapia production in Nepal

- Four percent of fish farmers are reported to be involved in tilapia farming
- Tilapia's contribution is about 1.5 % of total aquaculture production in 2014-2015 in Nepal (DoFD, 2015).

Constraints and Concerns

- Danger of unwanted scape of mixed-sex tilapia in natural waters has been the concerns for government and aquatic diversity conservationist.
- Currently, tilapia represents a major portion of the wild catch in Phewa and Begnas lakes of Pokhara though it was not intentionally introduced.
- Development of protocol for controlled culture and proper training for farmers before start of tilapia farming is essential.
- Controlled culture of mono-sex tilapia in ponds has been the emphasis of AFU.

Nepal



Future prospects

- Subtropical climate of southern Nepal, foothills basin and valley with warm climate are suitable for tilapia culture.
- Tilapia has potential to increase production and productivity through polyculture or by monoculture in Nepal.
- Development of tilapia hatcheries and availability of mono-sex fry will attract commercial fish farmers in near future.
- Incorporation of Nile tilapia in polyculture with carps, and tilapia monoculture will increase in future Nepalese aquaculture.
- Tilapia consumers are increasing with production of tilapia.

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Thank

Institutional and household factors in promoting the role of women in aquaculture value chain in Uganda

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Aquaculture in Uganda dates from the early 1950s having been introduced by the colonial government as a means to promote access to fish by rural poor communities. The target groups were households with low fish consumption due to limited access to lakes and rivers, the main sources of fish. Due to patriarchal system that determine household headship in Uganda, interventions particularly those requiring use of household land tend to focus on men as owners of land and therefore often obscure the role of women along the aquaculture value chain. Women's participation in aquaculture is limited to provision of farm labour but play important decision-making over fish consumption by household members. Following a number of successful experiments using various fish species, technologies for rearing fish in earthen ponds were popularised among target households who had access to water sources.

The study is informed by the 'efficiency approach' of Women in Development thinking and focused on analysing the contribution of women through active involvement in aquaculture to realise financial independence and poverty alleviation.The paper explores the role of women in aquaculture value chain in Uganda from institutional and household standpoint in relation to women's decisions and participation in pond fish farming. In addition, the paper examines women's understanding and perceptions of fish as a dietary asset for household members and determinants of fish diet in households. Opportunities to improve women's benefits in aquaculture are also explored focusing on access to training, extension servicesand strategies to promote women cooperatives.

Information was obtained through in-depth interviews with women involved in different aspects of aquaculture including policy planning level, training, production, marketing and fish provisioning at household level. Preliminary results show that despite women's under-representation in aquaculture related work, they play an important role that is currently not optimally recognised to maximise their full potentialto increase the benefits of aquaculture. The study also observed that the achievement of food (fish) level security at household level lies with women given their decision making and influencing role over the kind of diet for household members.

Efforts to increase fish production require engaging women to organise themselves from aquaculture planning stage through production and marketing.Policy support to existing women's initiatives in aquaculture is recommended.

INSTITUTIONAL FACTORS INFLUENCING THE ROLE OF WOMEN IN AQUACULTURE VALUE CHAIN IN UGANDA

Gertrude Atukunda *et.al*

Aquaculture America Conference

Paris Las Vegas Hotel & Convention Centre, NV USA.

20-22 February 2018

Introduction

- Aquaculture started in the 1950s and was aimed at promoting access to fish by rural poor communities.
  - dominated by earthen ponds on household land with water sources
- Fish ponds mainly owned by household head
  - patriarchal system ascribes ownership of land to men
- Women bear decisions and responsibilities of food provisioning at house hold level
- gender relations influence decisions and actions in undertaking fish farming including utilisation of benefits.
- Gender relations in fish farming overlooked at household, community and policy level)

Statement of the research problem

The role of women in aquaculture does not seem to be fully understood:

- Obscured by official statistics that do not disaggregate data by gender
- Limited studies on factors influencing women's roles and benefits along the aquaculture value chain

Objectives

1. To establish the gender division of labour in the aquaculture value chain
2. Asses institutional factors influencing the role of women in aquaculture value chain
3. Ascertain women's socio-economic benefits from aquaculture

Study area and methods

Fig. 1. Map of Uganda showing study districts

Selected characteristics

	Central	North
Pop'n (per Sq m)	176	65
Poverty levels (%)	6	47
Mean temp •C	21.0	24.6
Topography	hilly	lowland
Water sources	swamps	springs

Data collection methods

- Women Group discussions
- Men Group discussions
- Interviews with selected informants

Generic aquaculture value chain actors

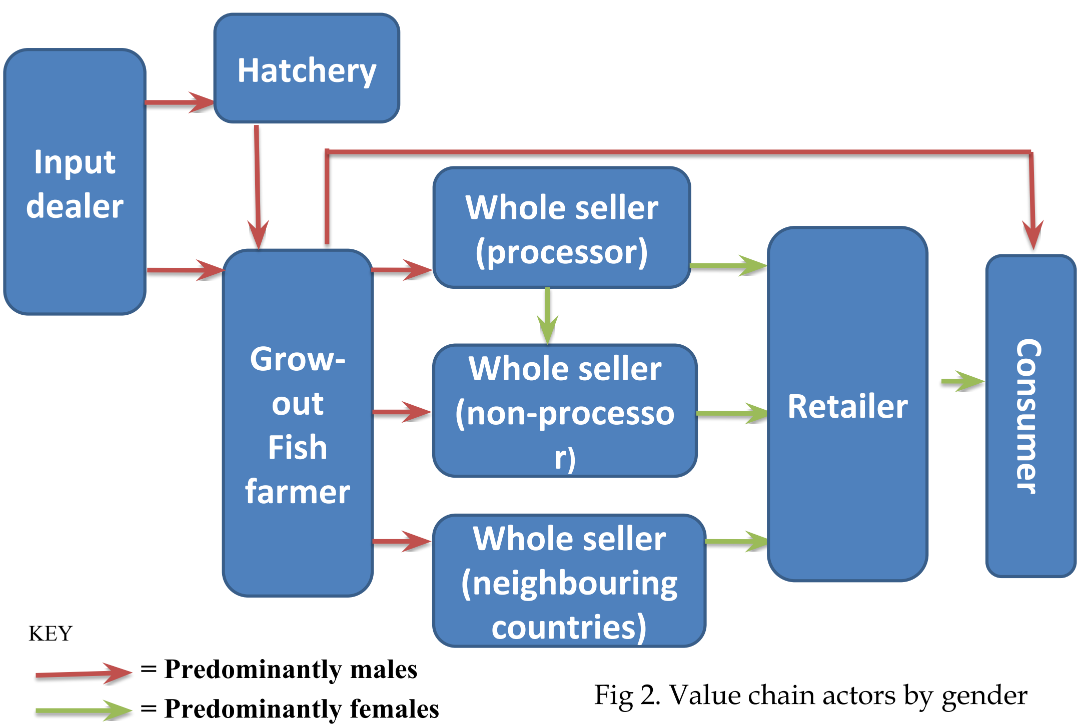

Fig 2. Value chain actors by gender

Gender division of labour in pond aquaculture

	Actors	
Activity	Males	Females
Pond site section and construction	♂	♀
Stocking	♂	♀
Sampling	♂	♀
Pond maintenance	♂	♀
Sourcing in-puts	♂	♀
Supervising workers	♂	♀
Feeding fish	♂	♀
Harvesting	♂	♀
Selling fish	♂	♀
Keeping records	♂	♀

Aquaculture value chain activities by gender

Fig 3. Woman feeding fish

Fig 4. Men sampling fish

Factors influencing women's role in aquaculture

Household level factors
- Socio-cultural perceptions and practices regarding household resources particularly land
- Aquaculture viewed and undertaken primarily for income generation
- Membership to fish farmers groups (dominated by men); women expected to belong to women groups
- Limited access to capital

Factors outside the household sphere
- Extension advice often biased towards men
- Limited promotion and use of ICTs
- Training scheduling, targeting in favour of the extension worker

Women's socio-economic benefits from aquaculture

- Fish for home consumption
  - change of diet
  - Health/nutrition of children and mothers
- Income
- Employment
- Improved relations
- Social status
- Knowledge and skills

Emerging opportunities for women's participation in aquaculture value chain

- Increasing recognition of role of women in aquaculture by male counterparts
- Partnering with youths (the case of Kasooka Youth Fish Farmers)
- Emerging women groups inclusive of various actors at different nodes of the value chain

Conclusion and recommendations

- Individual and policy interventions seem to be positively addressing household level factors
  - Awareness creation on women's empowerment through women's fund
  - Savings groups
  - Free government inputs (though more of a distortion than promotion)
- Extension needs to recognise and build on the changing patterns in women's roles
- Training should also target women and provide complete information along the value chain

Acknowledgement

Effect of salinity on the survival of pangasius catfish *Pangasius hypothalamus* in southern Bangladesh

Mohammad Lokman Ali*, S. Mahean Haque, M. A. Wahab, and Russell Borski

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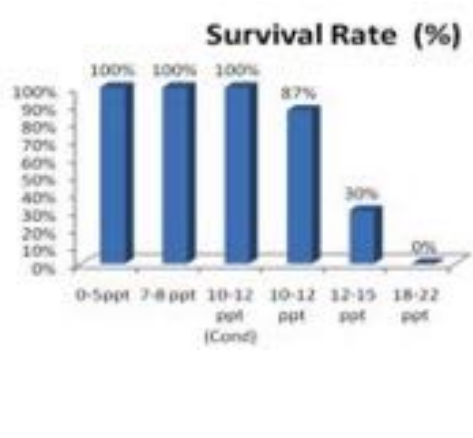
The river catfish (*Pangasius hypopthalamus*) was introduced to Bangladesh in the 1990's from Thailand, and has since become a thriving aquaculture industry with over 3 million tonnes produced annually. *Pangasius* is typically cultured in freshwater, however with the coastal waters of Southern Bangladesh being affected by salinity encroachment, we sought to determine whether catfish could be cultured in these hyposaline waters. This region is severely impacted by overfishing, and is underutilized due to increasing susceptibility to rising sea levels linked to global climate change. Thus, the aim of the present study was to assess the effect of salinity on growth and survival of *Pangasius* and in turn, determine the optimum tolerable salinity for culture of this species.

Overwintered *Pangasius* fingerlings were stocked at a density of 2/m2 in 18 ponds (averaging 400 m2 and 1.3 m deep) within the coastal Patuakhali district of Bangladesh. The experiment consisted of six treatments spanning a range of salinities: T1 (0-5 ppt), T2 (5-7 ppt), and T4 (10-12 ppt) did not involve prior conditioning while T3 (10-12 ppt), T5 (12-18 ppt), and T6 (18-22 ppt) had the fish acclimatized in 6 ppt water for 24 h prior to the start of the experiment. The fish were held at the experimental salinities for 7 days, during which time they were fed twice daily (09:00 and 14:00 h) with commercial feed (Mega floating feed, 28% CP, 7% fat) at a rate of 10% body weight per day. Survival rates were calculated for each treatment at the end of the 7-day period.

In T1 (0-5 ppt) and T2 (7-8 ppt), the survival rate was 100%. For T3 (10-12 ppt), in which the fingerlings were first acclimatized at 6 ppt, the survival rate was also 100% however in T4, where fingerlings were stocked directly at 10-12 ppt, survival rate was 87% with mortalities occurring as early as 5 days. For fish acclimated to 12-15 ppt (T5), survival rate was 30% while at the highest salinity (T6), all fingerlings died within one day. The results indicate that *Pangasius* catfish are able to survive in waters of up to 12 ppt when allowed a prior acclimation period in more dilute waters (6 ppt). A subsequent 6-month pond study evaluating growth performance of *Pangasius* catfish in different salinities (0 ppt, 6.5 ppt and 10.8 ppt) was conducted. The survival rate, weight gain, SGR, feed conversion ratio (FCR), yield, and benefit cost ratio (BCR) were similar (P>0.05) among the treatments. The results suggest that *Pangasius* catfish can be successfully cultured in salinities as high as 12 ppt. The ability to grow *Pangasius* in hyposaline waters of coastal Bangladesh or other regions can provide additional earnings and food sources for communities impacted by seawater encroachment linked to rising sea levels and climate change. (Supported by the AquaFish Innovation Lab - USAID)



Welcome To My Presentation

EFFECT OF SALINITY ON THE SURVIVAL OF PANGASIUS CATFISH *Pangasius hypopthalamus* IN SOUTHERN BANGLADESH'

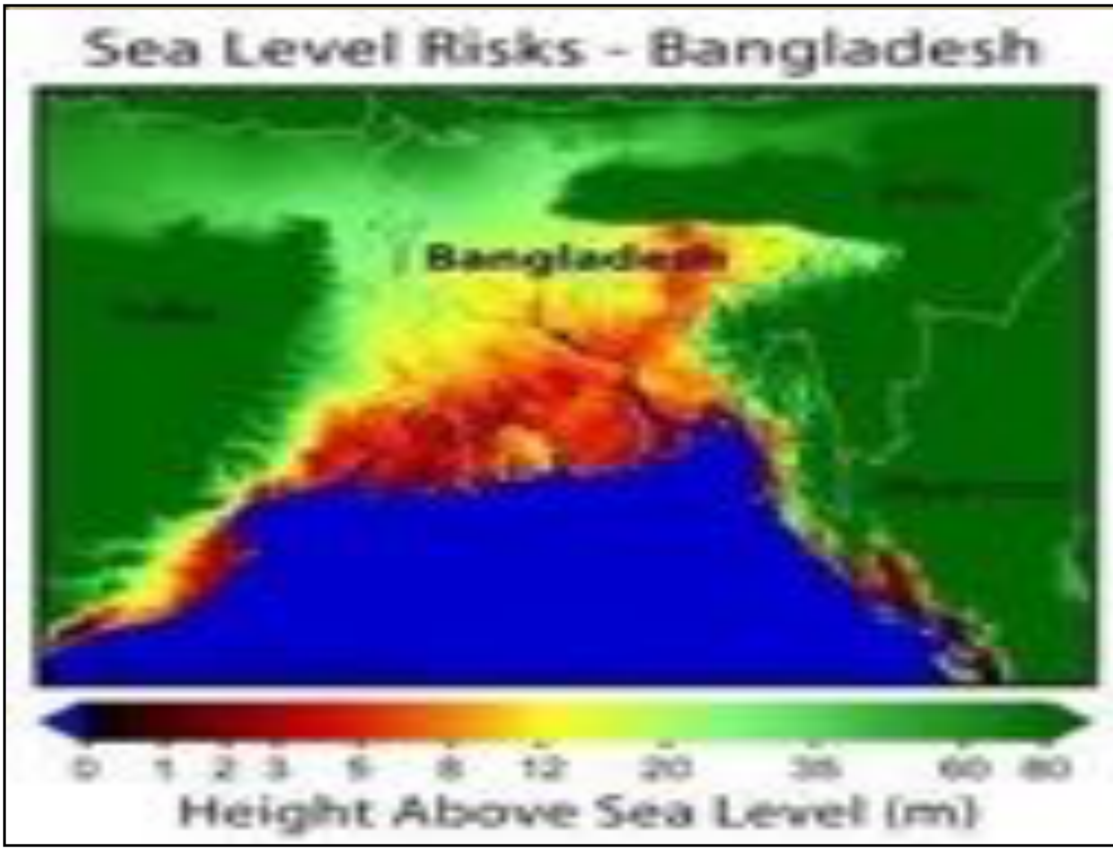
Presented By
Dr. Md. Lokman Ali
Professor
Faculty of Fisheries
Patuakhali Science and Technology University, Bangladesh

Background

- The river catfish (*Pangasius hypopthalamus*) was introduced to Bangladesh in 1990's, and since then it has become a thriving aquaculture industry with over 300,000 tones produced annually.
- Now *Pangasius* catfish is considered as one of the most successful aquaculture species in Bangladesh.
- Currently, much of the *Pangasius* production comes from the North and Central regions of Bangladesh (*e.g*., greater Mymensingh).
- The greater Barishal district is one such region, which has traditionally relied on fishing or aquaculture of marine species (*e.g*., shrimp) for their economic livelihoods. Through over-fishing and the increasing frequency of natural calamities like cyclones (*e.g.* Sidr, Aila), this region is nearing depletion of wild fish stocks and currently over half a million fishermen have been suffering from severe poverty.

Background

- The focus of this investigation is to assess the potential for expanding the culture of *Pangasius* to southern regions containing significant amounts of hyposaline waters, the areas that are severely impacted by overfishing and global climate change and are currently underutilized for fish production.
- If *Pangasius* culture can be achieved in greater Barishal and other coastal regions, the production levels of this fish could effectively double (600,000 metric tones), thus may significantly impact the diet and economic viability of coastal communities.



OBJECTIVES

- Evaluate whether the culture of freshwater *Pangasius* catfish can be successfully cultured in seawater-encroached hyposaline waters of coastal Southern region of Bangladesh.

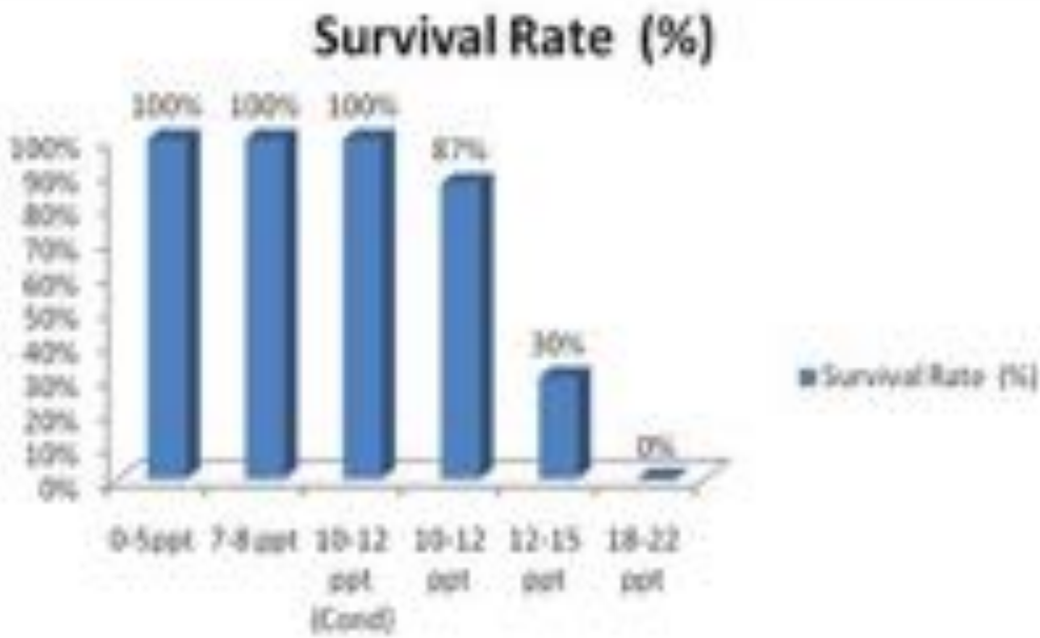
EXPERIMENT 1

Effect of short-term acclimation to different salinity ranges on *Pangasius* survival.

Effects of salinity on survival rate of Thai Pangas

Parameters	Salinity	Weight of Fish	Mortality Pattern	Survival Rate after 7 days
T_1	0-5ppt	5.78 gm	No mortality	100%
T_2	7-8 ppt	5.78 gm	No mortality	100%
T_3	10-12 ppt (conditioning at 6ppt)	5.78 gm	No Mortality	100%
T_4	10-12 ppt	5.78 gm	Mortality up to 5 days	87%
T_5	12-15 ppt	5.78 gm	Mortality up to 5 days	30%
T_6	18-22 ppt	5.78 gm	Mortality within 1 days	0%

Effects of salinity on survival rate of Thai Pangas



Results

Pangasius **catfish can easily survive up to 12 ppt saline water when provided a prior 24-h acclimation to moderate salinities of 6–7 ppt.**

Based on this work, *Pangasius* growth and production was assessed during a full grow-out trial in three salinity ranges up to 12 ppt.

EXPERIMENT 2

Evaluate the growth performance of *Pangasius* catfish cultured in hyposaline water of different salinities

METHODOLOGY:

1. Study area:

The proposed research was done for 5 months and 10 days at Kuakata, Kalapara and Amtoli Upozila of Barisal division.

The area was selected on the basis of different salinity.



Pond selection:

18 ponds were selected from three different areas on the basis of salinity. Among the pond owners 13 owners were the member of World Fish Centre.

Location	Pond distance from sea	Salinity	Pond Number	Women owners
Amtoli (Borgona District)	40 km	0 ppt	6	4
Kalapara (Patuakhali District)	23 km	5-7 ppt	6	1
Kuakata (Patuakhali District)	5 km	10-12 ppt	6	5
Total			18	10 (55%)

Table-1: Experimental Design

Parameter	Treatment 1	Treatment 2	Treatment 3
Pangasius fingerlings	800 (2.0/m^2)	800 (2.0/m^2)	800 (2.0/m^2)
Salinity range (ppt)	0-0.5	5-7	10-12
Replicates (*n*)	6	6	6

Size of ponds: The average sizes of pond was 10 decimal with an average water depth of 1.3 meter.

Pond Preparation :

Pond Drying: All ponds were completely dried and all unwanted species were removed from pond prior to the start of experiment.

Pond Netting: Ponds were surrounded by filter net to avoid the escape of fish during any natural disaster.

Pond Preparation :

Liming:

Liming was done at a standard rate of 1 kg per decimal on 1-3 May, 2014. Lime was mixed with water and kept overnight and distributed on the pond surface early in the morning.

Pond Preparation :

Water Filling: After 5-7 days of liming, the ponds were filled in with water from adjacent river and lake.

Fertilization: All ponds were fertilized initially on 10th May, 2014 with Urea and Triple Super Phosphate (TSP) at the rates of urea 150 g/decimal and TSP- 75 g/decimal.

Fingerlings collection and stocking

Fingerlings collection:

Over wintered fingerlings of Thai Pangas (~6g) were collected from World Fish supported Chanchal Hatchery, Bauphol, Patuakhali at Morning on 16th May, 2014 and stocked in 18 ponds as experimental design.

Feed distribution:

Mega floating feed (commercially produced in Bangladesh) was used for this experiment. Required amount of feed was distributed among the 18 farmers up to harvest of fish. Feed was collected from the local agent of Mega feed industries.

Feeding :

- Pangas was fed by Mega floating feed at the rate of 10% -3% body weight .

- The feeds were provided in two times in a day at 9.00 am and 4.00 pm.

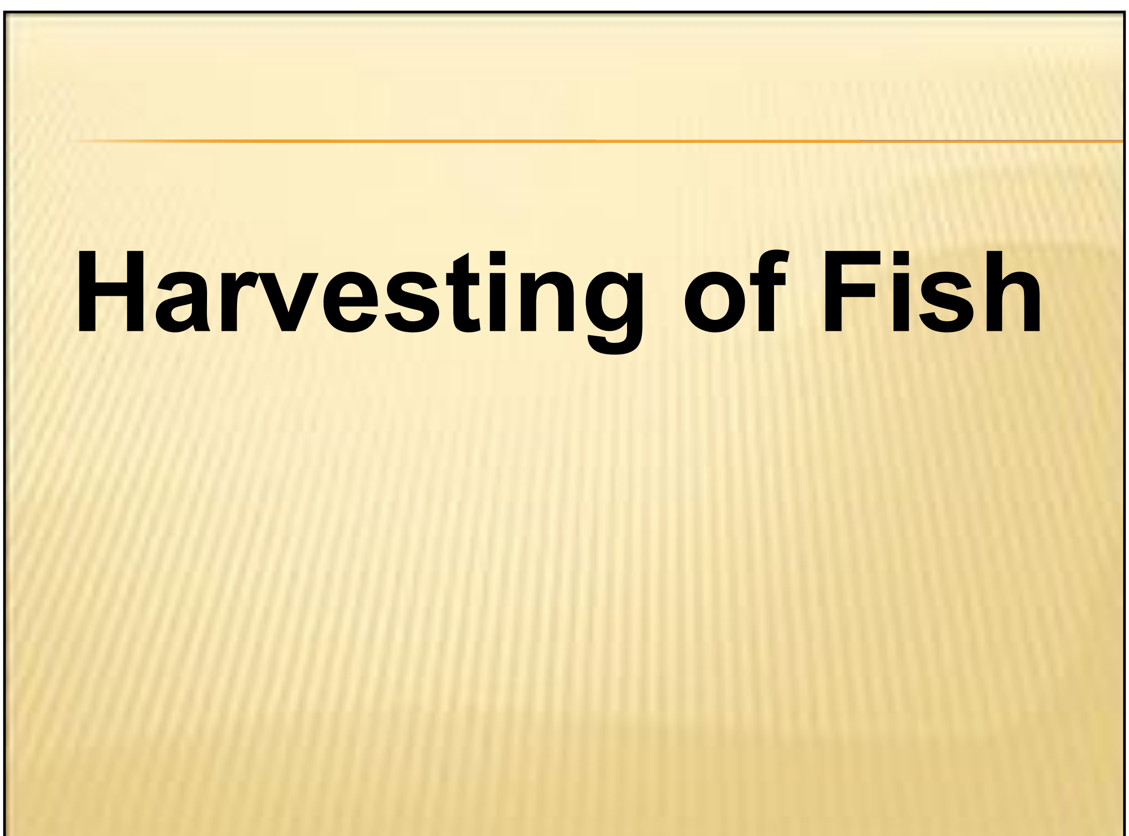
Observation of fish growth and water quality parameters

Sampling of fish:

Fortnightly sampling of the experimental fish was done by using cast net to observe the growth of the experimental fish and to adjust the feeding rate. Length of the 10 experimental fish in each sampling was measured by using measuring scale and weight by using a digital electronic balance.

Water quality parameters :

Water quality parameters such as water temperature, dissolved oxygen, pH, alkalinity, ammonia, nitrite and salinity were recorded regularly.


Harvesting of Fish

Fish Harvesting :

Fish were harvested after end of the experiment at 26 October/2014. The culture period was 5 months and 10 days. During harvesting length and weight of 10 fish from each pond were measured to calculate growth parameters. As well as the number of total fish was counted to observe survival rate.

Water Quality Parameters

Parameters	T_1 (mean ± SE)	T_2 (mean ± SE)	T_3 (mean ± SE)
Water Temperature (°C)	30.18 ± 0.95 °C	30.10 ± 0.42°C	30.52 ± 0.41°C
Dissolved Oxygen (mg/L)	5.16 ±0.12	5.24 ±0.13	5.98.18 ±0.21
pH	7.77 ± 0.37	7.49 ± 0.26	7.67± 0.14
Alkalinity (mg/L)	90.5±6.12	110±6.61	130±5.15
Ammonia (mg/L)	0.67 ± 0.02	0.64 ± 0.03	**0.02 ± 0.03**
Nitrite (NO_2) (mg/L)	0.37 ± 0.02	0.24 ± 0.23	**00**
Hardness (mg/L)	70±3.12	240±5.12	560±4.12
Salinity (PPT)	0	6.5	10.8

Yields parameters

Yield parameters	T_1	T_2	T_3
Mean initial weight (g)	6.56 ± 0.53	6.56 ± 0.53	6.56 ± 0.53
Initial length (cm)	9.18 ± 0.68	9.18 ± 0.68	9.18 ± 0.68
Mean final weight (g)	686.76 ± 50.26	684.67± 52.25	683.89±56.80
Final length (cm)	38.94 ±4.33	38.50±5.30	37.86±5.29
Survival Rate (%)	96.76±2.67	96.56±2.78	96.12±2.85
Mean weight gain(g)	680.2±2.41	678.11±2.64	677.33±2.21
% Weight gain	10368.90	10337.04	10325.15
SGR (% per day)	2.871	2.869	2.868
FCR	1.61±0.23	1.62±0.26	1.63±0.32
Total fish production (kg)	3,189.64 kg	3,173.36 kg	3,155.39 kg
Yield (kg/ha)	13,139±1293 [a]	13072±1374[a]	12998 ±1347 [a]

Economic analysis (Values are in US$. Costs and returns are based on 1 hectare)

Investment Costs (US$)	T_1 (0 ppt)	T_2 (6.5 ppt)	T_3 (10.8 ppt)
Pond reparation	447.69	447.69	447.69
Fingerling	1,185.60	1,185.60	1,185.60
Total feed used (kg)	12,725	12,725	12,725
Feed cost[ł**]	7,316.87	7,316.87	7,316.87
Total cost	8,950.41	8,950.41	8,950.41
Returns			
Total fish production	7,878.41	7,838.20	7,793.81
Retail price of fish/ton	1500.00	1500.00	1562.50
Income (from fish sale)	11,817.59	11,757.29	12,177.81
Net profit	2,848.65	2806.877	3,227.39
Benefit-Cost Ratio (BCR)	1.32	1.31	1.36

Off flavor compound:

By sensory test musty and woody flavor were found in freshwater pangas due to no water exchange and plankton bloom.

No off flavor compound were found saline water fish due to regular water exchange by tidal water.

In Bangladesh off flavour compound are responsible for low price of pangas.

Due to plankton bloom water quality of pond is degraded. Geosmin and 2-Methylisoborneol (MIB) are produced in polluted water. MIB causes a "musty" or "lagoon" and geosmin results in "earthy" or "woody" flavors of fish.

Training of Farmers

Conclusion

• Pangas can easily survive and grow in saline water up to 12 ppt like freshwater.

• In saline water pangas are not infected by disease free from off-flavour.

• By using this technology, pangas production could effectively double (60,0000 metric tones).

•Demonstration of this technology among the coastal people may significantly impact the economic viability and improve livelihood status of coastal communities.

Acknowledgement

PATUAKHALI SCIENCE AND TECHNOLOGY UNIVERSITY
P S T U

NORTH CAROLINA STATE UNIVERSITY

বাংলাদেশ কৃষি বিশ্ববিদ্যালয়

USAID
FROM THE AMERICAN PEOPLE

AQUA FISH
COLLABORATIVE RESEARCH
SUPPORT PROGRAM

Thank You All

Feminization of Protandrous Hermaphrodites *Centropomus poeyi* into functional females using 17ß-estradiol

Juan Manuel Vidal-López, Wilfrido M. Contreras-Sánchez, Arlette Hernández-Franyutti, María de Jesús Contreras-García and María del Carmen Uribe-Aranzábal

Laboratorio de Acuicultura Tropical. División Académica de Ciencias Biológicas, Universidad Juárez Autónoma de Tabasco, Km 0.5 Carretera Villahermosa, Tabasco, C. P. 86040.

Several Centropomid species support important recreational and commercial fisheries in the Gulf of Mexico, among them, the Mexican snook *Centropomus poeyi* is a unique species that spends most of its life history in fresh water, but requires to migrate to the coasts to spawn. It is considered endemic to Mexico with a distribution range reported only in watersheds discharging to the Gulf of Mexico. Very limited information has been generated concerning its biology, ecology or population status. In our laboratory we have confirmed the condition of protandric hermaphrodite through histological examination. Based on empirical observations, C. poeyi in captivity has advantages over other Centropomids (i.e. large size, high tolerance to handling, grow-out in a wide range of salinities, and fast growth). However, handling broodstock poses complications since females range from 5 to 10 kilograms generating high risk of loss and expenses during maintenance of the spawners. Therefore, the aim of this study was the production of batches of reproductive females at an early age and a small size through induced sex inversion using 17β-estradiol. For this, we conducted a study where low and high dosages of 17β-estradiol (10, 20, and 30 mg kg^{-1}) and (40, 50, and 60 mg kg^{-1}) impregnated in the food were assessed. Fish fed with 50 and 60 mg kg^{-1} of 17β-estradiol showed 100% feminization, while the control group presented only males (Fig 1). At four years of age, sex-reversed fish remained as females, producing oocytes and were capable of spawning, while fish from the control groups were ripe males with running milt.

UNIVERSIDAD JUÁREZ AUTÓNOMA DE TABASCO
División Académica de Ciencias Biológicas
Laboratorio de Acuicultura Tropical

FEMINIZATION OF PROTANDROUS HERMAPHRODITES *Centropomus poeyi* INTO FUNCTIONAL FEMALES USING 17ß-ESTRADIOL

Juan Manuel Vidal-López*, Wilfrido M. Contreras-Sánchez, Arlette Hernández-Franyutti, María de Jesús Contreras-García y María del Carmen Uribe-Aranzábal

Background

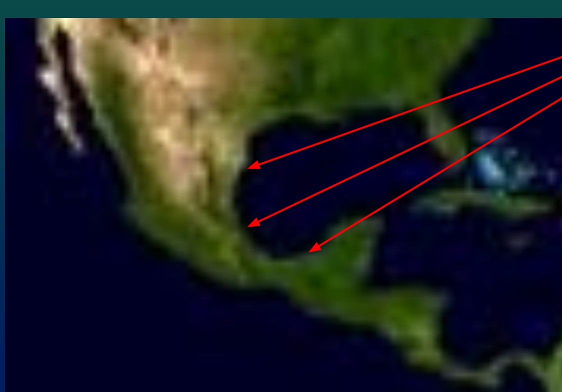
Snooks constitute one of the most important fisheries in Mexico

- **High commercial value**
- **Good flavor**
- **Big size**
- **Nice meat color**

The Mexican snook is one of the local fish species with high economic interest being an important component of the snook fishery in Mexico.

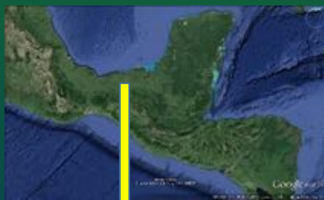
However, the resource is under a very strong pressure

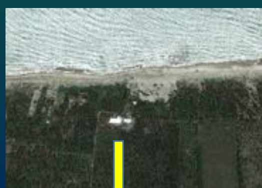
The Mexican Snook is endemic to the coasts of the Gulf of Mexico



C. poeyi

It has features that make it a good candidate for aquaculture





Objetive

To evaluate the feminizing effects of 17-β estradiol in the food of young of the year *C. poeyi* and determine reproductive viability of the females produced

Materials and Methods

Experiments		
Dosis de estradiol	Low dosages	**Completely randomized experiment:** Experiment I (0, 10, 20, 30 mg of E2 per kg of food) 20 juveniles per Experimental Unit 60 days of administration 
	High dosages	**Completely randomized experiment:** Experiment II (0, 40, 50, 60 mg of E2 per kg of food) 10 juveniles per Experimental Unit 60 days of administration 
	Feeding: ❖ Food preparation After Popma & Green (1990). ❖ Apparent satiation five times/day 8, 10, 12, 14 & 17 hours **Survival and growth:** ➢ Total countings at the end of the experiments ➢ Weight and Total Length at 0, 30, 180, and 300 DPT 	

Sex ID using Conventional Histology

Fixation (Bouin 48 h)

Dehidration and clearing (1-1.5 h)

Parafin inclusion

Cutting (7µ)

Staining (H-E y Masson)

Experiment	Sampling days	n	Total/treatment
Low dosages	30 – 180 -300	3 – 3 - 3	27
High Dosages	30 – 180 -300	3 – 2 – 1	18

Reproductive functionality

2015 – 2017

Jul – Sep, 2017

Females treated with 50 and 60 mg/kg of E2 were kept

Spawning induction

Five out of 30 females obtained with E2 (50 and 60 mg/kg) were selected on the basis of having oocites >150µ. They were implanted with a 150 µg/Kg of LHRHa for induction of final maturation and spawning

Treatment evaluation

Egg number

Fertilization rate

Hatching

E2 treated females:
Weight: 449.46 ± 161.33 g
TL: 37.17 ± 4.47 cm

oocites >150µ

Control group males:
Weight: 317.36 ± 11.36 g
TL: 34.50 ± 3.75 cm

Running milt after abdominal pressure

Statistical Analysis

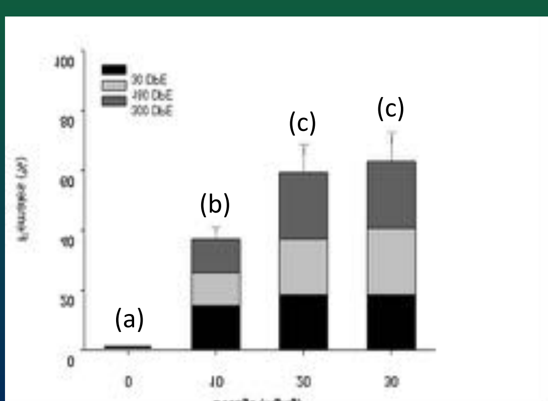
Contingency Tables χ^2 For sex proportion

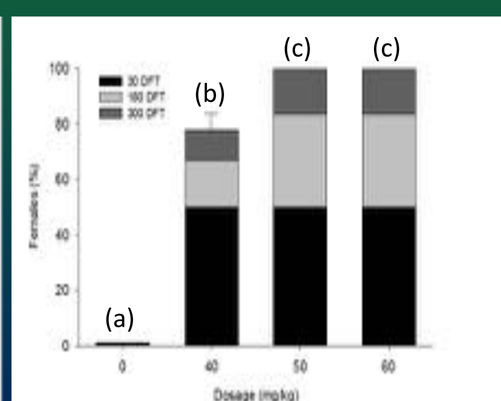
One-way ANOVA (Weight and length)

Statgraphics Centurión® v XVI

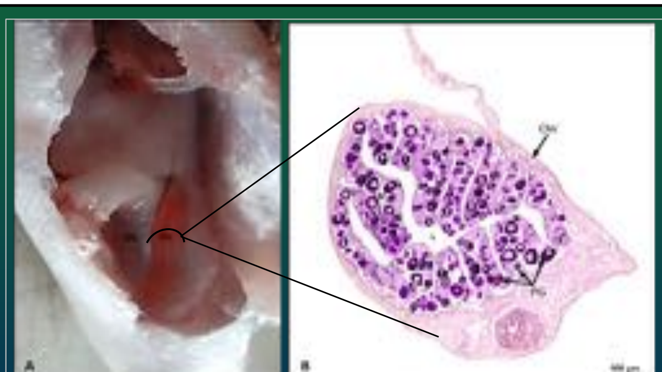
$P\alpha = 0.05$

Results



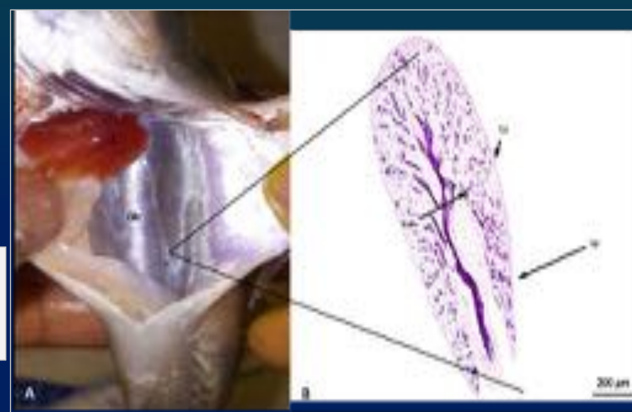


- Significant feminization in all treatments $p < 0.001$
- 100% females when fish were fed 50 and 60 mg per kg of food for 60 days.
- Higher feminization than Vidal *et al*. (2012) and Passini *et al*. (2016) for *C. undecimalis* using E2 in food and implants, respectively.
- In *C. parallelus* up to 100 % females were obtained when 25 mg E2 kg^{-1} were used for 45 days (De Carvalho *et al*., 2014).



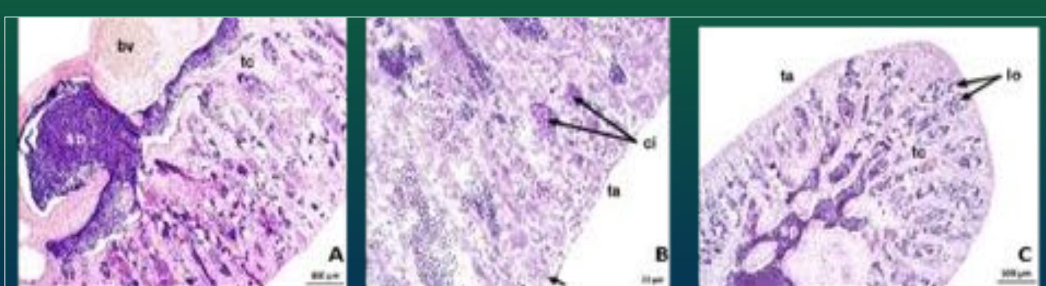
Females
E2 Treatments

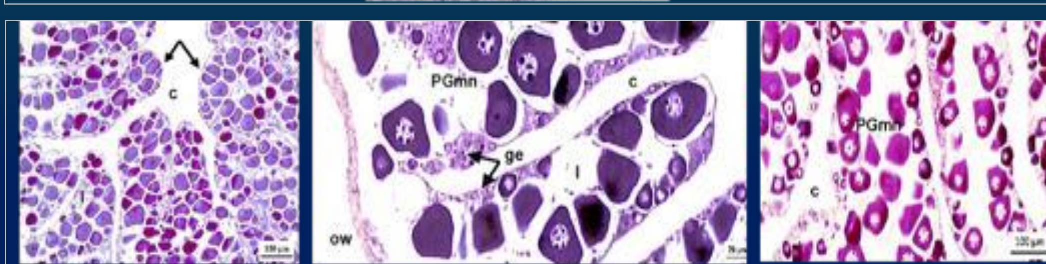
Males
Control Treatments



No morphological or structural anomalies nor regression towards male after 300 days post treatment

Hystological analysis of ovaries and testis





30 180 300

DPT

Survival and Growth
low dosages

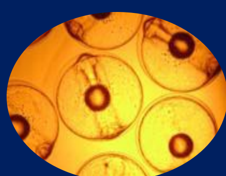
Treatment (E2 mg/kg)	30 DPT (n=9) Average ± SE	180 DPT (n=9) Average ± SE	300 DPT (n=9) Average ± SE	Survival n (%)
0	17.19 ± 0.24a 85.93 ± 0. 96a	35.13 ± 1.35a 189.22 ± 2.93a	40.02 ± 1.36a 192.11 ± 5.39a	60 (100)
10	18.36 ± 0.38a 98.12 ± 1.15b	44.32 ± 2.49b 197.87 ± 4.59b	48.32 ± 1.59b 209.53 ± 2.02b	60 (100)
20	18.72 ± 0.40a 99.33 ± 2.47b	61.88 ± 1.53c 207.00 ± 4.52bc	70.72 ± 0.89c 237.00 ± 2.35bc	60 (100)
30	18.47 ± 0.25a 99.23 ± 2.45b	63.37 ± 0.86c 211.94 ± 1.84c	73.59 ± 1.31c 257.50 ± 2.75c	60 (100)

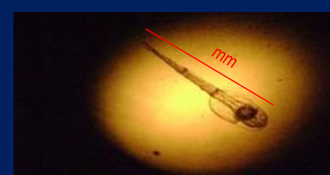
Survival and Growth
High dosages

Treatment (E2 mg/kg)	30 DPT (n=9) Average ± SE	180 DPT (n=9) Average ± SE	300 DPT (n=9) Average ± SE	Survival n (%)
0	35.93 ± 0.96a 164.90 ± 1.22a	49.18 ± 0.35a 173.10 ± 1. 66a	175.03 ± 1.93a 270.6 ± 1.43[a]	30 (100)
40	50.34 ± 1.93ab 183.60 ± 2.34b	57.48 ± 0.30b 198.30 ± 0.54b	179.97 ± 1.56a 272.0 ± 1. 67[a]	30 (100)
50	54.89 ± 2.33b 187.20 ± 1.78b	57.93 ± 0.33b 195.37 ± 1.53b	178.10 ± 0.97a 282.6 ± 2. 32[a]	30 (100)
60	55.46 ± 1.17b 184.70 ± 184.67b	58.80 ± 0.41b 215.57 ± 1.84c	193.73 ± 1.02b 279.3 ± 1. 86a	30 (100)

Reproductive Functionality

- ✓ Five females induced with LHRH-a implants
- ✓ 80 % spawned and produced fertile eggs.
- ✓ We obtained an average of 386,425 eggs (± 43,922) Fertilization rate of 76.4% (± 14.71).
- ✓ Average amount of larvae produced per femlaes was 243,621 (± 3,813).





Conclusions

Feminization of *Centropomus poeyi juveniles* is feasible using 50 mg/kg .

The gonadal development observed was normal for up to 300 DPT

E2 estimulates growth. The larger the dose, the larger the effect, remaining for 300 DPT.

Viable Females 1were obtained, producing high numbers of eggs and larvae

It is not the same

ACKNOWLEDGEMENTS

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CONABIO
INAPESCA

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Reducing off-flavour compounds geosmin and 2-methylisoborneol in tilapia through different cultivation technologies

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Off flavor in aquatic products is a rising concern among consumers and researchers. This study compares the effects of four different tilapia cultivation systems, namely tilapia-water spinach integrated system, sewage discharging system, sewage discharging and tilapia-water spinach integrated system with tilapia monoculture system as control on the water quality, tilapia production and off-flavor contents in water and tilapia. Using gas chromatography and mass spectrum (GC-MS) based on microwave assisted distillation followed by purge-and-trap, the off-flavor compounds geosmin (GSM) and 2-methylisobomeol (2-MIB) were determined in water and tilapia tissue. The results showed that the production of the tilapia-water spinach integrated system was the highest among the systems ($P < 0.05$). The contents of ammonia nitrogen and nitrite in the sewage discharging and tilapia-water spinach integrated system were significantly lower (0.64±0.06mg/L and 0.086±0.005mg/L, respectively). In addition, the concentration of 2-MIB and GSM in the tilapia muscle of the sewage discharging and tilapia-water spinach integrated system (0.31±0.02 μg/kg and 0.53±0.042 μg/kg respectively) were significantly lower than in the control group (0.67 ± 0.022 μg/kg and 0.87±0.018 μg/kg respectively). The results indicated that the sewage discharging and tilapia-water spinach integrated system reduced the accumulation of off-flavor compounds in water and tilapia muscle in the intensive tilapia farming system.

AQUAFISH INNOVATION LAB

Reducing off-flavour compounds geosmin and 2-methylisoborneol in tilapia through different cultivation technologies

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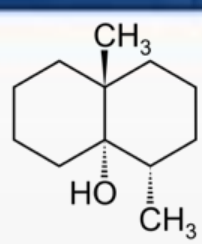
Outline

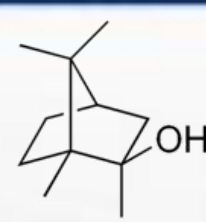
Introduction

- Tilapia (*Oreochromis spp*) is one of the main farming species in the world, and the culture has expanded rapidly with the production of 6.26 million tons in 2016(FAO, 2015).
- However, due to the cultivation conditions and the water quality affected by environment, there is often unpleasant smell of off-flavor in tilapia tissue.
- Exploring the causes of off-flavor, controlling and eliminating the earthy taste of aquatic products has become a rising concern in the fishery production activities.

Introduction



geosmin



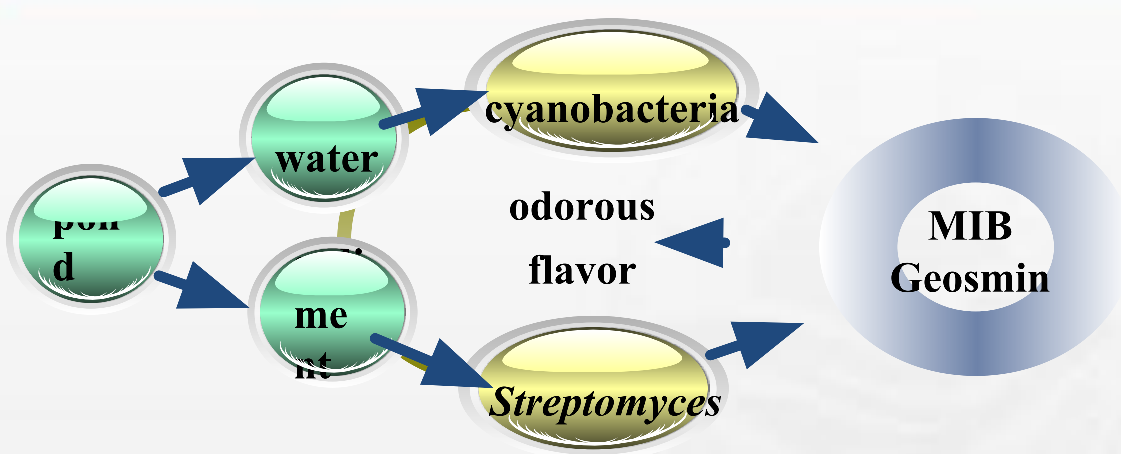
2-methylisoborneol(MIB)

Geosmin combines with 2-methylisoborneol(MIB), which concentrates in the fatty skin and muscle tissues, are responsible for the muddy smell in many commercially important freshwater fish.

Introduction

- Geosmin is produced by the gram-positive bacteria *Streptomyces*, a genus of *Actinobacteria* in the order Actinomycetes, and released when these microorganisms die.
- Some algae, particularly blue-green algae (cyanobacteria) such as Anabaena, produce MIB together with other odorous chemicals such as geosmin.
- These chemicals can be smelled musty or earthy odor and the human nose is extremely sensitive to geosmin and MIB able to detect them at concentrations as low as parts per trillion-.

Introduction



Material & methods

System setup

- Tilapia tanks(5m×3m×1.2m),cemented;
- 11 fish/m^2, 54.54±2.29g/fish; water spinach 150g/m^2
- 3 replicates for each treatment, 12 weeks.

tilapia monoculture system(**Control**)

tilapia-water spinach integrated system

sewage discharging system

sewage discharging and tilapia-water spinach integrated system

Material & methods

methods

Water quality: D.O, pH, W.T, nitrite, ammonia

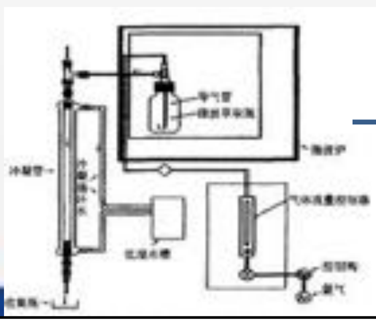
tilapia: weight gain, SPR, survival rate, net production and FCR

MIB & GSM detection in water: P&T GC-MS/MS

MIB & GSM detection: microwave assisted distillation-P&T GC-MS/MS

Material & methods

The earthy compounds were extracted in homemade microwave distillation equipment.
The microwave power and distillation time were set different to optimize the recovery of target compounds.
Target compounds were purged from 5mL distillate and absorbed onto the trap for 11 min.



Material & methods

2.1 *Method validation*

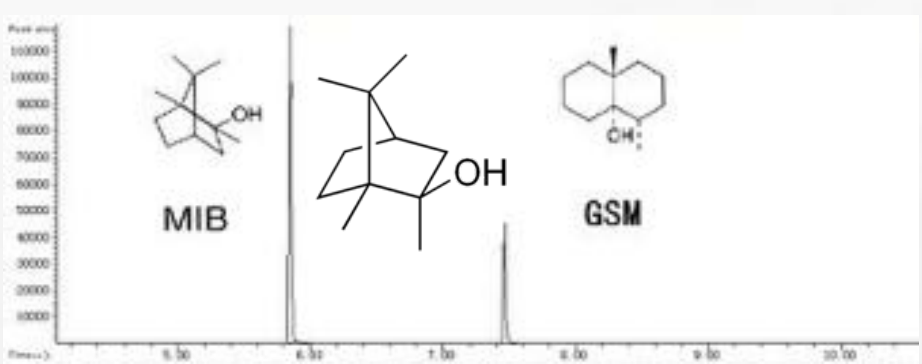


Fig.1 Extract Ion Chromatograms map of MIB and GSM

Material & methods

2.1 *Method validation*

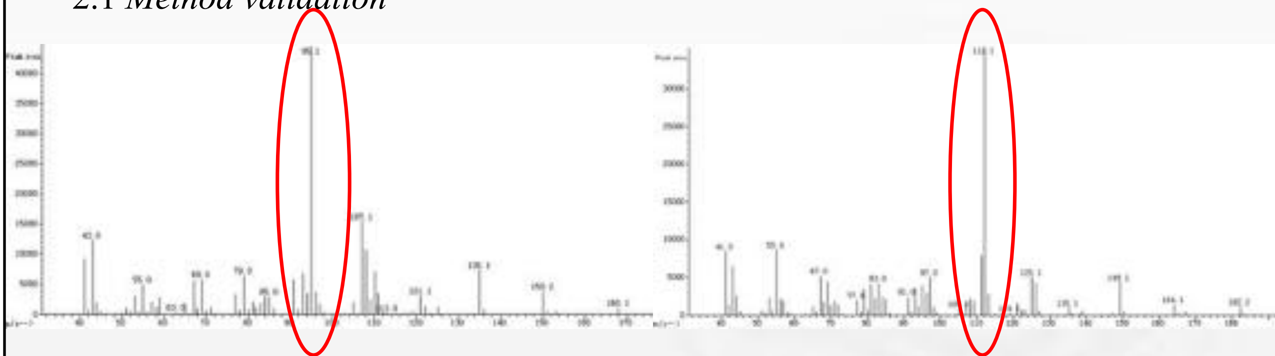


Fig.2 Component mass spectrogram of MIB and GSM

Results

2.2 Optimization of the extraction methods

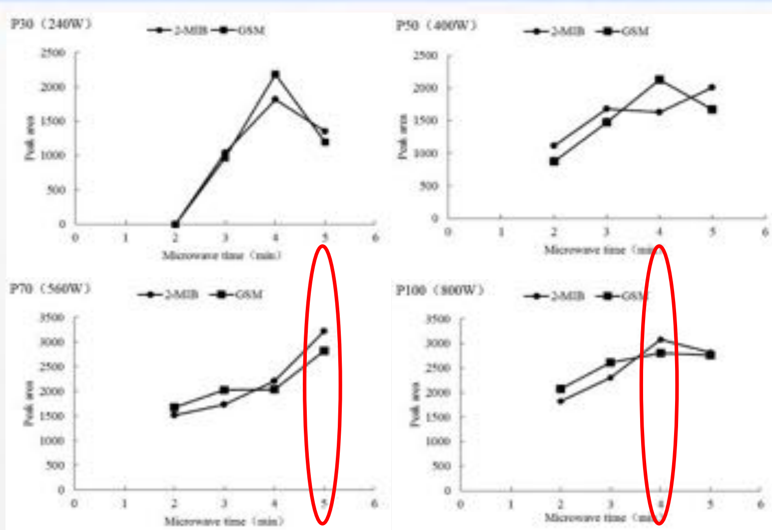


Fig.3 Effect of microwave power and treatment time on the extraction efficiency of MIB and GSM from fish meat

Results

2.2 Optimization of the detection methods

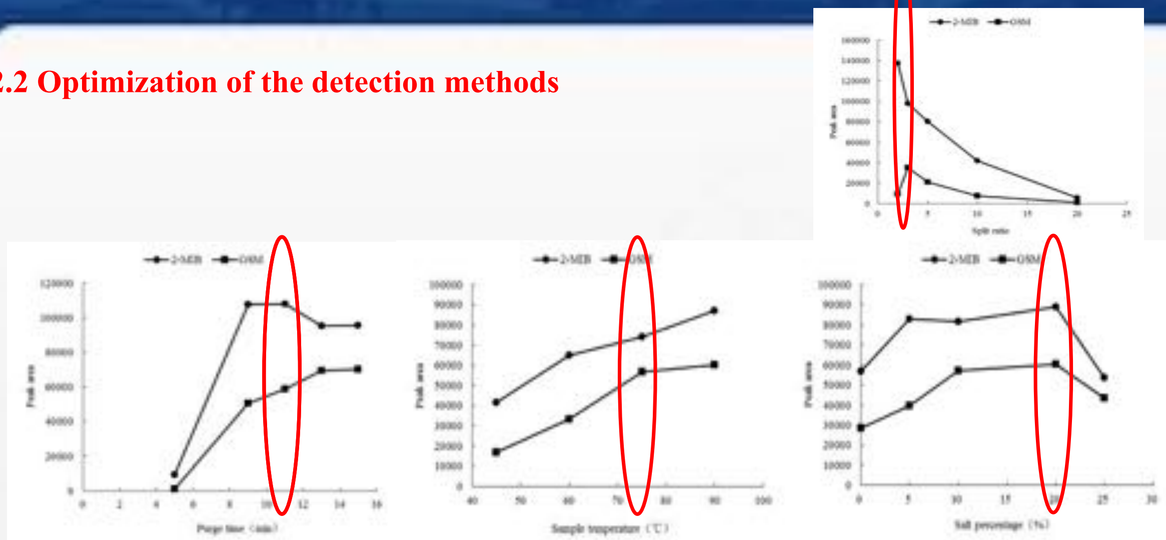


Fig.4 Effect of split ratio of GC/MS, purge time, sample temperature and salt percentage on the extraction efficiency of 2-MIB and GSM from fish meat

Results

2.3 *Calibration curves, limits of detection, and recovery for* 2-MIB and geosmin

Table1 Spike recovery of 2-MIB and GSM from tilapia samples

Analyte	t_R (min)	Selected ions (m/z)	Linearity (R)	Spiked Concentration (μg/L)					
				2		5		20	
				Recovery (%)	RSD[a] (%)	Recovery (%)	RSD (%)	Recovery (%)	RSD (%)
2-MIB	5.950	95[b],108,135	0.998	84-87	2.8	85-102	12	91-96	4.3
GSM	7.569	112[b],125,97	0.998	90-112	12.9	95-101	4.3	81-83	1.8

[a] Relative standard deviation. [b] Target ions for quantitation.

Results

Tab. 2 Growth performance of tilapia and water spinach cultured in each treatment

Note: the value in the same line with different superscript letters are significantly different($P < 0.05$).

index	control	tilapia-water spinach integrated	sewage discharge group	sewage discharge and tilapia-water spinach integrated
tilapia				
initial weight	54.54	54.54	54.54	54.54
final weight	407.47±8.08^{a}	478.57±14.96^{c}	428.27±17.26^{b}	461±10.47^{c}
biomass(kg/m³)	3.67±0.07^{a}	4.31±0.13^{b}	3.85±0.16^{a}	4.14±0.09^{b}
specific growth rate(%)	2.39±0.02^{a}	2.59±0.04^{b}	2.45±0.05^{a}	2.54±0.03^{b}
body weight increase	5.11±0.12^{a}	6.18±0.22^{c}	5.42±0.26^{b}	5.92±0.16^{c}
survival rate/%	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}
feed conversion rate	1.19±0.03^{a}	0.99±0.04^{b}	1.13±0.05^{a}	1.03±0.03^{b}
water spinach				
net production of water spinach/(kg·m^{-3})		0.60±0.04^{a}		0.69±0.03^{b}

Results

Water quality variations

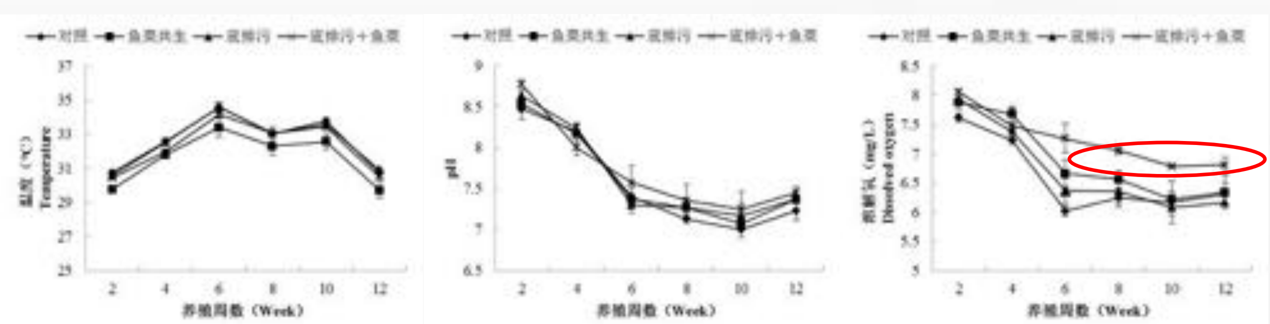


Fig. 5 Variations of water temperature, pH, D.O during the trial

Water quality, growth performance, and comparison on the content of geosmin and 2-methylisoborneol in different tilapia cultivation systems

Water quality variations

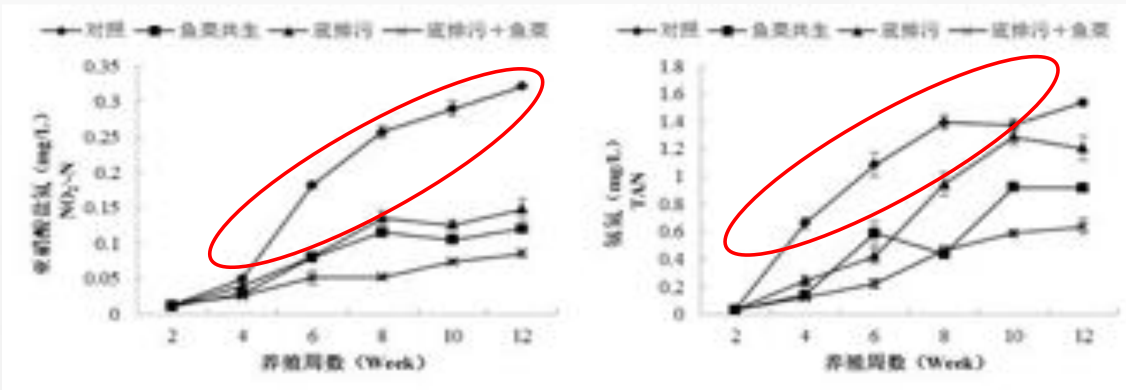


Fig. 6 Variations of nitrite-N, TAN during the trial

Water quality, growth performance, and comparison on the content of geosmin and 2-methylisoborneol in different tilapia cultivation systems

Content of geosmin and 2-methylisoborneol in different tilapia cultivation systems

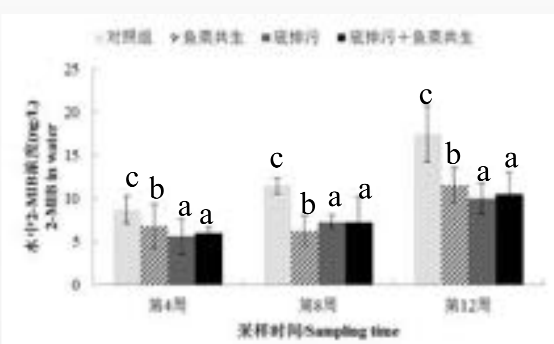


Fig. 7 Variations of 2-MIB in water from each treatment during the trial

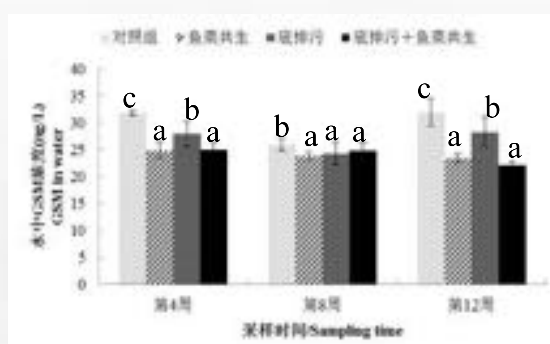


Fig. 8 Variations of GSM in water from each treatment during the trial

Water quality, growth performance, and comparison on the content of geosmin and 2-methylisoborneol in different tilapia cultivation systems

2.4 Variations of MIB and GSM in tilapia fillet from each treatment during the trial

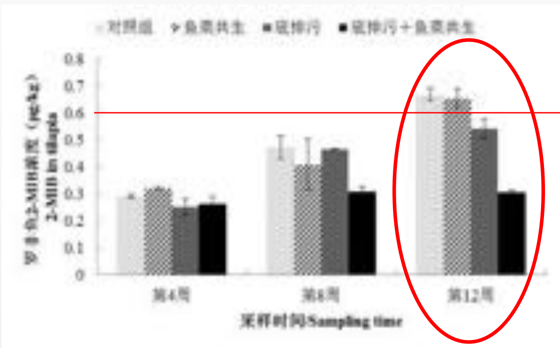


Fig. 9 Variations of 2-MIB in tilapia from each treatment during the trial

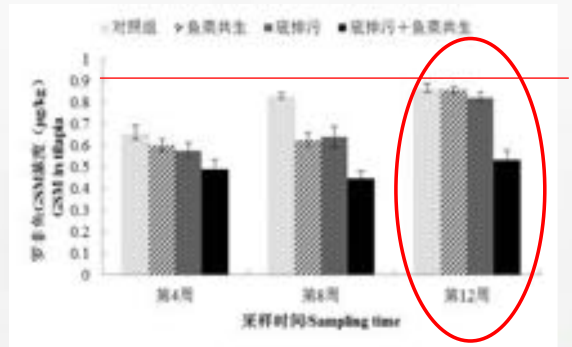


Fig. 10 Variations of GSM in tilapia from each treatment during the trial

Conclusion

- ✓ An analytical method was established for determining geosmin (GSM) and 2-methylisobomeol (MIB) as off-flavor compounds in tilapia tissue using gas chromatography and mass spectrum (GC-MS) based on microwave-assisted distillation followed by purge-and-trap.
- ✓ The sewage discharging and tilapia-water spinach integrated system reduced the accumulation of off-flavor compounds in water and tilapia muscle in an intensive tilapia farming system.

Prospects

Research shortage	To monitor the dominant microorganisms including blue-green algae and actinomycetes.
Prospects	It provides methods to reduce the off-flavor compounds in tilapia culture system, and criteria to improve tilapia products quality.

An overview of the status and potential of the mud crab fishery in coastal Bangladesh: Prospect, strategies, approaches

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Public awareness of the potential of the Mud crab fishery in coastal areas of Bangladesh has been particularly strong, in recognition of climate resilience and the particularly high export value of crabs. Endemic crabs show promise for cultivation, with potentially excellent economic and nutritional rewards. Despite such favorable prospects, the crab culture industry has remained undeveloped, and is restricted almost entirely to the fattening or growout of wild-caught juveniles; hatchery technology has not yet advanced sufficiently to deliver a reliable and abundant source of seedstock. The high aquaculture and export potential of the sector hinges on favorable biological, social and economic factors; coastal interest and international demand and price are compelling industry incentives. From a commercial perspective, efforts to close the life cycle of the burrowing mud crab *Scylla serrata* have had only limited success, and the hatchery and nursery phases of mass culture remain serious bottlenecks to mass culture. The current study has focused on the underlying perceptions and circumstances of crab fishery in coastal Bangladesh, as relevant to the potential for continuing aquaculture development. Our analysis focused on qualitative opportunities, approaches and impediments, using Strengths, Weaknesses, Opportunities and Threats (or SWOT) analysis. This was conducted to explore issues integral to the development of the crab sector toward sustainable growth of the industry in coastal Bangladesh. Interviews, focus groups, and a workshop were carried out in support of the analytical process. Evaluation and analysis of primary and secondary data revealed several unifying trends, such as consistently escalating price and demand, biological tolerance of variable and at times adverse environmental conditions, relatively low levels of investment required for farming, good benefits, appealing polyculture and integrated farming characteristics, availability of suitable resources, and nearly optimal climate and water quality conditions in coastal Bangladesh. Impediments to industry growth include a daunting dependence on wild-caught juvenile crabs. Challenges include the lack of suitable hatchery operation, limited technical knowledge, unavailability of specialized feeds, shallow and somewhat unstable domestic markets, susceptibility of young crabs to mortality, scarcity of technical and market support, and inadequate strategic policy. These must be considered together with promising incentives for industry development: high market potential, farming interest, prospects for employment generation, nutritional quality, and apparently robust business opportunities. Continuous extractive practices and compromised habitat quality have led to significant depletion of wild stocks, complicating a value chain already troubled by indiscriminate patterns of harvest. Market competition from imported crabs must be factored into plans for industry growth and development; these and other threats impose limitations on the capacity for sustainable expansion of the mud crab industry in coastal Bangladesh. Some recommendations are also detailed in the interest of adopting a responsible integrated coastal fisheries management approach and strategic policy development. This planning approach is based on anticipation of technological, environmental, regulatory and commercial management factors. Important guidance to industry development can be gained by considering past regional successes and failures with other crustaceans. For example, the remarkably successful growth of the mitten crab (*Eriocheirsinensis)* industry in China may have value as a model for the mud crab industry in Bangladesh.

An Overview of the Status and Potential of the Mud Crab Fishery in Coastal Bangladesh: Prospect, Strategies, Approaches

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Ph.D Research Fellow
Bangladesh Agricultural University

How mud crab fishery can be utilized and developed sustainably in the coastal region of Bangladesh?

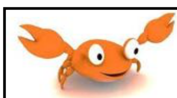
The mud crab fishery can be developed into a viable & sustainable aquaculture, capture fisheries & trade activity in Bangladesh

Objectives

▪ To benchmark & analyze the current situation & embedded issues of mud crab fishery in the coastal region of Bangladesh.

▪ To imply issues under SWOT as a matter of urgency to provide an outline for particular recommendations in terms of true management perspective & strategic decision-making to redound thriving of this sector.

▪ To assist in drawing a master plan as preamble for collaboration & collective action plans by private sector, govt. body, academicians, policy makers, development agencies & researchers.



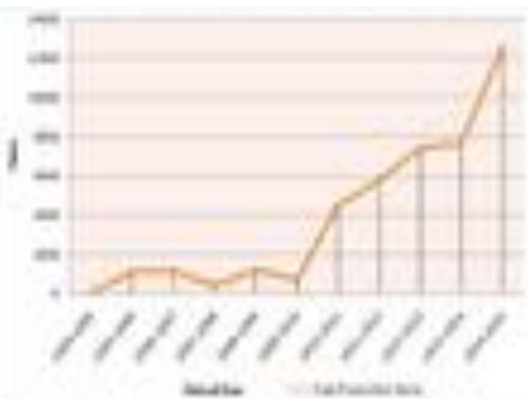
Importance

Mud crabs:

- Widely distributed species
- Crab fishery is rapidly increasing
- Production 1300 thousands tons
- Important coastal aquaculture species
- Most edible, popular and costly

Importance (Cont'd)

Mud crabs fishery in coastal Bangladesh:



- Fishery gained popularity
- Commercially important *sp.*
- Huge coastal landscape
- Very potential sector
- Thriving on crab aquaculture
- High demand and prices
- Ranked 2nd in exports

Different crab culture systems coexist in Bd

1. Crab Fattening

2. Grow-out culture

3. Soft-shell crab production

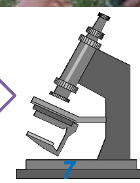
Research methodology

Literature review

Key informant interview

Focus group discussion

Workshop: SWOT Analysis



Why SWOT Analysis

- An SWOT is commonly used to initiate strategic planning in the fields of business & management

  Helms and Nixon (2010)

- Applications of SWOT to marine & freshH_2O fisheries have appeared in recent years in peer-reviewed journals

  Loefflad et al., 2014

- Applications of SWOT analysis to aquaculture systems are found more prevalent

  Rimmer et al., 2013

Study Areas

Coastal region of Bangladesh

Source: Islam *et al.*, 2012

Results

STRENGTHS (internal positives)

- High demand and price in local & international markets
- Crab itself less susceptible to disease & resistant to adverse environmental conditions
- Crab can tolerate a wide range of environmental factors
- Technically easy to culture with a short crop cycle
- Polyculture are carried out efficiently
- Crabs can easily fed trash fishes
- Diversified farming systems are occupied
- Increase farm production and income for impoverished HHs
- Generating huge employment opportunities
- Crab fishery involved more than 300,000 people

WEAKNESS (internal negatives)

- Aquaculture is entirely depended on wild-caught seeds
- Hatchery technology for seed production is absent
- Limited improved or sustainable production technology
- High stocking mortality in farms
- Commercial feed has not been developed or introduced yet
- Lack of capital & limited access to credits for fatteners
- No standard grading & pricing system
- Limited or no domestic consumption
- Poor transportation facilities lead mortality
- Poor background data on stock assessment
- Inadequate research initiatives to develop this sector
- Lack of sustainable & appropriate policy

OPPORTUNITIES (external positives)

- Well-suited water bodies are available
- Crab aq. can be adopted in changing climate conditions
- Improved technology can enhance farming production
- Large-scale shrimp farmers are shifting to crab farming
- Success in hatchery seeds supply will ensure rapid growth
- Poor women may be benefited through improved value chain
- High export market potential with growing demand & price
- International market has potential demand for value addition
- Potential for enterprise & industrial development
- Human resources are available to support a new industry
- Domestic consumers can enhance local demand
- Appropriate policy & initiatives can help sustainable fishery

THREATS (external negatives)

- Export trade based on harvesting wild stock may not be sustainable
- Excessive & indiscriminate harvesting may lead rapid depletion of wild stock & threaten species
- Dependence for seed on natural sources can hamper fishery growth
- Rapid depletion of wild population can create bio-diversity degradation
- Large-scale international competitors can challenge BD crab's demand & consumer preference
- Harvesting in breeding season & damage natural habitats & ecology can disrupt natural propagation

Conclusion

•Strengths can be utilized & opportunities can be welcomed as these are the main vehicles for sustainable exploitation and rapid growth of this potential sector

•Problems & limitations can be addressed by proper monitoring & critical examining to transfer weaknesses as asset to robust the sector viable towards economical,
•commercial, sociological & ecological return

•Data predict, crab fishery in the coastal zone will epitomize the blue economy & contribute to the tangible outcomes in support of SDGs.

Recommendations

▪ Determined initiatives should be taken to produce hatchery raised crab seeds commercially through induced breeding and larval rearing.

▪ Study for crab stock assessment is clearly warranted to known whether the species is already overexploited or underexploited & based on that findings, an effective strategic approach can be made for further development.

▪ Enforcement & proper application of law & a restriction policy should be applied to avoid such harvesting that leads indiscrimination & habitat degradation

Recommendations (Cont'd)

- Crab farmers must be trained on BMP, also introduce to improved technology to enhance production
- Breeding & nursery grounds need to be identified & crab sanctuary can be established on a priority basis for species conservation & long-term sustainable exploitation
- Transport systems should be modern & crab friendly to reduce mortality
- Crab marketing systems should be open for fair pricing
- The exploration and identification of more export markets is needed

Special Case (women in crab aquaculture)

Fig: women harvest crab and tying by string

Special Case (women in crab aquaculture)

Fig: women checking crab, applying feeds & preparing lime

Special Case (women in crab aquaculture)

Fig: women mince fish for crab, checking crabs, making gear

Special Case (women in crab aquaculture)

Fig: women making money through selling crabs to local markets

Acknowledgements

- beloved crab farmers
- Stakeholders
- Co-authors &

Thank you very much