AquaFish Innovation Lab Technical Meeting at Asian-Pacific Aquaculture
Surabaya, Indonesia
27-28 April 2016

Proceedings

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

Acknowledgements

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Disclaimers

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PREAMBLE

2016 AquaFish Technical Meeting
APA 2016 – Surabaya, Indonesia
27-28 April 2016

With a growing global population, food security is becoming increasingly important. More and more people will rely on fish from aquaculture, the fastest growing sector of animal protein production. Much of the global aquaculture occurs on a small to medium scale. Promoting smallholder aquaculture technologies is a focus of AquaFish Innovation Lab (AquaFish) because such technologies can promote the development of sustainable and innovative solutions local challenges in the aquaculture industry.

On 27-28 April 2016, researchers assembled in Surabaya, Indonesia for the AquaFish's five technical sessions, which were organized by AquaFish Innovation Lab's Director Dr. Hillary Egna and management team, at the 2016 Asian-Pacific Aquaculture Conference. These sessions created valuable opportunities for program partners and the research community to learn about AquaFish's research portfolio. Topics for the five sessions all pertained to innovations in smallholder aquaculture technologies, with focuses on tilapia, sustainable systems, snakehead, economics and marketing, and capacity building and gender. (The tilapia session was also part of the International Symposium on Tilapia in Aquaculture 11, held in Surabaya.)

2016 AquaFish Technical Meeting Agenda
APA 2016 – Surabaya, Indonesia

27-28 April 2016

Grand City Convention Center

Wednesday, 27 April 2016

AquaFish Technical Session 1 (11:00 – 14:10)
Innovations in Smallholder Aquaculture Technology: AquaFish Research on Tilapia

Chair: Dr. Hillary Egna, AquaFish Director and Lead Principal Investigator
Co-Chair: Dr. Ford Evans, AquaFish Associate Director

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11:20-11:40	**Evaluation of housefly *Musca domestica* maggot meal as protein source in Nile tilapia *Oreochromis niloticus* diets** Nazael A. Madalla*, Tausi Ally, & Sebastian W. Chenyambuga
11:40-12:00	**Efficacy of common carp *Cyprinus carpio* testis enducing sex reversal of Nile tilapia *Oreochromis niloticus*** Rahul Ranjan, Narayan P. Pandit*, Nabin B. Khanal, Madhav K. Shrestha, and James S. Diana
12:00-12:20	**Assessment of value chain of farmed Nile tilapia *Oreochromis niloticus* in costal and lake zones of Tanzania** Sebastian W. Chenyambuga*, Elibariki E. Msuya and Nazael A. Madalla
12:20-13:30	Lunch
13:30-13:50	**Performance evaluation of blended virgin coconut oil on growth, feed utilization, body composition, body fatty acids, plasma metabolites of Nile tilapia *Oreochromis niloticus* and resistance to *Streptococcus iniae* challenge** Liping Liu*, Andrews Apraku, Xiangjun Leng, Emmanuel J. Rupia, Christian Larbi Ayisi
13:50-14:10	**Inclusion of Nile tilapia *Oreochromis niloticus* and Sahar *Tor putitora* improves reproductivity in carp-polyculture system** Mahendra Bhandari, Rama N. Mishra, Madhav K. Shrestha, and James S. Diana

Thursday, 28 April 2016

AquaFish Technical Session 2 (8:30 – 10:10)
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Chair: Dr. Hillary Egna, AquaFish Director and Lead Principal Investigator
Co-Chair: Jenna Borberg, AquaFish Assistant Director of Research

8:30-8:50 **Aquaculture carrying capacity of Stung Chinit Reservoir, Cambodia: A pilot project**
David Bengtson, Phen Chheng, Puthearath Tith, Bunthang Touch, Nam So

8:50-9:10 **Growth and production of carp and SIS in periphyton enhanced systems**
Sabita Jha, Sunila Rai*, Madhav K Shrestha, and James S Diana

9:10-9:30 **Effects of reduced feeding strategies for combined polyculture of two major carps (Rohu and Catla) with Shingh catfish *Heteropneustes fossils***
Shahroz Mahean Haque *, Imrul Kaiser, Moon Dutta, M. A. Wahab and Russell Borski

9:30-9:50 **Spawning response of sahar *Tor putitora* in Terai region of Nepal**
Subash K. Jha, Jay D. Bista*, Narayan P. Pandit, Madhav K. Shrestha, and James S. Diana

9:50-10:10 **Understanding sex change and hermaphroditism in African lungfish *Protopterus aethiopicus* and its implication to aquaculture: Preliminary findings**
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AquaFish Technical Session 3 (11:00 – 12:20)
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Chair: Dr. Hillary Egna, AquaFish Director and Lead Principal Investigator
Co-Chair: Jenna Borberg, AquaFish Assistant Director of Research

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Navy, H., Minh, T. H. and Pomeroy, R.S

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Thi Thanh Hien Tran, Pham Minh Duc*, Tran Minh Phu, Tran Le Cam Tu, Dang Thuy Mai Thy, and Bengtson David

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Truong Hoang Minh, Tran Ngoc Hai and Robert Pomeroy

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Phanna Nen, Nam So, Seang Hay Pheng, Robert Pomeroy

AquaFish Technical Session 4 (13:30 – 15:30)
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Chair: Dr. Hillary Egna, AquaFish Director and Lead Principal Investigator
Co-Chair: Kat Goetting, AquaFish Assistant Director of Outreach

13:30-13:50 **Impact of stocking density and feeds on yield of Pangasius catfish *Pangasius hypophthalmus* in hyposaline waters**
M. Lokman Ali*, S. Mahean Haque, M. A. Wahab and Russell Borski

13:50-14:10 **Price volatility in the African catfish reseller markets in Uganda**
James O. Bukenya

14:10-14:30 **Implementing mobile marketing and technical support for fish farmers: Uganda grower experiences and aspirations**
Joseph Molnar*. M. Matuha*, G. Atukunda, J. Walakira, J. Terhune, J. Bukenya, S. Naigaga

14:30-14:50 **An assessment of household food security in fish farming communities in Ghana**
Kwamena Quagrainie* and Akua Akuffo

14:50-15:10 **Production and economic benefits of reduced feed inputs and addition of Indian carp (Rohu) on Nile tilapia growout in ponds**
Mst. Kaniz Fatema*, Md. Abdul Wahab, S.A.S.A. Tahmid, Amit Pandit, S. M. Masud Rana, Shahroz Mahean Haque, and Russell J. Borski

15:10-15:30 **Sustainable pearl farming in Africa using new spat collection techniques**
Narriman. S Jiddawi and Maria C. Haws

AquaFish Technical Session 5 (16:00 – 17:20)
Innovations in Smallholder Aquaculture Technology: AquaFish Research in Capacity Building and Gender

Chair: Dr. Hillary Egna, AquaFish Director and Lead Principal Investigator
Co-Chair: Kat Goetting, AquaFish Assistant Director of Outreach

16:00-16:20 **Improving the well-being of Bangladeshi women mud crab culturist using a value chain analysis**
Wilfred Jamandre*, Upton Hatch, Sattyananda Biswas, Emilia Quinitio, Md. Abdul Wahab, Sadika Haque, Russell Borski

16:20-16:40 **Establishing school ponds for educating students to improve health and nutrition of children and women in rural Nepal**
Dilip K. Jha*, Narayan P. Pandit, Ishori S. Mahato, Madhav K. Shrestha, and James S. Diana

16:40-17:00 **Fish and nutrient consumption among women and pre-school children in rainy season in Cambodia**
Touch Bunthang, So Nam, Chheng Phen, Pos Chhantana, En Net, and Robert Pomeroy

17:00-17:20 **Role of the AquaFish Innovation Lab in university capacity building and aquaculture development in Nepal**
Madhav K. Shrestha and James S. Diana

Abstracts and Powerpoint Presentations

In the order they appear in the agenda

AquaFish Technical Session 1
Innovations in Smallholder Aquaculture Technology: AquaFish Research on Tilapia

Effect of pulsed feeding on growth, gut metagenome, and intestinal nutrient transporters of tilapia in pond culture

Russell J. Borski*, Scott Salger, David Baltzegar, Jimi Reza, and Md. Abdul Wahab
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russell_borski@ncsu.edu

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. Here we assessed if reduced feeding might improve feed efficiency of tilapia grown in ponds in Bangladesh by utilizing pulsed feeding strategies along with weekly pond fertilization [fed daily (Tx1), fed alternate days (Tx2), fed every third day (Tx3), not fed (Tx4)] and without fertilization [fed daily (Tx5)]. Tx1, Tx2, and Tx5 had the greatest growth and survival, while Tx2 had the best feed efficiency and overall benefit:cost ratio of all groups. Metagenomic studies were designed to establish gut microbial diversity changes due to these pulsed feeding strategies. We obtained about 20 million total reads aligning to 225 16S (prokaryotic) operational taxonomic units (OTUs, e.g. different genus/species) and 288 18S (eukaryotic) OTUs. Metagenomic analyses indicated that Tx1 and Tx2 had the greatest diversity of bacteria and eukaryotes in the tilapia fecal material (Figure 1). The predominant bacteria found were *Cetobacterium somerae* (common gut colonizers of Nile tilapia), bacteria of family Peptostreptococcaceae, and *Clostridium perfringens*. 20 unique species were found in Tx2 including an antibiotic producing *Actinoplanes* sp., the methanol utilizing *Methylobacterium hispanicum*, and the biodegrative *Sphingomonas* sp. The predominant eukaryotes in the tilapia fecal material were the diatoms of class Mediophyceae, phylum Rotifera, green algae of class Chlorophyceae, and the angiosperms of class Magnoliophyta. Gene expression of solute transporters found in the proximal intestine was investigated. Transporter gene expression in the Tx2 regime tended to be higher than feeding alone, but lower than the other feeding + fertilization and fertilization alone regimes.

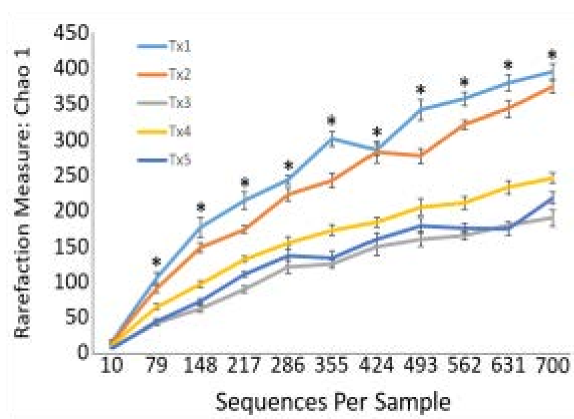


Figure 1. Chao 1 indices of tilapia gut prokaryotic microbial diversity. Diversity was higher in Tx1 and

This intermediate expression of transporters with alternate day feeding may reflect a condition for most efficient uptake of nutrients from the GI tract of tilapia. Overall, the results indicate that feeding tilapia on alternate days in fertilized ponds can provide significant cost savings to Bangladesh tilapia farmers with little impact on fish growth, which supports previous studies in the Philippines. Additionally our results suggest that combined alternate-day feeding and fertilization increases the diversity of microbiota available to the fish and regulates nutrient uptake, which may contribute to the improved efficiency of tilapia growout.

Effect of Pulsed Feeding on Growth, Gut Metagenome, and Intestinal Nutrient Transporters of Tilapia in Pond Culture

Russell J. Borski[1], Scott A. Salger[1], David A. Baltzegar[1], Jimi Reza[2], and Md. Abdul Wahab[2]

[1] Department of Biological Sciences
North Carolina State University
[2] Department of Fisheries Management
Bangladesh Agricultural University

Background

- Tilapia production > 5 million metric tons
- 50-70% of production costs for tilapia is attributable to feeds. Reducing costs through improved feed management strategies or formulations is important.
- Gut microbes are essential to efficient digestion of nutrients, energy homeostasis, innate immunity, maintenance and growth of epithelium
- Role of gut microbes in tilapia nutrient utilization, growth, and health poorly understood – the metagenome has yet to be evaluated in growout of tilapia.

Objec0ves

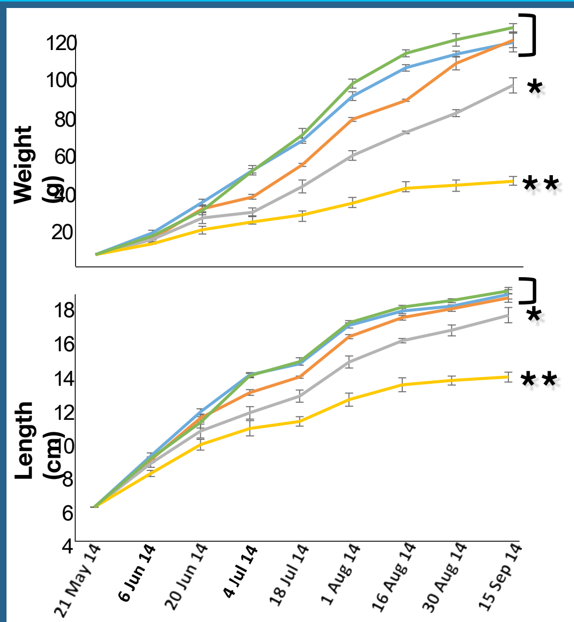
- Evaluate the effectiveness of pulsed feeding strategies (e.g. daily, alternate day, every 3rd day feeding) on Nile tilapia (*Oreochromis niloticus*) production
- Identify key molecular factors associated with nutrient uptake efficiency (nutrient transporter gene expression)
- Characterize changes in gut microbial communities in response to pulsed feeding strategies

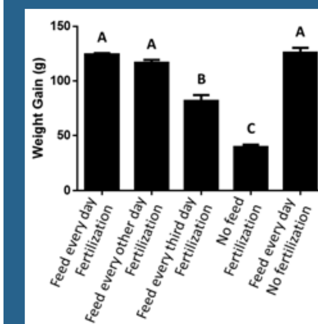
Study Design

- 12 Week Pond Study – Fisheries Field Laboratory, Bangladesh Agricultural University
- Gene Expression and Metagenomics Studies – NC State University

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

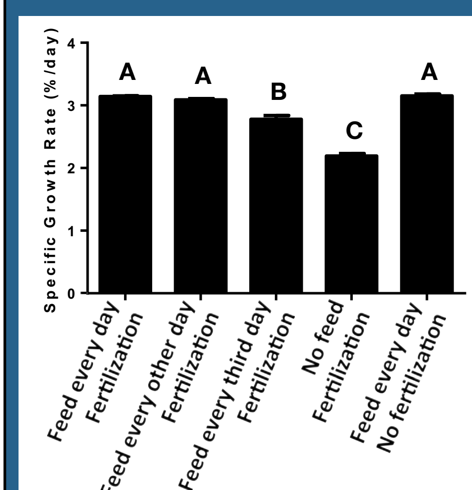
Results – Growth Metrics

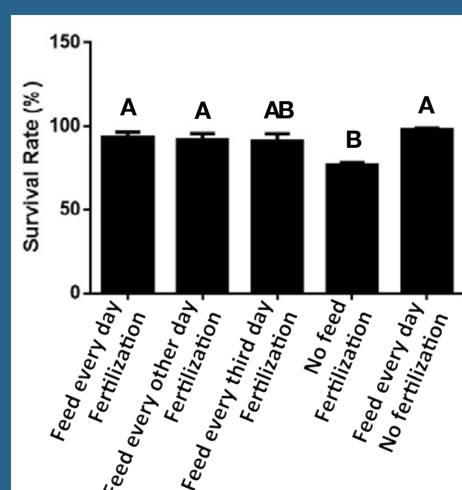




Sta+s+cal significance determined by ANOVA.
*p < 0.05; **p < 0.01

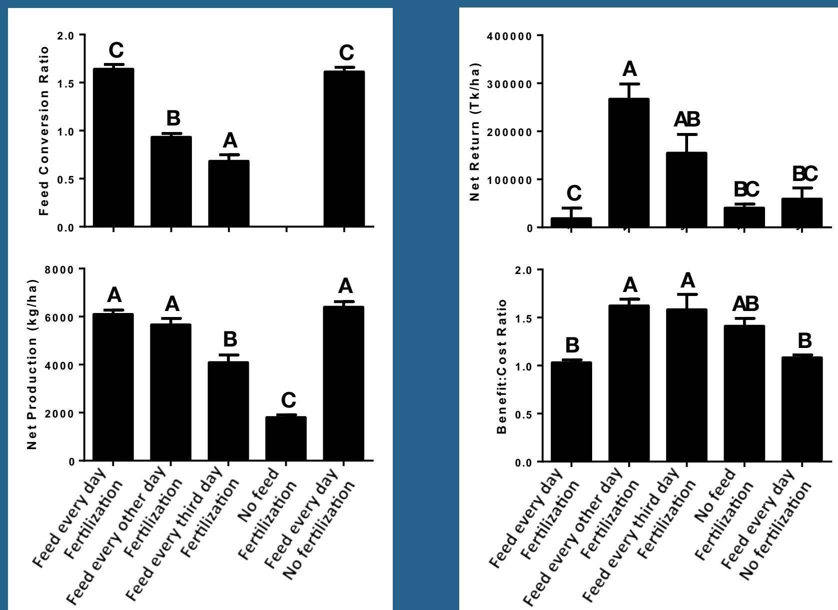
Results – Produc0on Metrics





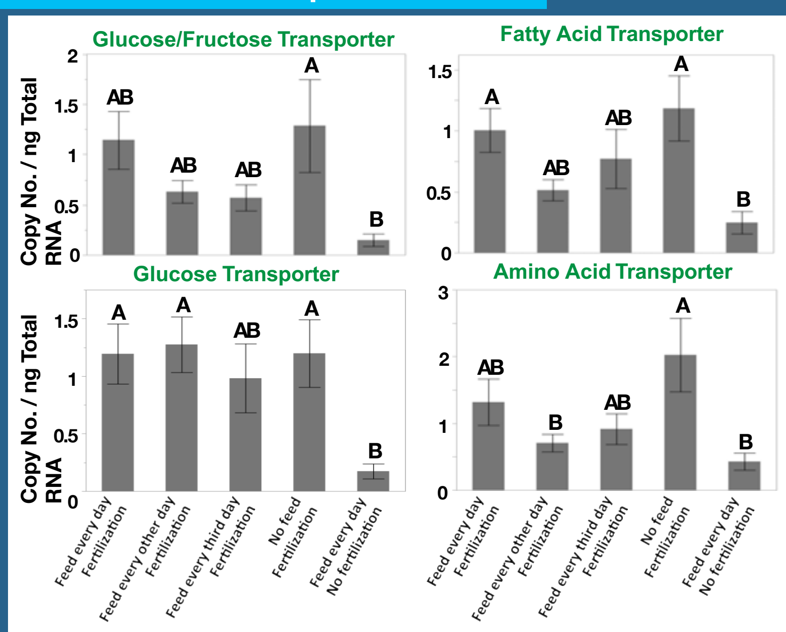
Le@ers designate sta+s+cal differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

Results – Economic Metrics



Le@ers designate sta+s+cal differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

Results – Gut Nutrient Transporters

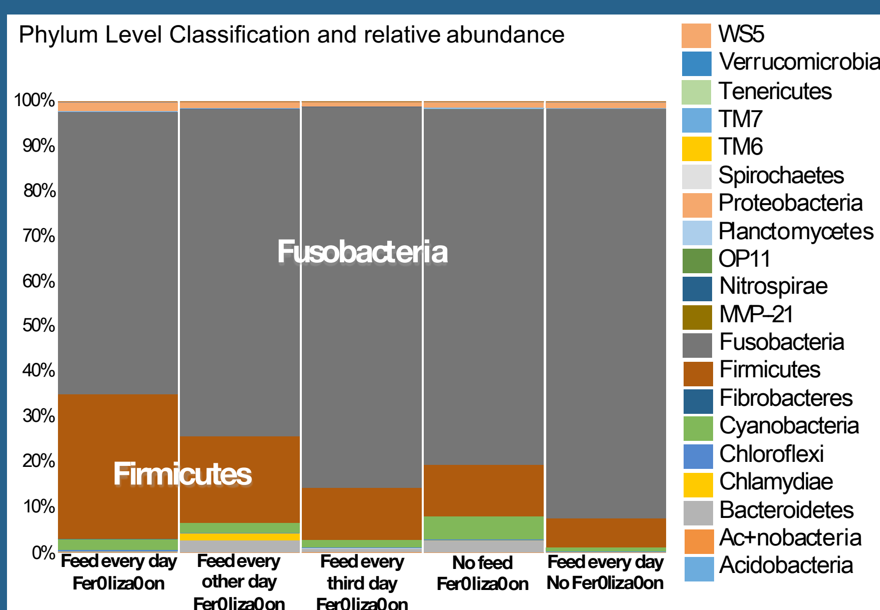


Le@ers designate sta+s+cal differences determined by ANOVA followed by Tukey's posthoc analysis. $P = 0.05$

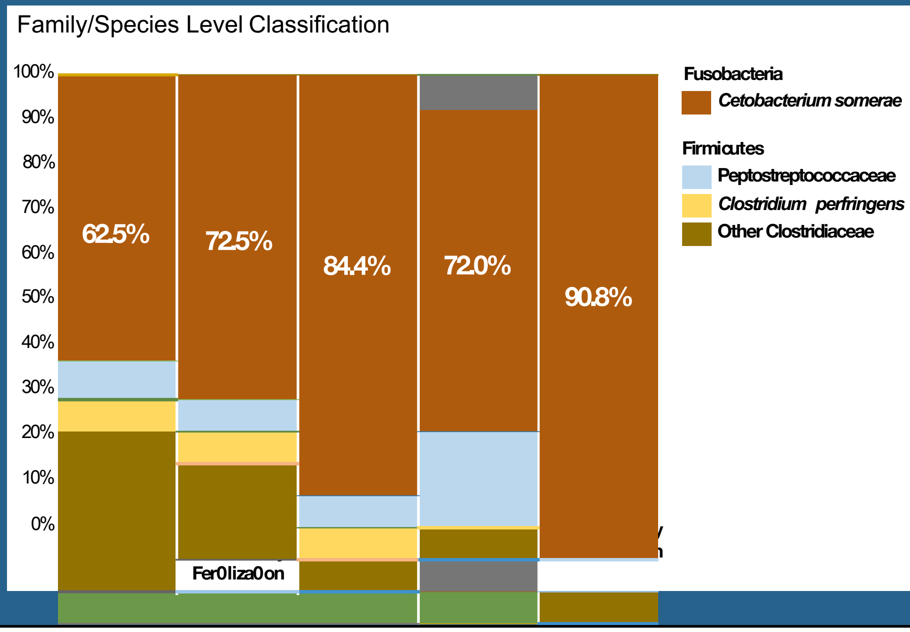
Results – Tilapia Microbiome

- Feces collected (12 weeks of growth trial)
- Identified microbial communities by 16S (prokaryote) and 18S rRNA (eukaryotes) sequences via QIIME using Greengenes/Silva databases
- 715,725 total reads after quality filtering
  - 330,883 prokaryotic reads
  - 384,842 eukaryotic reads
- These contributed to:
  - 20 prokaryotic phyla, 43 classes, 92 orders,145 families, and 215 species
  - 8 major eukaryotic phyla, 132 genera, and 289 species

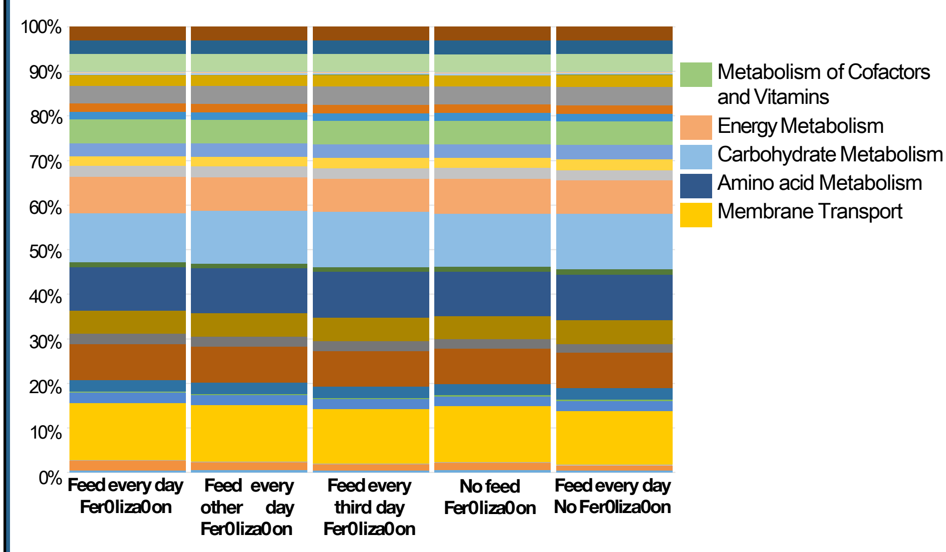
Results – Bacterial Metagenome



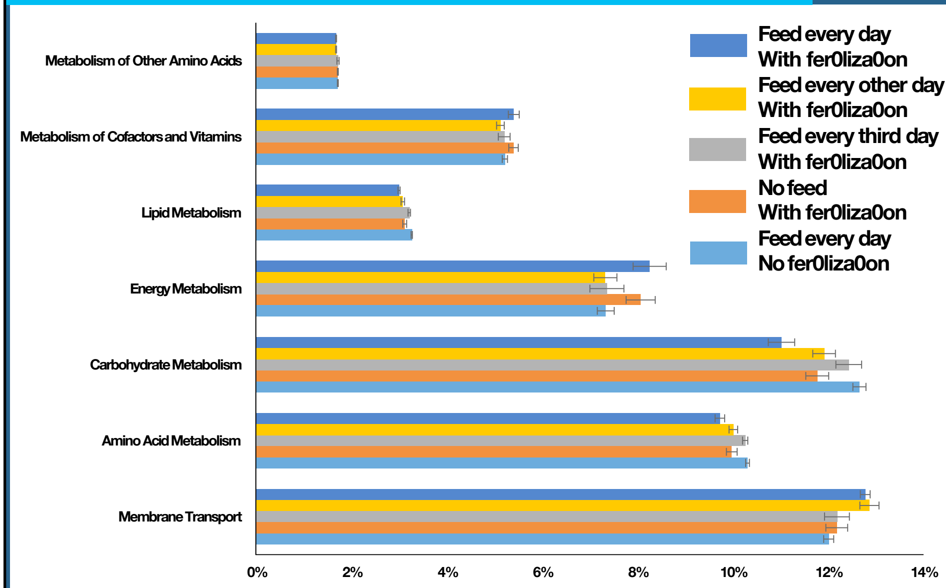
Results – Bacterial Metagenome



Results – KEGG Func0onal Analysis –Predicted metabolic func0on of bacterial communi0es

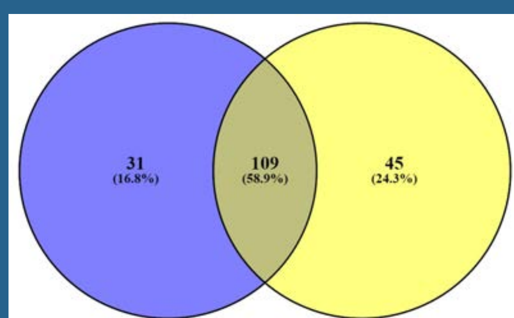


Results –Predicted Metabolic Func0on of Gut Flora that may Affect Metabolism and Nutri0on in Fish



Results – Poten0al for Probio0c Development

Feed every day Fer0liza0on

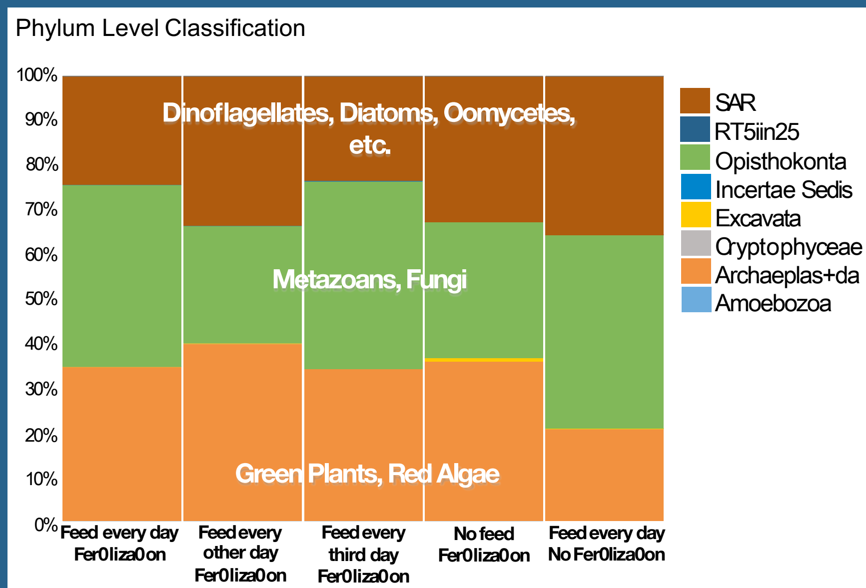


Feed every other day Fer0liza0on

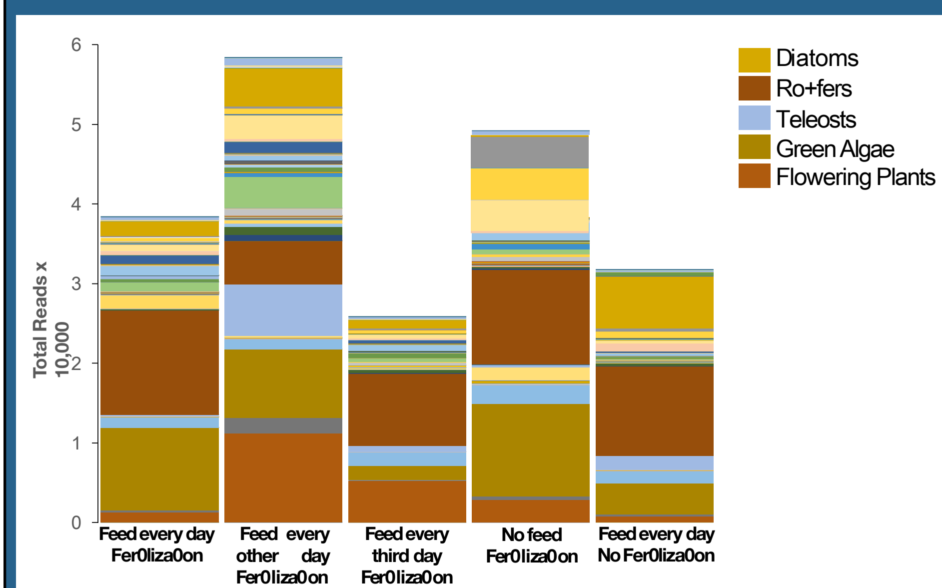
<u>Poten+al bacteria from alternate day fish that could lead to probio+c development</u>:

Acutodesmus obliquus – lipid produc2on
Bacillus sp. – known probio+c
Blau2a sp. – degrada+on of complex polysaccharide to fa@y acids
Anaerovorax sp. – ferments toxic putrescine to nontoxic forms
Sphingomonas sp. – biodegra+ve and biosynthe+c
Desulfococcus sp. – sulfate reducing, u+lize acetone for growth

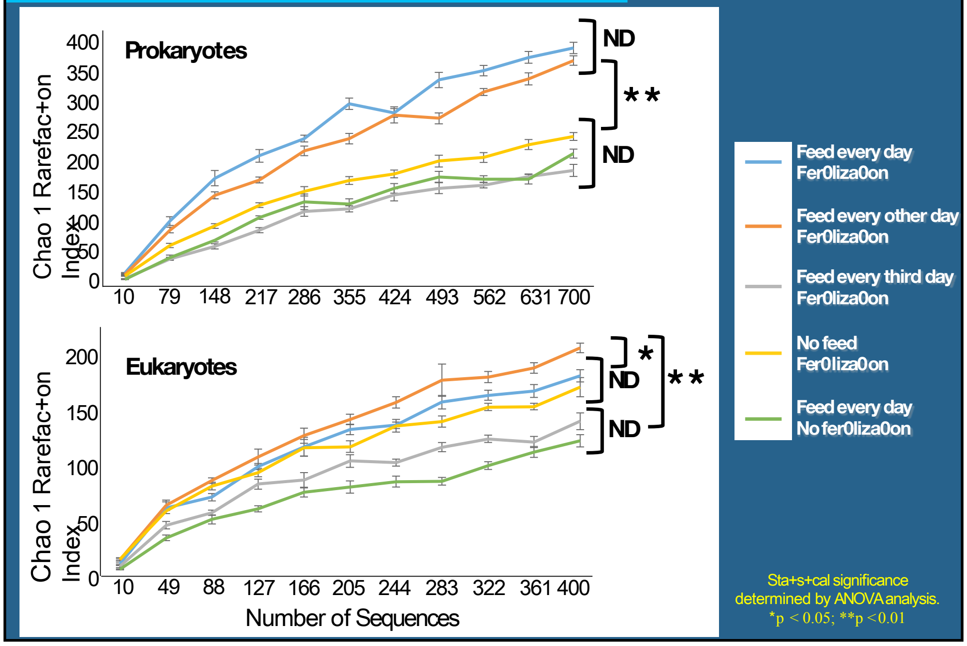
Results – Eukaryo0c Metagenome



Results – Eukaryo0c Metagenome



Results – Microbial Diversity



Conclusions

- No difference in growth or production parameters of Nile tilapia when employing alternate-day feeding vs. daily feeding strategies
  - ➢➢ Feed costs decreased by 50%
- Nile tilapia may more efficiently utilize available nutrients when fed on alternate days
- A greater diversity of organisms found in the intestines of tilapia when fed on alternate days
  - ➢➢ Potential for more diverse nutrients being available
  - ➢➢Potential probiotic support for more efficient absorption of nutrients and general fish health

Funding for this research was provided by the

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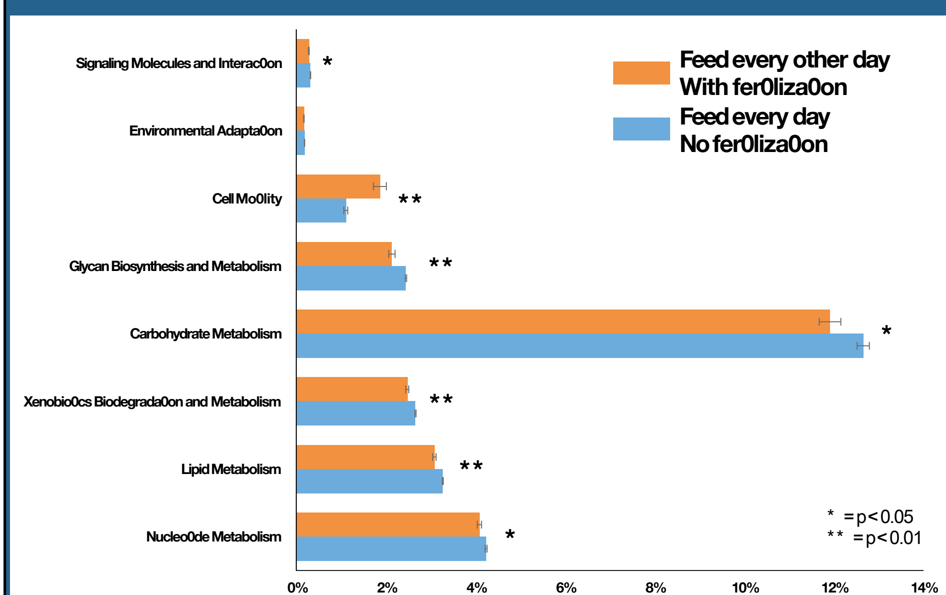
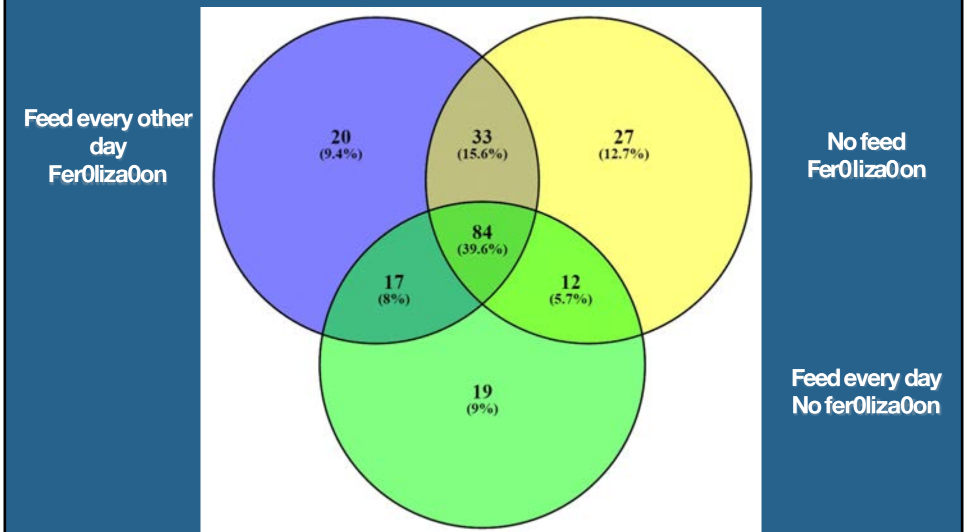
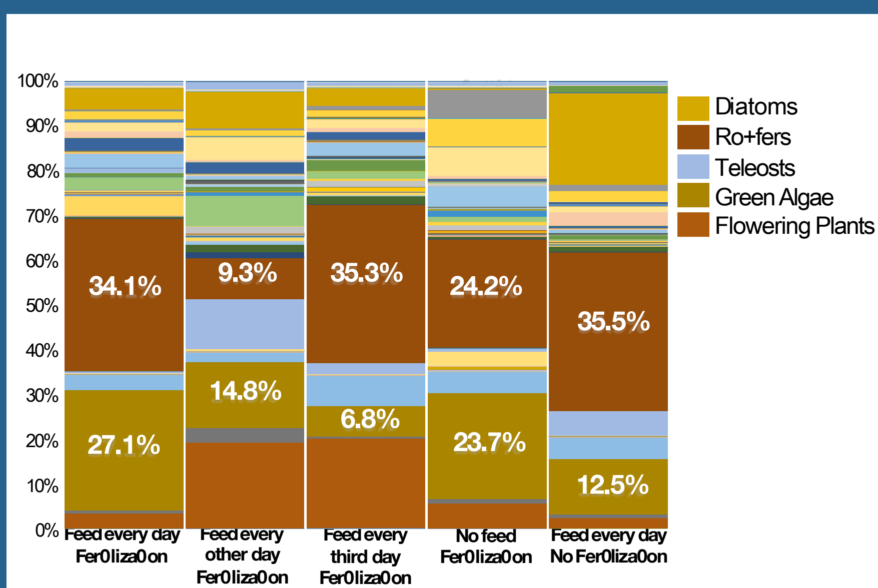
Results – Func0onal Analysis Predicted from Metagenome



Results –



Results – Eukaryo0c Metagenome



Background

- Small-scale tilapia farmers in underdeveloped countries (e.g. Bangladesh) often use extensive culture practices, where fertilizer is added to stimulate pond primary production but no feeds are used (Belton et al 2011)
- Even modest amounts of feed (semi-intensive) can effectively quadruple production, promoting increases in personal household income and fish consumption, and greater food security for impoverished farmers (Belton et al 2011; Dey et al 2008)
- Reducing costs of feed, which comprises 50-70% of total production costs, is critical for enhancing incomes and sustainability

Evaluation of housefly *Musca domestica* maggot meal as protein source in Nile tilapia *Oreochromis niloticus* diets

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Despite phenomenal growth of aquaculture in the world, such growth has growth has remained elusive Tanzania. It has remained mostly rural taking place in small semi-intensive freshwater ponds mostly stocked with Nile tilapia. Lack of quality and affordable fish feeds is one of the limiting factors as fishmeal and oil seedcakes are scarce and unaffordable. Housefly maggots are locally available, palatable and relatively more affordable thus a potential protein source. Moreover, they have short life cycle and high fecundity rate within a short period time. The current study evaluated suitability of housefly maggot meal (HFM) as protein sources in the Nile tilapia diets. The maggots were produced using chicken manure as substrate. Four test diets were formulated to contain graded levels of HFM (25, 30, 35 & 40%) which were compared against a non-HFM control diet (HFM0) as shown in Table 1. All diets were isonitrogenous with 30% crude protein.

Table 1: Percentage inclusion levels of the ingredients in HFM Based Diets (g/100g diet)

	Diets				
Ingredients	**HFM0**	**HFM25**	**HFM30**	**HFM35**	**HFM40**
Fish Meal	5	5	5	5	5
Housefly Maggot Meal	0	12	25	40	49
Cotton Seed Meal	50	39	25	9	0
Others	45	44	45	46	46

FM = Fish Meal, CSM = Cotton seed meal, Others include Maize meal, Wheat meal, Sunflower oil, Minerals/Vitamin premixes

The diets were fed to juveniles with an average weight of 2.6g in a growth trial which lasted for eight weeks. Growth, feed utilization and cost effectiveness was best in fish fed diet HFM35 (Table 2). Therefore HFM can be included at 35% in Nile tilapia diets containing 5% fish meal and cotton seedcake or any similar plant protein without compromising biological and economical performance.

Parameter	Diets				
	HFM0	**HFM25**	**HFM30**	**HFM35**	**HFM40**
Final Weight (g)	7.71[a]	8.07[a]	8.19[a]	8.33[a]	7.81[a]
Weight Gain (% day-1)	220a	243a	265a	267a	213a
Feed Intake (gfish^{-1}day^{-1})	0.22[b]	0.26[ab]	0.30[ab]	0.28[a]	0.24[b]
Feed Conversion Ratio	2.47[c]	2.24[abc]	2.05[b]	1.85[a]	2.66[dc]
Specific Growth Rate (% day^{-1})	2.00[a]	2.11[a]	2.18[b]	2.16[a]	1.88[b]
Protein Efficiency Ratio	1.35[b]	1.49[b]	1.64[ad]	1.81[a]	1.26[c]
Survival (%)	88.1[b]	97.6[a]	95.2[a]	97.6[a]	95.2[a]
Price of Feed (TZS/Kg)	1509	1374	1359	1329	1329
Cost effectiveness (TZS/Kg of fish)	3727[c]	3077[b]	2779[ab]	2453[a]	3534[c]

Evaluation of Housefly ***Musca domestica*** **Maggot Meal as Protein Source in Nile Tilapia** ***Oreochromis niloticus*** **Diets**

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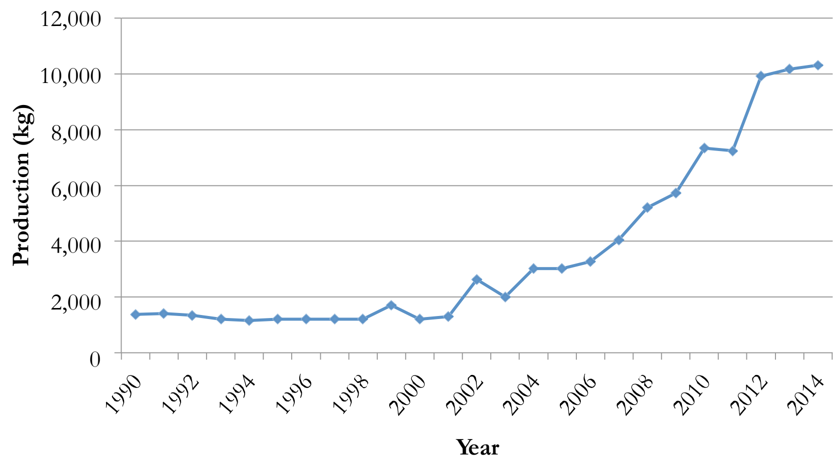
Introduction

- Despite phenomenal global growth of aquaculture, such growth remained elusive in Tanzania.
  - 73.8 Million MT vs. 10,317 MT in 2014
- Mostly subsistence, small semi-intensive freshwater ponds typically stocked with tilapias
- Lack of quality and affordable fish feeds is one of the limiting factors as fishmeal and oil seedcakes are scarce and unaffordable.

Aquaculture Production Trend in Tanzania



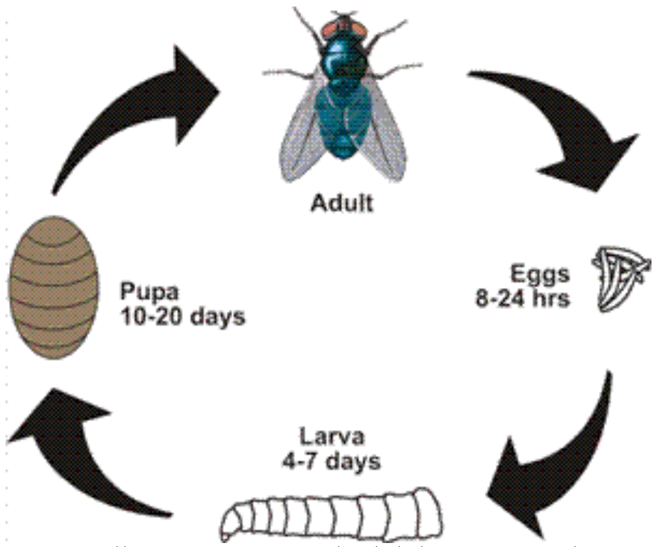
Source: FAO FishStat

…Introduction

- Housefly maggots are promising protein source
  - locally available
  - palatable
  - relatively affordable
  - short life cycle
  - high fecundity
- The current study evaluated suitability of housefly maggot meal (HFM) as protein source in practical Nile tilapia diets.

…Introduction

Life Cycle of House Fly



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

Methodology

- The maggots were produced indoors
  - Substrate: cattle manure
  - Attractant: cattle offals and fish remains.
- Harvested maggots were blanched, oven dried at 65^0C for 48 hours and then ground into a meal
- Five diets were formulated to contain 30% protein and 10% lipid.

…Methodology

Maggot Culture

…Methodology

Maggot Harvest

…Methodology

Formulation of HFM Diets (g/100g diet)

	Diets				
Ingredients	**HFM0**	**HFM12**	**HFM25**	**HFM40**	**HFM50**
Fish meal	5.0	5.0	5.0	5.0	5.0
Housefly maggot meal	0.0	12.0	24.5	40.0	49.8
Cottonseed meal	50.0	39.0	25.0	9.0	0.0
Maize meal	40.0	38.5	40.5	42.0	42.2
Wheat meal	2.0	2.0	2.0	2.0	2.0
Sunflower oil	1.0	1.5	1.0	0.0	0.0
Vitamin/mineral premix*	2.0	2.0	2.0	2.0	2.0

*Vitamin A 25,500,000 IU, Vitamin D3 5, 000, 000 IU, Vitamin E 5,050 IU, Vitamin B2 mg 4,750, Vitamin B6mg 2,750, Vitamin B12 mcg 11, 750, Vitamin K3 mg 4,850, CAL PAN mg 5,750, Niacinamide mg 16, 500, Vitamin C 10, 000 mg, IRON 5,250 mg, MANGANESE 12, 760 mg, COPPER 13, 250 mg, ZINC 13, 250 mg, SODIUM CHLORIDE 48, 750

…Methodology

- The five diets were randomly allocated in triplicates to 20L tanks each stocked with 14 tilapia juveniles with an average weight of 2.4±0.048 g
- The juveniles were fed twice a day at 0900 and 1700 hrs according to feeding response but not exceeding 5% of body weight for eight weeks

…Methodology

Experiment Units

…Methodology

- Proximate analysis was done using methods described by AOAC, (2005).
- Body weight and feed intake were measured weekly and used to compute
  - Growth
  - Feed Utilization
  - Cost Effectiveness
- Data were analysed using one-way ANOVA at significant level of 5%

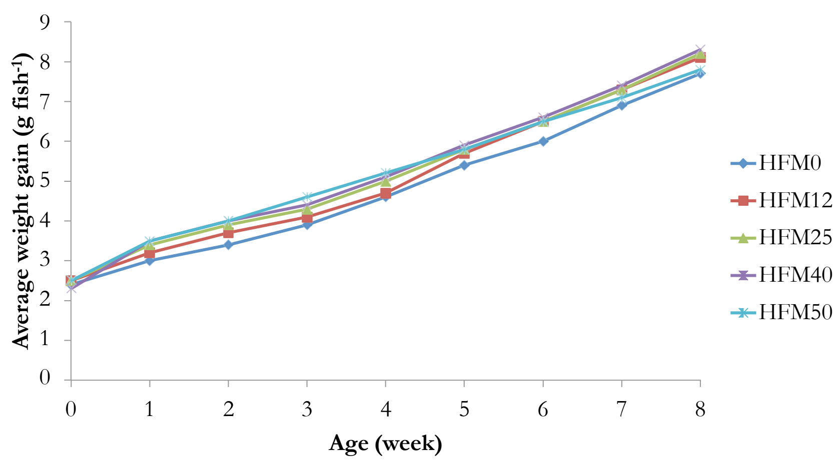
Results

Proximate Composition of Feedstuffs Used in Formulation (g/100g)

Items	Ingredients				
	HFM	FM	MM	WM	CSM
Dry matter	97.52	98.96	88.01	96.9	97.50
Crude Protein	48.55	69.20	10.5	11.74	41.60
Ether Extract	19.07	10.28	3.60	1.80	8.5
Crude Fibre	5.71	1.0	2.3	1.55	14.37
Ash	11.13	22.76	1.30	1.91	6.70

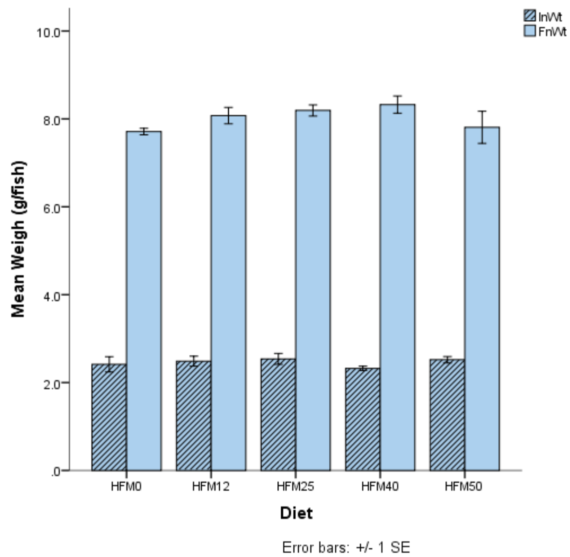
Results

Growth - AWG



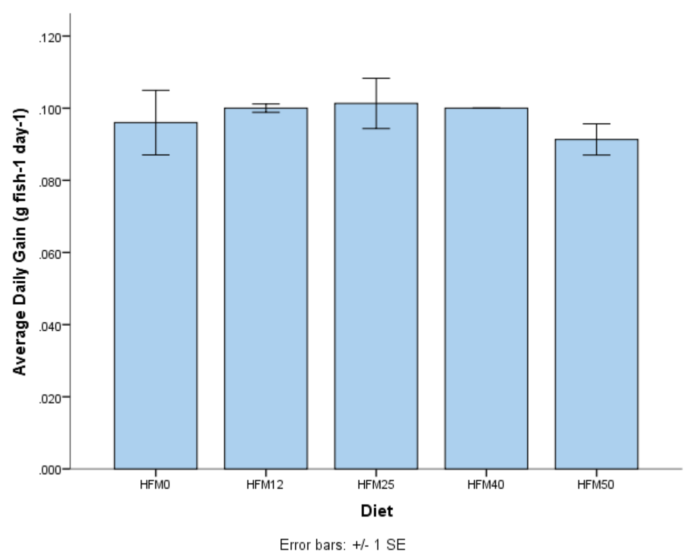
…Results

Growth – Initial and Final Weights



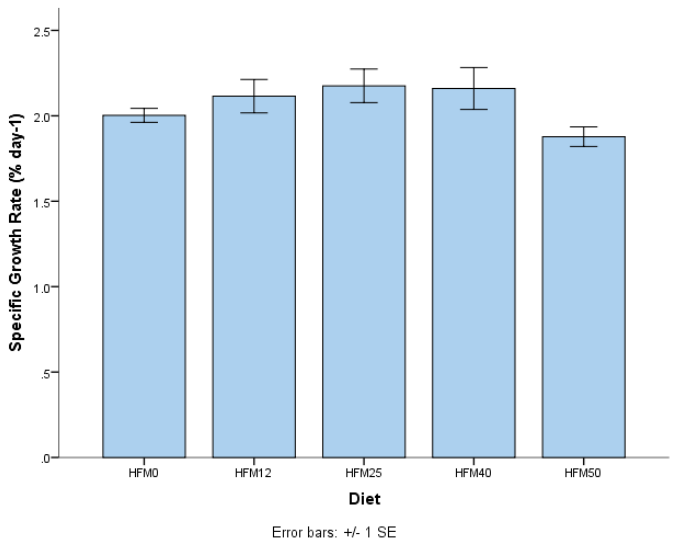
…Results

Growth - ADG



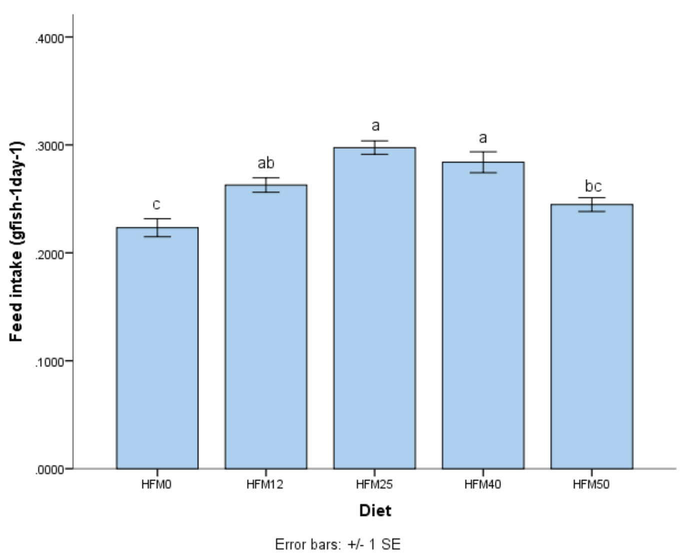
…Results

Growth - SGR



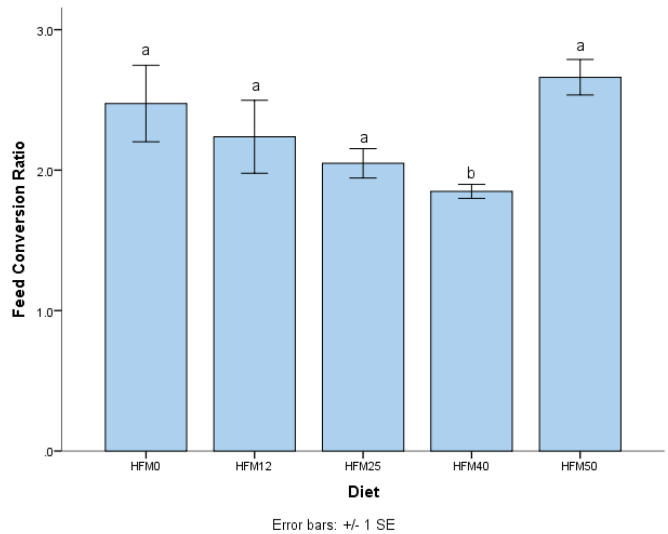
…Results

Feed Utilization – FI



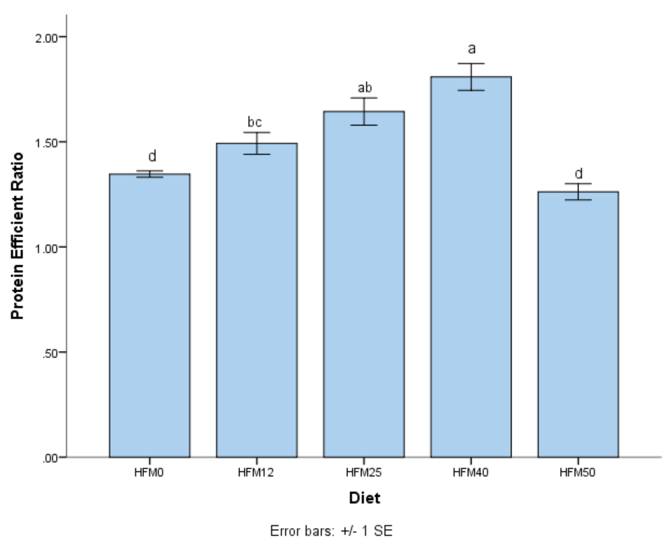
…Results

Feed Utilization - FCR



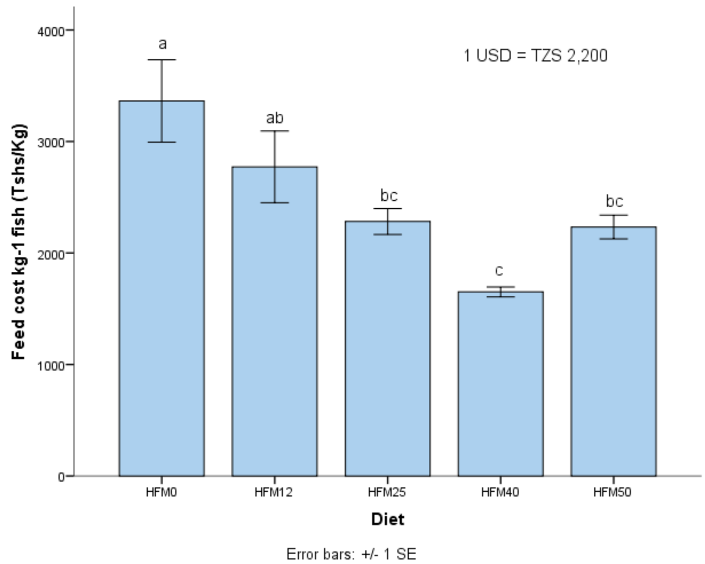
…Results

Feed Utilization - PER



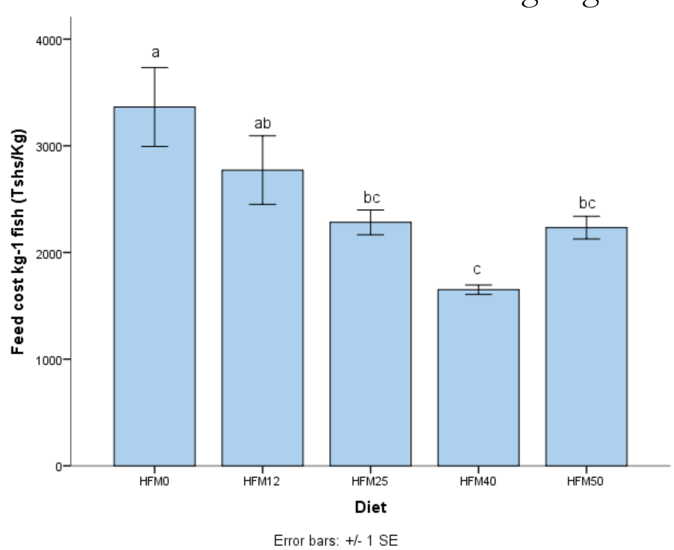
…Results

Cost Effectiveness - Price of Feed



…Results

Cost Effectiveness – Cost of Producing 1kg of Fish



Conclusion

- Conclusion
  - HFM can be included at 40% in practical Nile tilapia diets without compromising biological and economical performance
- Further studies
  - On-farm validation trials
  - Explore effect of different culture conditions on nutrient content of the HFM

Funding for this research was provided by the

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

Efficacy of common carp Cyprinus carpio testis enducing sex reversal of Nile tilapia Oreochromis niloticus

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Sex reversal of Nile tilapia (*Oreochromis niloticus*) using 17α-methyl testosterone is the most commonly used method. An experiment was carried out to explore the possibility of using common carp (*Cyprinus carpio*) testis as natural androgen source as an alternative for sex reversal of Nile tilapia fry. Six diets containing different proportions of dried common carp testis (CCT) were fed to sexually undifferentiated fry in aquaria for 25, 30 and 35 days. Feed types included 0% (Control), 50%, 65%, 80%, 95% and 100% dried CCT mixed with fish meal. After treatment, fish were transferred to nylon hapas suspended in an outdoor concrete tank and fed with normal diet until they reached 160 days of age.

Feeding CCT to Nile tilapia fry during the critical period of sex differentiation increased the fraction of male fish in a dose-dependent manner (Table 1). The highest proportion of males was 95.8±4.2% grown on the diet of 100% CCT for 30-35 days and lowest proportion was 62.5±7.2% on the diet with 50% CCT fed for 25-30 days. There were significant differences in male proportion with different diets but the differences in male proportion over different times of exposure were not significant. This experiment clearly demonstrates that common carp testis can efficiently masculinize Nile tilapia fry when fed for at least 30 days after hatching. However, it suggests a need for further study on 100% CCT feed and duration of feeding.

TABLE 1. Effect of CCT dosage and treatment duration on proportion of male of Nile tilapia (Mean±SE). Mean values with different superscript letters within column and within row are significantly different ($p<0.05$)

Feed type (CCT%)	Treatment duration (days)			Mean
	25	30	35	
0 (Control)	50.0±0.0	54.2±4.2	54.2±4.2	52.8±1.4^{c}
50	62.5±7.2	62.5±7.2	75.4±4.0	66.8±4.3^{b}
65	68.8±3.6	75.0±7.2	72.6±8.3	72.1±1.8^{b}
80	62.5±7.2	69.6±10.9	79.2±4.2	70.4±4.8^{b}
95	83.3±4.2	91.7±4.2	90.5±4.8	88.5±2.6^{a}
100	87.5±0.0	95.8±4.2	95.8±4.2	93.1±2.8^{a}
Mean (Excluding Control)	72.9±5.3^{a}	78.9±6.4^{a}	82.7±4.5^{a}	

A F U

EFFICACY OF COMMON CARP *Cyprinus carpio* TESTIS ENDUCING SEX REVERSAL OF NILE TILAPIA *Oreochromis niloticus*

Rahul Ranjan, Narayan P. Pandit*, Nabin B. Khanal, Madhav K. Shrestha, and James S. Diana

Department of Aquaculture and Fisheries
Agriculture and Forestry University, Nepal

Introduction

- Sex reversal of Nile tilapia (*Oreochromis niloticus*) using 17α-methyl testosterone (MT) is the most commonly used method.
- There is concern about the residual effect of MT on human health and environment.
- It is not easily available and more costly in developing countries.
- There is a need of exploring alternative natural androgen sources.
- Use of animal testis as a source of natural androgen might be an alternative.

- Testis is a good source of androgen.

- Bull testis (Phelps et al., 1996), hog testis (Mayer et al., 2008), and ram testis (Haylor and Pascual, 1991)

- Fish testis is more suitable for sex reversal in tilapia

- Common carp *(Cyprinus carpio)*
  - Early maturation
  - Higher gonadosomatic index
  - Two seasons of maturity
  - Easily available
  - Less costly than synthetic hormone

Common carp testis (CCT)

Objectives

- To assess the effectiveness of common carp testis (CCT) feeding on sex reversal of Nile tilapia.
- To assess the optimum feeding dose of CCT for maximum sex reversal in Nile tilapia.
- To find optimum feeding duration of CCT for maximum rate of sex reversal in Nile tilapia.

Materials and Methods

- 8-dah (days after hatching) mixed-sex Nile tilapia (GIFT strain) were used



- **Experimental setup and design**
  - Six levels of CCT diets were prepared.

1. 0 % CCT with fish meal
2. 50 % CCT with fish meal
3. 65 % CCT with fish meal
4. 80 % CCT with fish meal
5. 95 % CCT with fish meal
6. 100% CCT with fish meal

  - Fed for three different durations (25, 30 and 35 days)

- **Experimental design- RCBD**
  - Treatment duration- block
  - Feed types- factors

- 60 fry in each aquarium (1.5 ft x 1.0 ft x 1.5 ft)
- 90% water replaced in each 2 days
- Feeding (Twice a day; 10-11 am and 3-4 pm)
  - 20% initial week
  - Reduced 2.5% each week till 5%
  - Quantity fixed on basis of sampled fish
- After treatment, fish were transferred to nylon hapa and reared until 160 dah with normal feed.

Feed preparation

Collection of Common carp testes (CCT)
→ Sun dried for 1-3 days
→ Dried testes crushed into pieces and grinded
→ Fine particles sieved
→ Mixed in required amount with fish meal powder

Fresh CCT for drying

Dried CCT

CCT Powder

Post treatment phase

- After treatment, fry were transferred to nylon happa (50 cm x 50 cm x 100 cm) and reared until 160 dah
- Feeding- 5% of body weight with 28% CP feed
- Fortnightly sampling
- 50% water changed weekly

Feeding in hapa

Sex differentiation

- Gonad observation
  - All fish taken out
  - Dissected
  - Gonad observed
- Determined with naked eyes

- Confirmed using staining material
  - Acetocaramine (0.5 g caramine in 100 mL of 45% acetone)

Results and Discussion

Sex reversal

- Sex reversal towards male was based on dose dependent manner

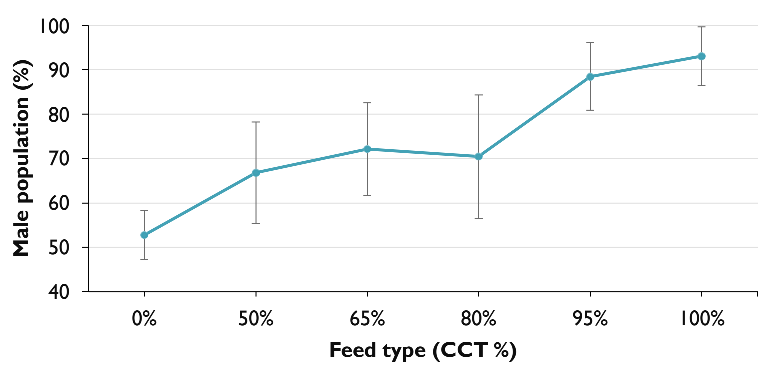


Figure: Average male population with different doses of CCT

Table: Effect of CCT dosage and treatment duration on proportion of male of Nile tilapia (Mean±SE).

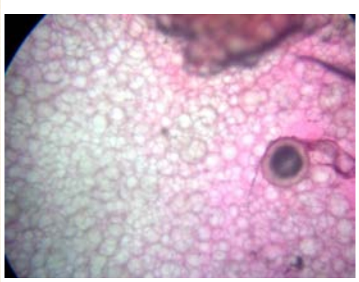
Feed type (CCT %)	Treatment duration (days)			Mean
	25	30	35	
0 (Control)	50.0±0.0	54.2±4.2	54.2±4.2	52.8±1.4^{c}
50	62.5±7.2	62.5±7.2	75.4±4.0	66.8±4.3^{b}
65	68.8±3.6	75.0±7.2	72.6±8.3	72.1±1.8^{b}
80	62.5±7.2	69.6±10.9	79.2±4.2	70.4±4.8^{b}
95	83.3±4.2	91.7±4.2	90.5±4.8	88.5±2.6^{a}
100	87.5±0.0	95.8±4.2	95.8±4.2	93.1±2.8^{a}
Mean (Excluding Control)	72.9±5.3^{a}	78.9±6.4^{a}	82.7±4.5^{a}	

Mean values with different superscript letters within column and within row are significantly different ($p<0.05$)

Gonadal structure

Female

Male



Female gonad under 100x

Male gonad under 100x

Growth during treatment phase

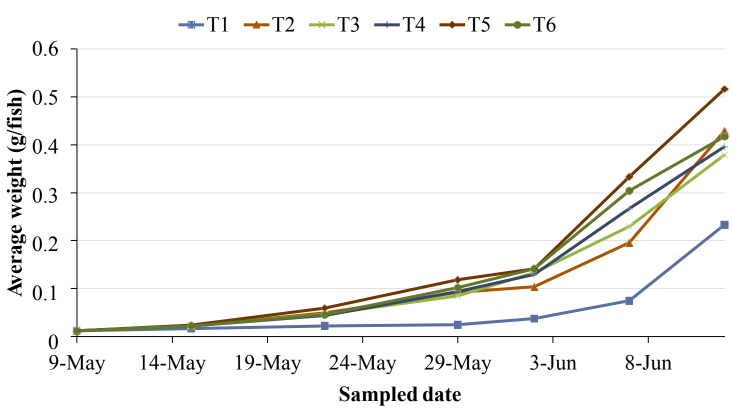


Figure: Growth trend of fish during sex reversal phase (35 days)

Table 7: Growth parameters of fry during treatment phase after 35 days

Treatment (CCT %)	Survival (%)	DWG (mg/ fish/day)	SGR (%/day)
0 (Control)	90.00±4.41[a]	6.33±0.31[c]	8.55±0.14[c]
50	60.00±14.81[b]	11.93±0.78[ab]	10.29±0.19[ab]
65	57.78±10.18[b]	10.50±0.60[b]	9.94±0.16[b]
80	62.78±13.47[b]	10.98±1.55[b]	10.01±0.43[b]
95	65.00±13.64[b]	14.43±0.43[a]	10.83±0.08[a]
100	61.67±7.64[b]	11.57±1.14[ab]	10.19±0.27[ab]

Mean values with different superscript letters within column and within row are significantly different ($p<0.05$)

- Growth difference may be due to higher crude protein in CCT compared to fish meal.
  - Higher dietary protein
  - Increased amount of hormone in diet
  - Lower density

Water quality during treatment phase

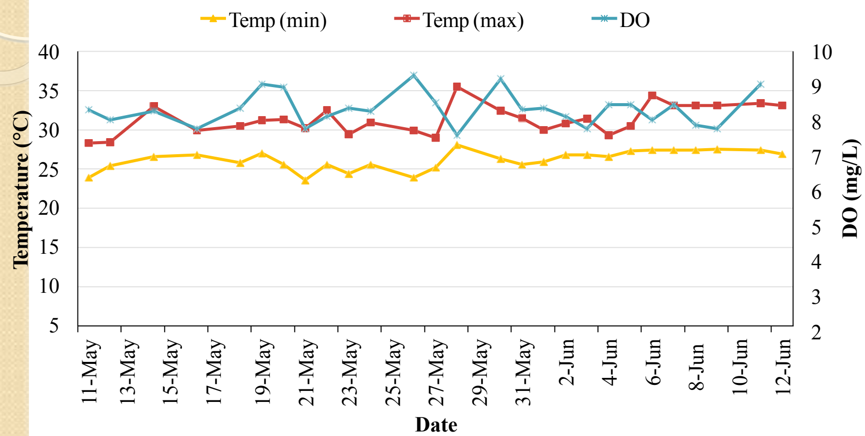


Figure 13: Min- Max temperature and DO in aquarium during sex reversal phase

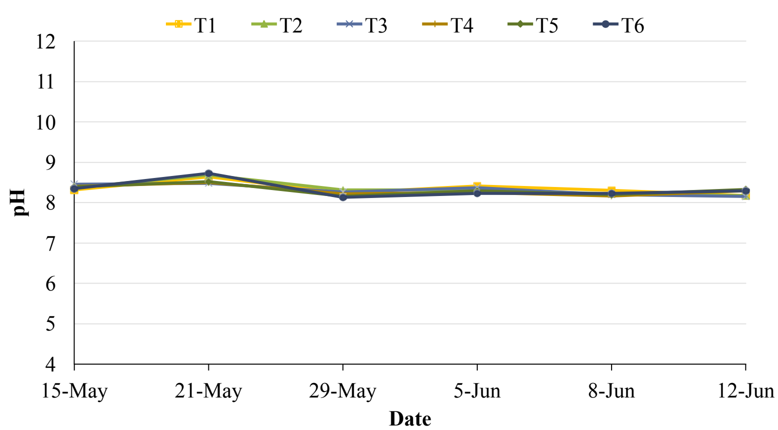


Figure 14: pH in aquarium during sex reversal phase

Conclusion

- 100% CCT fed for 30-35 days produce significantly higher (95.83±7.22%) male population.
- Male population increased with increased CCT dose
- Increased male population with increased treatment duration

Recommendations for further study

- Study on androgens present in CCT.
- Development of processing method.
- Histological, Immunohistological and steroid hormone profile of sex changed fish.
- Develop a methodology for extracting hormone from testis.

Funding for this research was provided by the

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

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Thank You

Assessment of value chain of farmed Nile tilapia *Oreochromis* niloticus in costal and lake zones of Tanzania

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In Tanzania Fish farming is currently being promoted as an option for rural development as it provides an important opportunity for reducing poverty and protein malnutrition of the rural poor people. Furthermore, fish farming is emphasized as an alternative to capture fisheries due to decline of wild fish from natural water bodies. Pond culture of Nile tilapia (*Oreochromis niloticus*) is given first priority due to better characteristics of the Nile tilapia, which include fast growth, efficiency conversion of food, high fecundity, tolerance to a wide range of environmental conditions and good meat quality. Value chain analysis is a prerequisite for poverty alleviation as it contributes to overall improvement of the systems from production through to the final consumers. This study was conducted in four regions of Tanzania (Dar es Salaam, Coast, Mwanza and Geita) to assess the value chain of pond cultured Nile tilapia. The study aimed at determining and mapping actors and identifying constraints and opportunities of various actors in the value chain.

The study involved 113 fish farmers, 16 input suppliers, 74 fish marketers/retailers, 16 fish distributors/wholesalers and 41 restaurant owners/managers. The value chain actors for farmed Nile tilapia included input suppliers, fish farmers, fish traders and fish consumers. The input suppliers were private individuals (12.5%), farmers' groups (25%) and government institutions (62.5%) and supplied fingerlings, concentrate feeds, information and training on fish farming to farmers. The fish farmers owned 2.3 ± 0.3 ponds (mean ± se) with average size of 598.3 ± 56.4. All fish farmers cultured Nile tilapia and a few (23%) of them cultured African catfish. Average (± se) Nile tilapia yield was 4,928.4 ± 427.4 kg/ha/year and 68.1% of the fish produced were sold, mainly to retailers (26.5%), neighbour consumers (21.2%) and distributors (17.7%). For most farmers (85.8%) price of fish was based on market price. However, the selling price was sometimes negotiable. The Fish traders included retailers, wholesalers, restaurant operators and food vendors. Fish retailers bought fresh fish, mainly Nile tilapia, not only from fish farmers but also from fishermen and they sold to distributors/wholesalers, restaurants, food vendors and consumers. Before selling the fish, they added value by washing, dressing, frying, smoking and sun drying. Wholesalers sold fish to other traders, consumers and restaurants. Restaurants sold cooked or fried fish to consumers. For all traders the price of fish was based on market price and cost plus pricing. Constraints for fish farmers included shortage of water for fish ponds, high costs of inputs, lack of proper knowledge on fish farming, shortage of fish feeds, low price of fish, slow growth of cultured fish and lack of reliable source of fingerlings. Problems encountered by fish traders included low capital, inadequate fish supply, lack of storage facilities and buying spoiled fish. Lack of contractual arrangement between input suppliers and fish farmers and fish farmers and fish traders was identified as the weakness among the various actors in the value chain. Opportunities for fish farmers included readily available markets for Nile tilapia in the villages and towns. For traders opportunities included high demand for Nile tilapia, availability of tenders in hotels and rising income for the majority of the people and increase of the middle class group in the country.

ASSESSMENT OF VALUE CHAIN OF FARMED NILE TILAPIA (*Oreochromis nilo-cus*) IN COASTAL AND LAKE ZONES OF TANZANIA

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Sokoine University of Agriculture, Morogoro, Tanzania.

Introduc>on

- In Tanzania it is es>mated that 28.2% of the popula>on is poor, with monthly consump>on per adult equivalent below the basic needs poverty line, and 9.7% lives in extreme poverty, below the food poverty line.
- Over 80% of the poor and the extreme poor i live in the rural areas.
- More than half of the rural poor depend on subsistence agriculture for their livelihoods.

Introduc>on

- In Tanzania Fish farming is being promoted as a means for reducing poverty and protein malnutri>on of the rural poor people.
- Fish farming is emphasized as an alterna>ve to capture fisheries due to decline of wild fish from natural water bodies.
- Fish produc>on from aquaculture is es>mated to be 2,676.7 metric tones, Nile >lapia (*Oreochromis nilo-cus*) accounts for 79.6% (MLFD, 2014)

- Nile >lapia (*Oreochromis nilo-cus*) is a good fish for resource poor farmers because it is easy to raise, fast growing and tasty, able to eat many types of foods, highly tolerant to diseases, able to reproduce easily under cap>vity and can tolerate poor water quality condi>ons.
- The demand for >lapia both for domes>c consump>on and exports is high and increasing, but produc>on from natural water bodies has shown a declining pa\ern due to overfishing.

- Tilapia produc>on from aquaculture is low and s>ll at subsistence level.
- There is a need to increase the produc>vity of cultured Nile >lapia to meet the demands of the growing human popula>on and foreign markets.
- Value chain analysis provides informa>on needed for developing interven>ons, designing appropriate development programmes and policies to improve produc>vity and support market par>cipa>on of small–scale farmers.

- Value chain analysis involves mapping the actors par>cipa>ng in the produc>on, characteris>cs of actors, profits and costs structures, flow of goods throughout the chain, the des>na>on and volumes of domes>c and foreign sales, the distribu>on of benefits to actors in the chain and the role of upgrading and governance within the chain.

- In Tanzania li\le is known about the value chain of cultured Nile Tilapia, this makes the government to put li\le effort to promote fish farming for poverty allevia>on.

Objec>ve

- This study aimed at determining

–the roles of various actors in the value chain of Nile >lapia,

–the distribu>on of benefits among the actors in the chain,

– value addi>on along the chain,

– the role of the governance in the chain and

- Iden>fying constraints and opportuni>es for improvement along the chain.

Materials and Methods

- The study was carried out in Geita, Mwanza, Coast and Dar es Salaam regions.
- Purposive sampling was done to select the district with high number of fish farmers.

- In Geita region the study was conducted in Geita and Chato dsitricts
- In Mwanza region it as done in Ilelemela, Nyamagana, Misungwi and Sengerema districts.
- In Coast region it was done in Kibaha and Bagamoyo districts.
- In Dar es Salaam region it was done in Kinondoni, Ilala and Temeke districts.

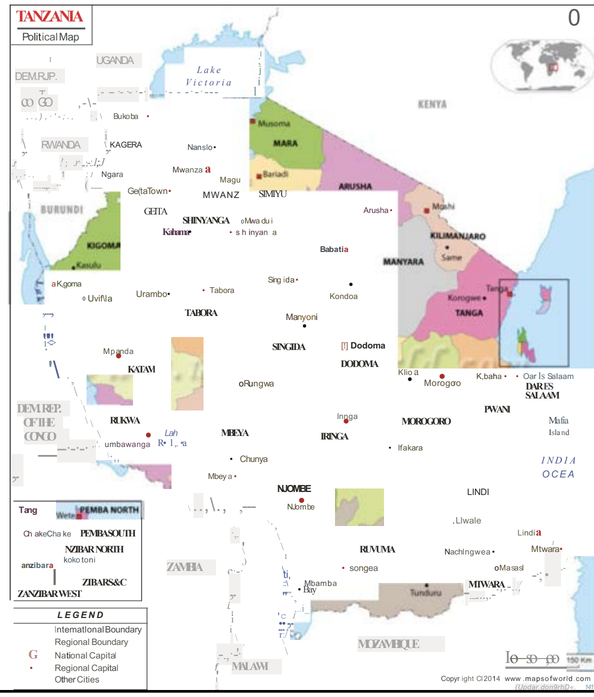


Table 1: Number of respondents for each category of value chain actors

Category	Geita	Mwanza	Coast	DSM	Total
Fish farmers	32	28	30	23	113
Input supplier s	2	4	6	4	16
Traders	30	–	24	20	74
Distributors	–	6	4	6	16
Restaurants	14	7	10	10	16

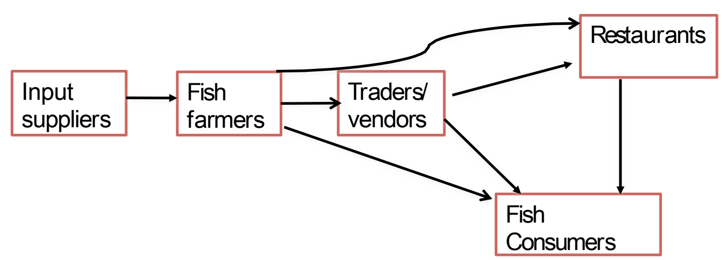
- During the survey structured ques>onnaires were administered to individual fish farmers, input suppliers, traders and distributors/wholesalers.

- For fish farmers informa>on was collected on households' socio–economic characteris>cs, number and size of ponds, fish species cultured, fish produc>on yield, inputs sources and costs, propor>on of harvested fish consumed at home and sold to consumers/markets, income obtained from fish, marke>ng of fish, main customers, produc>on constraints and opportuni>es.

- For input suppliers informa>on was collected on type of organiza>on, type of input supplied, price determina>on and mode of payment and problems faced.
- For fish traders, wholesalers and restaurant operators informa>on was collected on households' socio–economic characteris>cs, type of business, fish species sold, source of fish, value addi>on ac>vi>es done, customers, price determina>on and mode of payment, main compe>tors, services received, problems faced and available opportuni>es.

RESULTS

Value chain of pond cultured Nile tilapia



Input suppliers

- Private individuals , farmers' groups and government institutions .
- Supplied fingerlings, concentrate feeds , information on fish production and training on fish farming .

Fish farmers

- Owned 2 ponds with mean size of 598 m^2.
- Cultured Nile tilapia mainly under monoculture system

Fish traders/ vendors

- Didn't provide any assistance to farmers
- Add value by cleaning, dressing, smoking, frying and sun drying

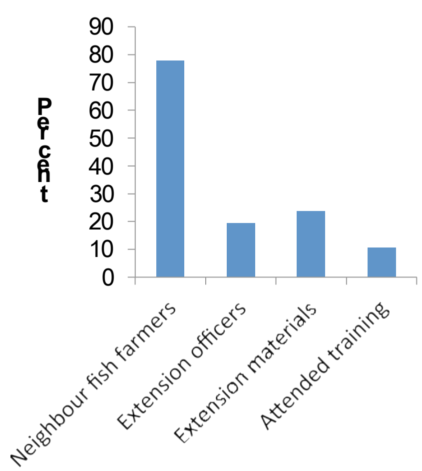
Restaurants

- Sold cooked or fried tilapia to consumers and no restaurant sold African catfish
- Add value by cleaning, dressing, frying and drying

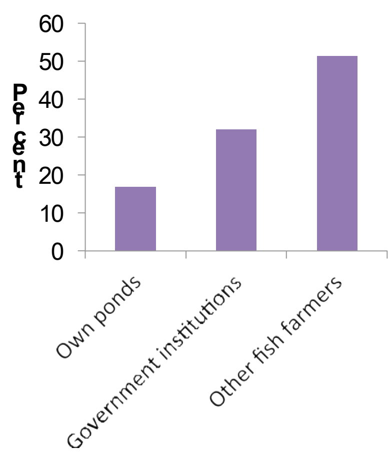
Table 2: Socio-economic characteristics of value chain actors

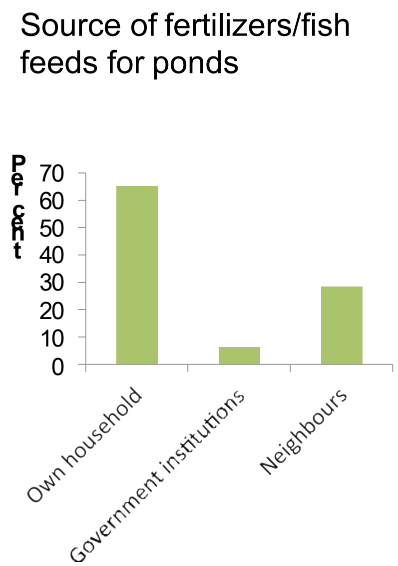
Variable		Small-- -scale farmers	Small-- -scale traders	Restaurant owners
Sex	Male (%)	90.3	89.2	63.4
	Female (%)	9.7	10.8	36.8
Age (years)		40.7		35.4
Marital status	Single (%)	7.1	40.5	26.8
	Married (%)	92.0	56.8	70.7
	Divorced/ widow (%)	0.9	2.7	2.4
Educa>on level	Informal (%)	8.0	2.7	14.6
	Primary (%)	62.8	73.0	34.1
	Secondary (%)	24.8	24.3	48.8
	University (%)	4.4	0	2.4
Species cultured/ sold	Tilapia (%)	100	100	100
	Cahish (%)	23.0	–	–

Source of fish farming knowledge for farmers



Source of fingerlings for farmers





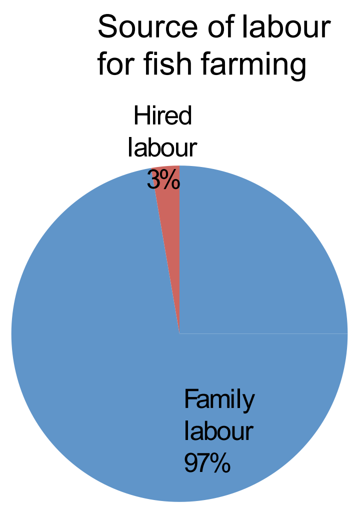


Table 3: Yield and marketing of Nile tilapia produced by fish farmers

Variable	Region				
	Geita	Mwanza	Coast	DSM	Overall
Fish yield (mean ± se) kg/ha/year)	4,706.5	5,006.3	4,088.8	5,750.0	4,928.4
Proportion of fish consumed at home (%)	37.0	36.6	27.9	24.6	32.0
Proportion of fish sold (%)	63.0	63.4	72.1	75.4	68.0
Place where farmers sold fish					
Farm gate (%)	53.1	57.1	73.3	82.6	65.5
Market (%)	12.5	17.9	0.0	0.0	8.0
Customer delivery (%)	34.4	25.0	26.7	17.4	26.5

Table 4: Customers for fish cultured by small-scale famers

Variable	Region				
	Geita	Mwanza	Coast	DSM	Overall
Proportion of fish sold to neighbour consumers (%)	42.3	52.0	63.4	48.0	51.8
Proportion of fish sold to traders/ vendors (%)	51.9	46.8	21.2	23.8	34.5
Proportion of fish sold to restaurants (%)	5.8	1.2	15.3	28.2	13.8

Table 5: Suppliers and customers of fish sold by traders and restaurants

		Traders	Restaurants
Suppliers of >lapia	Fish farmers	18.9	12.5
	Fishermen	81.1	–
	Fish traders	–	77.5
	Shop	–	10.0
Customers			
	Consumers	86.5	100
	Restaurants	70.3	–
Contractual arrangements			
	Yes	13.5	17.9
	No	86.5	82.1

Table 6: Payment method and price determination mechanism

		Farmers	Traders	Restaurants
Payment method	Cash	100	100	100
Pricing system				
	Market price	85.4	81.1	65.9
	Cost plus	42.2	51.4	65.9
	Mark up	6.2	0	17.1
	Targeted return	2.1	13.5	2.4
	Profit max.	0	0	12.2
	Break even analysis	0	0	0

Problems facing different actors in the value chain

- The main constraints affec>ng fish farming were shortage of water supply to fish ponds, high cost of inputs, lack of proper knowledge on fish farming, lack of good quality fish feeds, low price of fish, slow growth of the cultured species and thej of fish.
- The problems which affected fish traders were lack of appropriate infrastructure for fish handling and storage, low capital and inadequate supply of fish.
- The constraints for restaurants included fish scarcity, low capital and unfaithful suppliers who supply spoiled fish.

Weakness for the value chain

- The main weaknesses in the value chain were:

i. Lack of contractual arrangement between input suppliers and fish farmers, fish farmers and fish traders and fish traders and consumers.

ii. Fish farmers considered fish farming as a secondary economic ac>vity and, hence, invested li\le in terms of >me, labour and money.

iii. Most value chain actors depended on self financing even though they have low capital.

Opportuni>es for various actors in the value chain

- Opportuni>es for fish farmers included readily available markets for fish in the villages and nearby towns.
- Opportuni>es for traders included high demand for Nile >lapia due to availability of tenders in hotels and increase of the middle class group in the country

Funding for this research was provided by the

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Performance evaluation of blended virgin coconut oil on growth, feed utilization, body composition, body fatty acids, plasma metabolites of Nile tilapia *Oreochromis* niloticus and resistance to *Streptococcus iniae* challenge

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The use of alternative lipids as a means to spare protein activity in Nile tilapia (*O. niloticus*) feeds is becoming increasingly expensive due to the inadequacy and overexploitation and rising cost of fish oil (FO). However, the effect of coconut oil (CO) as alternative to FO on growth performance, feed utilization efficiency, plasma metabolites, and lipids in *O. niloticus* remain poorly understood.

In the present study, five isolipidic experimental diets (32% crude protein) were formulated to contain fish oil (A) and virgin coconut oil (E) as sole lipids or blends of FO+VCO in ratio of 75:25% (B), 50:50% (C) and 25:75% (D) respectively. Triplicate groups of fish were fed one of five diets to apparent satiation, twice daily for 8 weeks. No significant differences ($P<0.05$) were observed in growth performance, protein efficiency ratio and weight gain. However, it was observed that, fish fed diet C (FO 50:50 VCO) exhibited the best performance among all parameters measured, while feed intake and final weight was the highest in fish fed diet E. No significance ($P\geq0.05$) was observed among biochemical parameters. Significant effects of dietary fatty acid profile reflected in those fed the diets in whole body, muscle and liver C12:0 and C14:0. However, eiccosapentaenoic (EPA, 20:5n-3) and docosahexaenoic (DHA, 22:6n-3) were significantly different ($P\geq0.05$) compared to their respective diets while liver n-3:n-6 ratio significantly increased and recording low levels in whole body and muscle. Plasma metabolites indicators and bacteria challenge among treatments were not altered by the inclusion of the alternative lipid. These results suggest that the inclusion of elevated levels of VCO in diets enhance growth and are viable for feeding *O. niloticus*.

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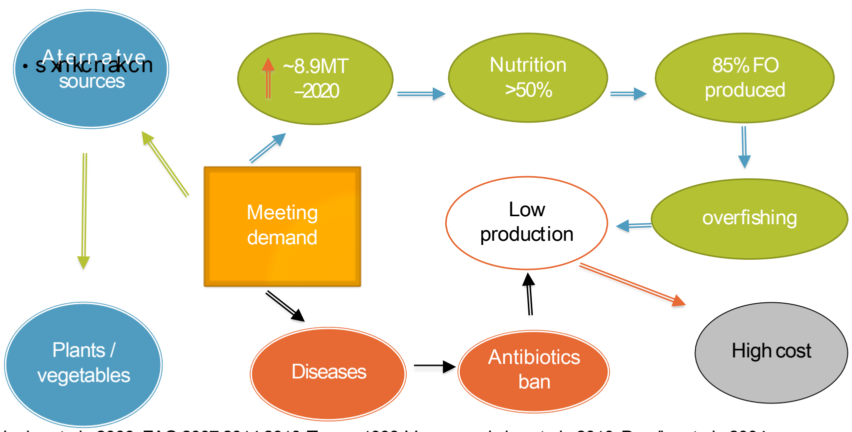
Performance evaluation of blended coconut oil and fish oil on growth performance and response to *Streptococcus iniae* challenge on Nile Tilapia (*Oreochromis niloticus*)

Andrews Apraku, Xiangjun Leng, Emmanuel J. Rupia, Christian L. Ayisi
Shanghai Ocean University
Speaker: Liping Liu

上海海洋大學

Contents

Introduction



Naylor et al., 2000; FAO,2007,2014,2010; Tacon, 1993, Venega–calerion et al., 2010; De–silva et al., 2004

Coconut oil

- Accounts for 20% of world vegetable oil –[CRB Fundamentals, 2008]
- High SFA'S,92%; Low MSFA and PUFA of 6% and 2% respectively– [Applewhite, 1994]
- C10:0 and C18:0 act as energetic substrate – [Benevenga, 1989; Alice et al., 2006].
- Higher lauric acid– antibacterial, antiprotozoal and antiviral properties – [Ogbolu et al., 2007]
- High resistance to oxidative reaction
- Stable under warm temperatures (stable) – [Alice et al., 2006]

Coconut oil

- C12 is absorbed easily –[Olsen et al., 1993]
- Improve LC-PUFA retention and restoration in feeds – [Trusheuski et al., 2008, 2009]
- It gives diet flavor – [Bozzolo et al., 1993]
- price: 29 cents per pounds in 2006 – [CRB Fundamentals, 2008]

Year	2005--06	2006--07	2007--8	2008--09	2009--10	2010--11
Production/ Million tonnes	5.91	5.42	5.79	5.62	6.60	6.24

–[US Department of Agriculture, 2011]

Objectives

- Evaluate the effect on dietary levels on growth performance and feed utilization
- Evaluate the effects of dietary lipid levels on body composition and fatty acid profile of Nile tilapia, *Oreochromis niloticus*
- Evaluate the effects of dietary lipid levels on blood metabolites of Nile tilapia, *Oreochromis niloticus*

Materials and methods

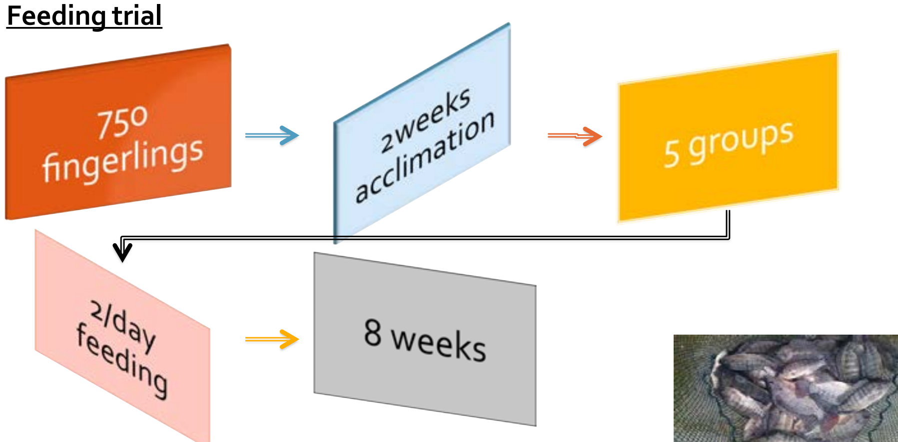
Table 1: Proximate composition of ingredients (%DM) in experimental diets with different added lipid sources.

Fish meal	10.00	10.00	10.00	10.00	10.00
Soybean meal	20.00	20.00	20.00	20.00	20.00
Wheat bran	20.00	20.00	20.00	20.00	20.00
Rape seed meal	24.26	24.26	24.26	24.26	24.26
Wheat Middling	20.00	20.00	20.00	20.00	20.00
Fish oil (FO)	**3.00**	**2.25**	**1.50**	**0.75**	**0.00**
Virgin coconut oil (VCO)	**0.00**	**0.75**	**1.50**	**2.25**	**3.00**
Vitamin and Mineral mix	0.65	0.65	0.65	0.65	0.65
Vitamin C	0.05	0.05	0.05	0.05	0.05
Choline Chloride	0.50	0.50	0.50	0.50	0.50
Inositol	0.04	0.04	0.04	0.04	0.04
$Ca(H_2PO_4)$	1.50	1.50	1.50	1.50	1.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

FO/VCO=100%(Diet A), 3:1 (Diet B), 1:1 (Diet C), 1:3(Diet D), 0%(Diet E).

Materials and methods

Feeding trial



Materials and methods

Measurements

- Weight and length: 15 fish/15th day
- Termination point: All experimental fish
- Feed: amount fed to fish calculated daily
- Ammonia and nitrite measured as well on weekly basis -[APHA, 1998]
- Dissolved oxygen (DO) concentration, pH, and water temperature monitored on daily basis with appropriate instrument and methods.

Materials and methods

Sampling and analytical methods

Whole body proximate analysis

- 15 fish –initial
- 15fish / group
- Moisture, Lipid, Ash, protein

[AOAC, 1995]

Plasma metabolites

- Blood serum
- Cholesterol, TP, TG (BS 2000)

Fatty acid

- LIVER, MUSCLE
- WHOLE BODY, FEED

[Folch et al., 1957]

Materials and methods

Bacteria challenge

S. iniae (ARS 98–60)

0.1mL of 1×10^6 CFU/mL

IP / 30 fish/group

16 days monitoring

[Yildrim et al., 2003]

Data analysis and statistics

- SGR (%) = (ln final weight – ln initial weight / number of days *100
- WG (%) = (final body weight – initial body weight / initial body weight) * 100
- K = Body weight (g) / total length $(cm)^3$*100
- FCR = Feed intake (g) / Weight gain (g)
- FI = Total feed consumed (g) during the 56 days trial.
- SR = Total number of fish stocked / Total number at the end of the feeding trial

Data analysis and statistics

- FCR = 100 ((ln initial fat content of fish – ln final fat content of fish)/T
- PER = Weight gain (g) / Protein intake (g)
- HSI = Liver weight (g) / Whole body weight (g) * 100
- Data was analysed by one–way analysis of Variance (ANOVA) to test the effects of the five experimental diets.
- Statistical analysis was made using graph Pad prism 5.1 .
- All data were presented as mean ± SEM.

Results

Fatty acid (FA) composition (% total FA) of experimental diets

FATTY ACID(S)	Diet A	Diet B	Diet C	Diet D	Diet E
12:0	0.23±0.04^{a}	5.51±2.79^{ab}	14.87±0.41^{bc}	19.64±0.36^{c}	20.97±5.60^{c}
14:0	3.63±0.13^{a}	5.56±0.23^{ab}	6.84±0.04^{ab}	8.31±0.05^{b}	8.65±1.10^{b}
Total SFA's	21.90±8.12	25.64±4.54	38.01±2.70	49.37±1.51	53.17±9.37
18:1(n-9)	19.98±7.53	19.11±6.26	21.65±0.70	13.91±4.50	10.71±3.92
TOTAL	38.42±13.99	37.65±13.50	30.60±1.18	25.44±9.59	21.62±10.58
MUFAs					
18:2(n-6)	25.22±2.38	25.96±0.81	24.14±0.76	20.87±0.26	23.12±5.01
20:4(n-6)ARA	0.49±0.06^{a}	0.19±0.10^{ab}	0.16±0.08^{b}	0.11±0.03^{b}	0.04±0.02^{b}
Total n-6	25.73±2.45	26.15±0.91	24.34±0.86	20.98±0.29	23.16±5.03
18:3(n-3)	0.46±0.12^{a}	0.27±0.03^{ab}	0.27±0.06^{ab}	0.27±0.05^{ab}	0.11±0.05^{b}
20:5(n-3)EPA	4.18±0.40^{a}	3.56±0.07^{a}	2.40±0.05^{c}	1.57±0.05^{b}	0.85±0.01^{b}
22:6(n-3)DHA	7.35±0.81^{b}	5.22±0.17^{b}	3.35±0.07^{b}	1.87±0.07^{a}	0.87±0.06^{a}
Total n-3	13.25±1.87^{a}	10.19±0.75^{b}	6.45±0.22^{c}	3.98±0.18^{d}	1.98±0.16^{e}
Total PUFAs	39.13±4.37^{b}	36.46±1.72^{b}	30.92±1.09^{b}	25.07±0.48^{a}	25.21±5.20^{a}
Total LC-PUFAs	12.53±1.73^{a}	9.63±0.76^{b}	6.34±0.24^{c}	3.82±0.16^{d}	1.87±0.10^{e}
Total MC-PUFAs	26.45±2.60^{a}	26.71±0.90^{a}	24.45±0.84^{b}	21.14±0.31^{c}	23.27±5.19^{b}
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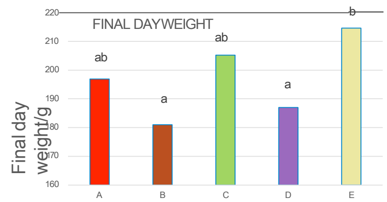
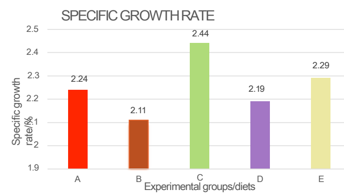
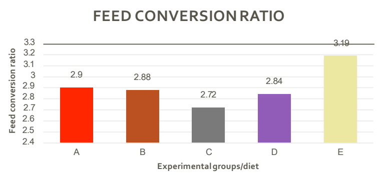
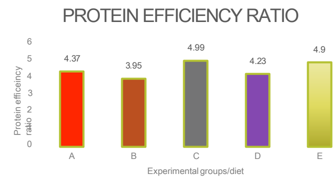
Results

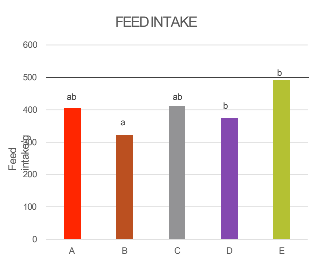


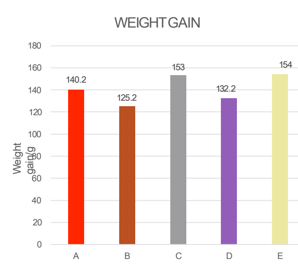






Results





Results

Major nutrient composition of moisture, crude lipid, protein and ash content of whole body and muscle of Nile tilapia fed different diets for 8 weeks

	Initial whole body	Diet A	Diet B	Diet C	Diet D	Diet E
		Final whole body				
Moisture	10.75±1.20	11.40±1.45	11.21±0.90	11.18±1.20	11.07±0.31	11.09±0.58
Protein	63.30±1.42	58.40±0.87	59.69±0.33	61.00±1.60	62.61±2.46	64.06±1.48
Lipid	7.04±0.32^{bc}	2.74±0.90^{a}	3.26±0.33^{a}	4.67±0.59^{ab}	7.44±0.36^{c}	6.62±0.15^{bc}
Ash	0.28±0.00^{d}	0.80±0.01^{a}	0.73±0.01^{b}	0.72±0.00^{b}	0.78±001^{ac}	0.72±0.01^{bc}
MUSCLE						
Moisture		10.45±0.15^{a}	10.52±0.86^{a}	10.42±0.48^{a}	10.69±0.18^{ab}	10.90±0.90^{b}
Protein		94.33±0.41^{a}	95.85±0.20^{ab}	96.47±0.32^{b}	95.63±0.60^{ab}	96.48±0.26^{b}
Lipid		2.22±0.22^{a}	1.77±0.18^{ab}	1.15±0.04^{bc}	1.07±0.17^{bc}	0.90±0.13^{c}
Ash		0.28±0.00^{ab}	0.26±0.00^{ab}	0.27±0.00^{ab}	0.25±0.02^{a}	0.29±0.00^{b}

Results

Fatty acid (%area) of **whole body of tilapia** fed diets of elevated VCO levels for 8 weeks

FATTY ACID(S)	Diet A	Diet B	Diet C	Diet D	Diet E
12:0	0.000±0.00^{c}	2.40±0.07^{b}	5.27±0.46^{b}	7.39±0.59^{a}	8.93±0.65^{a}
14:0	3.68±0.07^{a}	4.18±0.43^{a}	6.44±0.31^{c}	7.61±0.35^{b}	8.67±0.31^{b}
Total SFA's	38.59±0.46^{a}	39.64±0.83^{a}	44.61±1.62^{b}	46.14±1.87^{b}	48.61±1.74^{b}
18:1(n--9)	30.60±0.32^{a}	30.02±0.35^{ab}	28.79±0.73^{abc}	27.64±0.43^{c}	26.91±0.47^{bc}
TOTAL MUFAs	41.89±2.91^{b}	39.68±0.51^{b}	39.00±1.25^{b}	36.30±1.42^{a}	35.35±1.67^{a}
18:2(n--6)	16.11±0.39^{ab}	18.25±0.20^{a}	15.22±1.00^{ab}	16.40±0.90^{ab}	14.39±0.59^{b}
20:4(n--6)ARA	0.11±0.06	0.17±0.06	0.14±0.05	0.08±0.05	0.16±0.14
Total n-6	16.22±0.45	18.42±0.26	15.39±1.08	16.48±0.95	14.55±0.73
18:3(n--3)	0.27±0.12	0.12±0.02	0.19±0.06	0.18±0.04	0.11±0.09
20:5(n--3)EPA	0.13±0.10	0.10±0.02	0.12±0.08	0.18±0.05	0.13±0.05
22:6(n--3)DHA	2.03±0.06^{b}	1.28±0.03^{b}	0.94±0.03^{b}	0.50±0.06^{a}	0.40±0.03^{a}
Total n-3	3.17±0.55^{c}	2.18±0.32^{a}	1.66±0.11^{ab}	1.01±0.22^{b}	1.04±0.34^{b}
Total PUFAs	19.39±1.0^{a}	20.60±0.58^{a}	17.05±1.19^{b}	17.49±1.17^{b}	15.59±1.07^{c}
Total LC--PUFAs	2.91±0.39^{a}	1.96±0.23^{ab}	1.58±0.19^{ab}	0.85±0.19^{b}	0.99±0.33^{b}

Results

Fatty acid **composition of muscle** (% area) of tilapia fed different diets for 8 weeks

FATTY ACID(S)	Diet A	Diet B	Diet C	Diet D	Diet E
12:0	0.00±0.00^{a}	1.44±0.43^{ab}	2.81±0.05^{ab}	6.03±1.28^{bc}	7.61±1.86^{c}
14:0	2.48±0.14^{a}	2.70±0.19^{a}	3.97±0.37^{ab}	4.78±1.09^{ab}	6.26±1.11^{b}
Total SFA's	40.56±1.36^{a}	46.27±1.90^{ab}	52.33±1.46^{bc}	50.00±4.07^{bc}	53.20±4.80^{c}
18:1(n--9)	22.71±0.68^{ab}	22.00±0.28^{ab}	21.65±0.18^{ab}	23.24±0.77^{a}	20.93±0.25^{b}
TOTAL MUFAs	31.86±1.82^{abc}	29.15±0.61^{a}	29.06±0.85^{b}	30.11±1.69^{c}	27.99±0.62^{c}
18:2(n--6)	13.31±0.15^{ab}	14.81±0.71^{b}	10.92±0.14^{a}	13.90±0.60^{b}	13.24±0.70^{ab}
20:4(n--6)ARA	1.93±0.33	1.37±0.30	1.08±0.17	1.52±0.62	0.11±0.23
Total n-6	15.47±0.62	16.18±1.01	12.00±0.31	15.42±1.22	13.35±0.93
18:3(n--3)	0.15±0.06	0.18±0.13	0.16±0.09	0.55±0.14	0.37±0.03
20:5(n--3)EPA	0.06±0.06	0.02±0.02	0.03±0.02	0.06±0.03	0.08±0.01
22:5(n--3)	1.52±0.65^{b}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
22:6(n--3)DHA	9.02±0.14^{d}	6.53±0.23^{a}	5.04±0.69^{ab}	2.31±0.38^{c}	3.14±0.54^{bc}
Total n-3	12.37±1.34^{b}	8.05±0.61^{b}	6.55±1.01^{b}	3.42±0.82^{a}	4.42±0.70^{a}
Total PUFAs	27.84±1.96^{b}	24.23±1.62^{b}	18.55±1.32^{a}	18.84±2.04^{a}	17.77±1.63^{a}
Total LC--PUFAs	14.38±1.75^{b}	9.24±0.78^{b}	7.47±1.09^{b}	4.39±1.30^{a}	4.16±0.90^{a}
Total MC--PUFAs	13.46±0.21^{a}	14.99±0.84^{a}	11.08±0.23^{b}	14.45±0.74^{a}	13.61±0.73^{a}
n-3:n-6	0.70±2.16^{c}	0.50±0.60^{a}	0.55±3.26^{a}	0.22±0.67^{b}	0.33±0.75^{b}

Results

Liver fatty acid composition of *O. niloticus* fed elevated levels VCO for 8 weeks

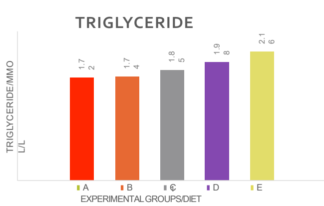
FATTY ACID(S)	Diet A	Diet B	Diet C	Diet D	Diet E
12:0	0.00±0.00^{a}	0.34±0.17^{a}	3.02±0.76^{b}	4.15±0.89^{bc}	6.30±0.21^{c}
14:0	3.32±0.24	4.59±0.15	6.05±0.10^{a}	6.64±0.28^{a}	8.32±0.08
Total SFA's	39.23±4.03^{b}	50.10±3.52^{b}	52.04±1.53^{a}	48.85±6.80^{b}	52.59±5.27^{a}
18:1(n--9)	27.41±0.29^{b}	31.38±1.72^{ab}	29.58±1.13^{ab}	33.08±0.92^{a}	26.52±0.74^{b}
TOTAL MUFAs	39.61±1.13^{ab}	40.84±2.89^{a}	37.421.95^{c}	40.65±2.00^{b}	33.39±2.29^{d}
18:2(n--6)	11.45±1.26	9.27±0.78	7.15±0.07	8.82±1.96	9.36±0.45
20:4(n--6)ARA	0.08±0.08	0.19±0.19	0.00±0.00	0.00±0.00	0.49±0.49
Total n-6	11.53±1.34	9.46±0.97	7.15±0.07	8.82±1.96	10.24±1.33
20:5(n--3)EPA	0.16±0.16^{a}	3.06±1.17^{b}	0.07±0.07^{a}	0.00±0.00^{a}	0.08±0.08^{a}
22:6(n--3)DHA	6.25±0.38^{c}	1.05±0.39^{b}	3.20±0.27^{a}	1.06±0.12^{b}	2.48±0.78^{ab}
Total n-3	8.49±1.26^{c}	5.17±1.61^{c}	3.67±0.55^{a}	1.60±0.12^{b}	2.88±1.18^{ab}
Total PUFAs	20.83±3.11^{a}	14.63±2.58^{c}	10.82±0.62^{b}	10.42±2.08^{ab}	13.12±2.51^{c}
Total LC--PUFAs	8.41±1.18^{c}	5.36±1.80^{c}	03.42±0.42^{a}	1.60±0.12^{b}	2.88±1.18^{ab}
Total MC--PUFAs	11.61±1.42^{c}	9.27±0.78^{b}	7.40±0.20^{a}	8.82±1.96^{ab}	9.36±0.45^{b}
n-3:n-6	0.74±0.94^{c}	0.55±1.66^{a}	0.51±7.86^{a}	0.18±0.06^{b}	0.28±0.89^{b}

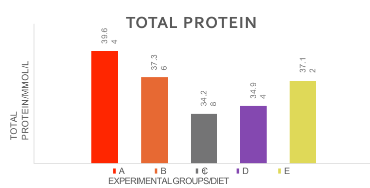
Results

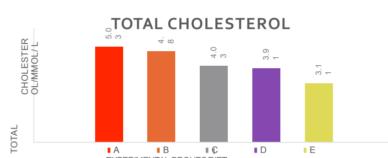
Plasma metabolites *O. niloticus* fed on elevated levels of VCO for 8 weeks

Parameters/Lipid sources	Diet A	Diet B	Diet C	Diet D	Diet E
HDL--Cholesterol	2.85±0.12[a]	2.04±0.30[b]	2.60±0.10[ab]	2.35±0.07[ab]	2.51±0.10[ab]
LDL--Cholesterol	0.43±0.03	0.32±0.06	0.27±0.02	0.38±0.04	0.51±0.09
HDL--C/LDL--C	6.63±4.00[a]	6.38±5.00[ab]	9.63±5.00[c]	6.18±1.75[ab]	4.92±1.11[b]

Results
Plasma Metabolites







Results

Mortality (%) of *O. niloticus* 16 day post *S. iniae* challenge

Lipid sources	Diet A	Diet B	Diet C	Diet D	Diet E
Mortality	53.33±0.67	40.0±2.31	33.33±1.33	46.67±1.76	26.67±1.76

Discussion

- >WG, FW and FI in VCO: (Ng et al., 2013; Aderolu & Akinremi, 2009;Pie et al., 2004.)
- Good growth performance: (Yildrim-Aksoy et al., 2007)
- MUFA's in VCO sparing protein for tissue growth: (Eckarstein et al., 2002)
- FA composition of fish depends on FA profile of diets: (Luo et al., 2004.)
- Varying differences in SFA's: (Trushenski et al., 2008; 2009.)

Discussion

- Significant TG: (Vegusdal et al., 2005; Yildrim-Aksoy et al., 2013.)
- <Plasma cholesterol: Agree- Richard et al., 2006.
- <LDL-C: Agree- Nevin & Rajamohan, 2004.
- Mortality in group A and C: Agree – Kiron et al., 1995
- >Survival in fish fed diet E: Agree – Ogbolu et al., 2007; Fracalossi & Lovell, 1994; Eckarstein et al., 2002; Manisha et al., 2011.

Conclusion

- VCO did not impair growth, feed utilization and body composition
- Diets were accepted indicating the suitability of lipid at 3% inclusions
- Diet E exhibited the best performance showing the importance of n-6 to freshwater fishes
- decrease in muscle lipid of fish fed increasing levels of VCO, and increase in the crude protein of whole body and the muscle. This indicates better utilization of protein for growth as evident in the results obtained for PER.
- Plasma metabolites were not impaired by alternative lipid
- VCO has potential to replace FO in diets for tilapia
- Recommended to countries which has high productions in CO to use as lipid fish diets.

Acknowledgement

- This study received financial support through the EU- FP7 project “Sustaining Ethical Aquaculture Trade” (SEAT),
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Inclusion of Nile tilapia Oreochromis niloticus and Sahar Tor putitora improves reporductivity in carp-polyculture system

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Carp polyculture is commonly practiced in Nepal but improving productivity of this aquaculture system is a major concern. An experiment was conducted at the Fisheries Development Center, Bhairahawa, Nepal in nine earthen ponds of 200 m^2 for 240 days (9 August 2014 to 9 May 2015). The experiment was conducted in a completely randomized design with three treatments in triplicate: a) Carps only or control (10000 fish/ha) (T_1); b) Carps (10000/ha) + tilapia (3000/ha) (T_2); and c) Carps (10000/ha) + tilapia (3000/ha) + sahar (1000/ha) (T_3). Silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) of mean stocking size 6.7, 3.8, 7.3, 3.1, 1.9 and 2.0 g, respectively were stocked in all ponds at the ratio of 3.5:1:2.5:0.5:1.5:1. The mean stocking size of Nile tilapia (*Oreochromis niloticus*) and sahar (*Tor putitora*) were 4.4 and 7.2 g, respectively. The ponds were fertilized weekly with urea and di-ammonium phosphate at 4 g N and 1 g P m^{-2} day^{-1}. Fish were fed once daily with locally made pelleted feed (1:1 rice bran and mustard oil cake; 20% CP) at 2% body weight. At harvest, the combined net fish yield was significantly higher in T_3 (3.93±0.15 $t \cdot ha^{-1} \cdot yr^{-1}$) compared to T_1 (3.05±0.26 $t \cdot ha^{-1} \cdot yr^{-1}$) whereas there was no significant difference between T_2 and T_3 (Table 1). There were no significant differences in survival and water quality among treatments. The gross profit margin was significantly higher in T_3 (2357.4±210.8 USD/ha) compared to T_1 (1299.5±315.9 USD/ha) without any significant difference between T_2 and T_3.

TABLE 1. Production and economic parameters of different treatments (Mean±SE). Mean values with different superscript letters within a row are significantly different ($p<0.05$)

Parameters	Treatments: Carp polyculture (T_1)	Tilapia + carps (T_2)	Sahar + tilapia + carps (T_3)
GFY ($t \cdot ha^{-1} \cdot yr^{-1}$)			
Carps	$3.13±0.26^a$	$3.02±0.15^a$	$3.33±0.12^a$
Nile tilapia	-	$0.49±0.05^a$	$0.45±0.02^a$
Sahar	-	-	0.14±0.02
Combined	$3.13±0.26^b$	$3.51±0.20^{ab}$	$3.93±0.16^a$
Including tilapia recruit	-	$3.72±0.22^a$	$4.04±0.15^a$
NFY (t/ha/yr)	$3.05±0.26^b$	$3.57±0.25^{ab}$	$3.93±0.15^a$
Overall survival	$81.2±5.1^a$	$76.0±3.0^a$	$80.5±1.3^a$
Gross margin ($USD \cdot ha^{-1} \cdot yr^{-1}$)	$1300±316^b$	$1568±182^{ab}$	$2357±211^a$

A F U

INCLUSION OF NILE TILAPIA *Oreochromis nilo-cus* AND SAHAR *Tor pu-tora* IMPROVES RODUCTIVITY IN CARP-POLYCULTURE SYSTEM

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Asian Pacific aquaculture 2016 (26–29 April) , Surabaya Indonesia

IntroducUon

- Aquaculture is the one of the fastest growing food producing sector in Nepal for the last 5-6 years with a growth rate of 8.4% per annum.
- Pond area has increased from 6500 ha to 9200 ha during last 6-7 years.
- Pond aquaculture is the major aquaculture system contribuUng more than 95% of total aquaculture producUon.
- Semi–intensive carp polyculture is the established and commonly pracUced system and carps contributes about 90% of the producUon.

IntroducUon (Contd.)

- Besides carps, rainbow trout, African ca_ish, Ulapia, pangasius ca_ish has been iniUated in culture with limited volume of producUon.
- Mostly the increase in producUon is from expansion of the area.
- IntervenUon in carp polyculture system to increase producUvity might be the best opUon to make big producUon increment.
- AquaFish research has developed mixed–sex Ulapia culture system with sahar (*Tor pu-tora*) to small farmers.
- Further more, sahar is a popular indigenous species which needs due abenUon to conserve and Nile Ulapia is a government recommended species for commercial aquaculture.

- Inclusion of Ulapia and sahar in carp polyculture system might be a small intervenUon but significant growth in aquaculture producUon if it increases producUvity.

ObjecUves:

- To increase pond producUvity through species diversificaUon;
- To assess the producUvity of carp polyculture system with adding Ulapia and Ulapia–sahar species.
- To develop parUal enterprise budgets of costs and values of fish crops in different polyculture systems.

Materials and Methods

- Two experiments were conducted.
- First on–staUon experiment at the Fisheries Development Center, Bhairahawa (Government Fish Farm)
- Experimental units: 9 earthen ponds of 200 m^2
- Experimental period: 240 days (9 August 2014 to 9 May 2015)
- Treatments in triplicates:
  a) Carps only or control (10000 fish/ha) (T_1)
  b) Carps (10000/ha) + Ulapia (3000/ha) (T_2)
  c) Carps (10000/ha) + Ulapia (3000/ha) + sahar (1000/ ha) (T_3)

Materials and Methods (Contd.)

- Species combinaUon and raUo for carp polyculture (government recommended):
  - Silver carp (35%)
  - Bighead carp (10%)
  - Common carp (25%)
  - Grass carp (5)
  - Rohu (15%)
  - Mrigal (10%)

Pond preparaUon:

- Ponds were completely drained and treated with lime at 10.0 kg per 200 m^2 pond.
- Sun dried for 3 days and filled the water.

Materials and Methods (Contd.)

- FerUlized pond with di–ammonium phosphate (DAP), urea and farm yard manure (FYM) as a basal dose of 7 days.
- DAP and urea were used at 700 and 940 g, respecUvely and FYM 60 kg at for the 200 m^2 pond area.
- Fingerlings were stocked one week aker pond ferUlizaUon.
- Weekly ferUlizaUon with DAP and urea at 0.4 g N and 0.1 g P m^{-2} day^{-1}
- Feeding with locally made mass feed (20% CP) made from 1:1 mustard oil cake and rice bran at 2% of fish biomass per day.

Materials and Methods (Contd.)

- Pond water quality – temperature, dissolved oxygen, pH and Secchi disk depth were monitored monthly.
- Pond fish sampling were performed monthly for fish growth measurement, biomass calculaUon and feed adjustment.
- Ponds were completely drained for final harvest and all fish were counted and weighed.

Materials and Methods (Contd.)

- Second on–farm trial was conducted in farmer's ponds in Dayanagar village of Rupendehi district.
- Twelve individual farmers ponds of 380 – 930 m^2 were selected.
- Two treatments were compared with 6 replicates.
    a) Carps only or control (10000 fish/ha)
    b) Carps (10000/ha) + Ulapia (3000/ha) + sahar (1000/ha)
- Trial was conducted for 165 days (10 July to 24 December 2015).

Materials and Methods (Contd.)

- Carps stocking combinaUon and raUo is similar to above as of government recommendaUon.
- The ponds were ferUlized weekly with urea and di-ammonium phosphate at 0.4 g N and 0.1 g P m^{-2}day^{-1}.
- Fish were fed once daily with locally made pellet feed (1:1 rice bran and mustard oil cake; 20% CP) at 2% body weight.
- Water quality – temperature, DO and pH were measured monthly.
- Fish sampling were done monthly for growth trend and feed adjustment.

Results

On–staUon experiment at
Government Fish farm

ProducUon comparison between treatments (mean ± SE)

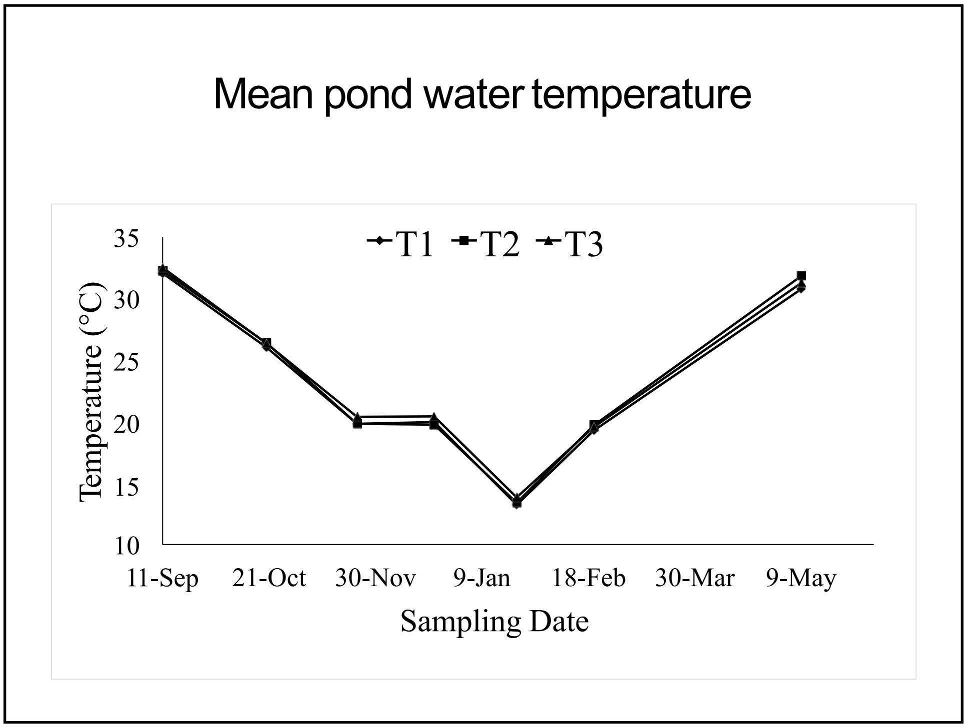
Parameters	Treatments		
	Carps only (T1)	Carps + tilapia (T2)	Carps+tilapia+sahar (T3)
Extrapolated GFY (t/ha/yr)			
Carps	3.13±0.26[a]	3.02±0.15[a]	3.33±0.12[a]
Tilapia	-	0.49±0.05[a]	0.45±0.02[a]
Sahar	-	-	0.14±0.02
Combined	3.13±0.26[b]	3.51±0.20[ab]	3.93±0.16[a]

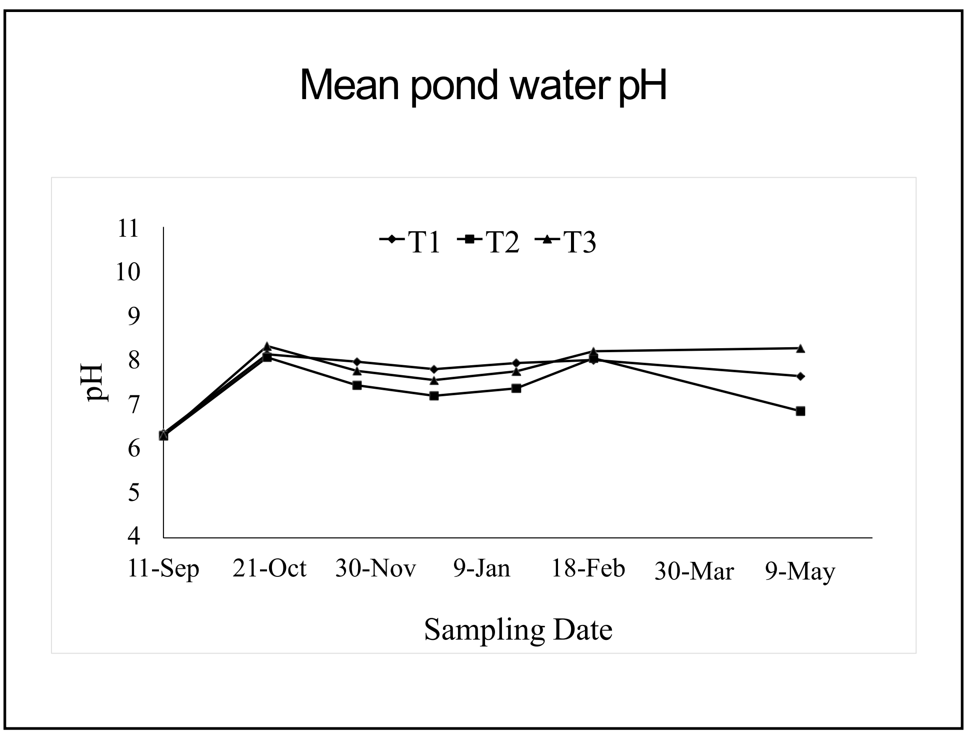
ProducUon comparison between treatments (Contd.)

Parameters	Treatments		
	Carps only (T1)	Carps + tilapia (T2)	Carps + tilapia + sahar (T3)
Extrapolated GFY (t/ha/yr)			
With recruits	3.13±0.26[b]	3.72±0.22[ab]	4.04±0.15[a]
Extrapolated			
NFY (t/ha/yr)	3.05±0.26[b]	3.57±0.25[ab]	3.93±0.15[a]
AFCR	2.53±0.24[a]	2.62±0.17[a]	2.41±0.11[a]
Survival (%)	81.2±5.1[a]	76.0±3.0[a]	80.5±1.3

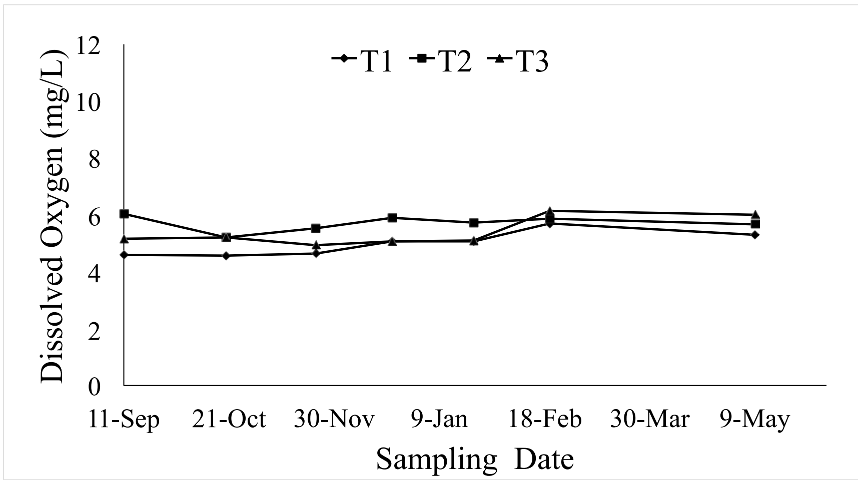
Tilapia recruits (per pond)

Size	Parameter	T2	T3
Small (2–3 cm)	Total count	2829	795
	Total wt. (kg)	4.71	1.21
	Mean wt. (g)	1.66±0.06	1.53±0.06
Large (6–10 cm)	Total count	152	149
	Total wt. (kg)	3.49	3.29
	Mean wt. (g)	22.9±1.0	21.3±1.3

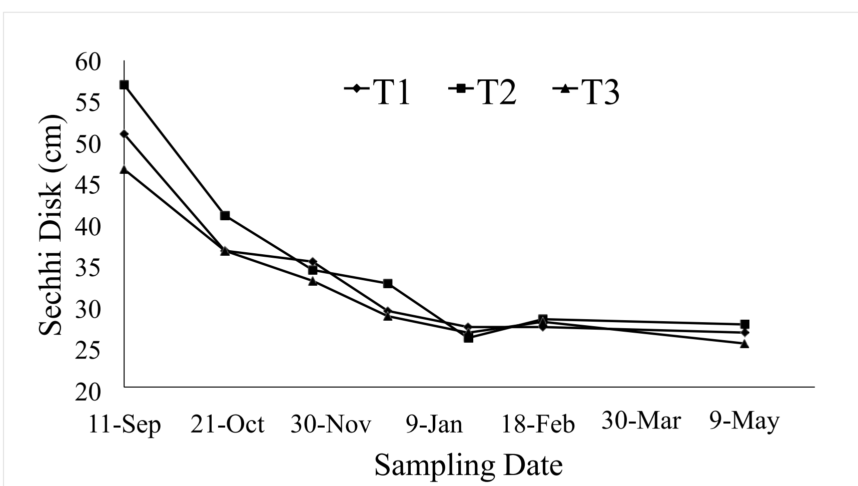

Mean pond water temperature
T1 T2 T3
Temperature (°C)
35
30
25
20
15
10
11-Sep
21-Oct
30-Nov
9-Jan
18-Feb
30-Mar
9-May
Sampling Date


Mean pond water pH
T1 T2 T3
pH
11
10
9
8
7
6
5
4
11-Sep
21-Oct
30-Nov
9-Jan
18-Feb
30-Mar
9-May
Sampling Date

Mean DO



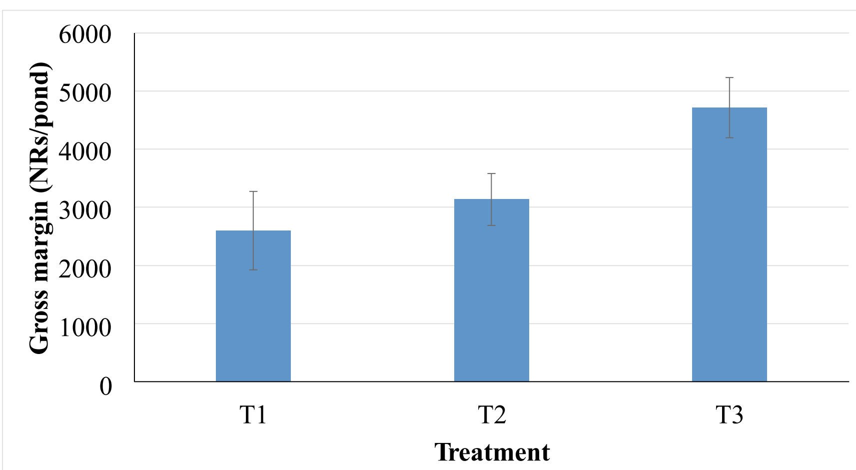
Sechhi disk depth



Gross margin (USD/pond)

ParUculars	carps	Carps + Ulapia	Carps + Ulapia + sahar
Total input	45.01±0.21[b]	53.50±2.12[a]	55.07±0.58[a]
Total output	71.00±6.53[b]	84.87±5.76[ab]	102.22±4.80[a]
Gross margin	24.90±6.32[b]	31.37±3.54[ab]	47.15±4.22[a]
Gross margin/ha	1300±316[b]	1570±177[ab]	2357±211[a]

Gross margin (NRs/pond)



On–farm trial at Farmers pond

ProducUon Comparison between treatments

Parameters	Treatment	
	Carps only (T1)	Carps + Ulapia + sahar (T2)
GFY ($t \cdot ha^{-1} \cdot crop^{-1}$)	2.2 ± 0.1^{b}	2.9 ± 0.4^{a}
NFY ($t \cdot ha^{-1} \cdot crop^{-1}$)	2.1 ± 0.1^{b}	2.8 ± 0.4^{a}
GFY ($t \cdot ha^{-1} \cdot yr^{-1}$)	4.4 ± 0.2^{b}	5.8 ± 0.8^{a}
NFY ($t \cdot ha^{-1} \cdot yr^{-1}$)	4.2 ± 0.2^{b}	5.6 ± 0.8^{a}
Survival (%)	74.0 ± 2.4^{b}	89.9 ± 2.3^{a}
AFCR	2.6 ± 0.4^{a}	2.2 ± 0.3^{a}

Water Quality

Parameters	Treatment	
	Carps only (T1)	Carps + Ulapia + sahar (T2)
Temperature (^oC)	28.3±2.6 (21.0 – 34.5)	27.4±2.4 (21.3 – 35.1)
DO ($mg{\cdot}L^{-1}$)	3.4±0.2 (1.4 – 5.1)	3.4±0.2 (0.3 – 6.7)
pH	7.5 (7.0 – 8.3)	7.6 (7.1 – 9.0)

Gross margin (USD/500 m^2 pond)

Parameters	Treatment	
	Carps only (T1)	Carps + Ulapia + sahar (T2)
Total input	118.0±2.5	156.5±5.0
Total output	208.0±12.9	317.4±22.3
Gross margin	90.0±12.5 ^{b}	161.0±18.4 ^{a}
Gross margin/ha	1800±250 ^{a}	3219±367 ^{a}

Nile Ulapia

Grass carp

Common carp

Silver/Bighead carp

Conclusions

- Adding Nile Ulapia and sahar did not affect the growth and producUon of carp species.
- Adding these species increased total fish producUvity.
- Problem of Ulapia recruitment can be addressed parUal by the introducUon of sahar in polyculture.
- Nile Ulapia and sahar can be added in carp polyculture ponds without affecUng the producUvity of carp species.
- The on–staUon experiment showed 25.5% increase in yield and in on–farm trial with six farmers showed 33.3% increase with this new producUon system.
- This is predicted to result in an 81% increase in gross margin for carp–Ulapia–sahar polyculture treatment. On–farm trials showed similar results of 78% increase in gross margin

Funding for these resear pro d by the

AQUAFISH INNOVATION LAB

USAID FROM THE AMERICAN PEOPLE OSU AQUAFISH INNOVATION LAB

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Thanks

AquaFish Technical Session 2
Innovations in Smallholder Aquaculture Technology: AquaFish Research on Sustainable Systems

Aquaculture carrying capacity of Stung Chinit Reservoir, Camboida: A pilot project

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The objective of the study was to plan for sustainable aquaculture development in Cambodia by training Cambodian scientists in the use of models to estimate the amount of aquaculture waste. Staff of the Inland Fisheries Research and Development Institute were trained in the uses of modeling to estimate Aquaculture Carrying Capacity (ACC). Stung Chinit Reservoir, located in Kampong Thom province, was selected as the pilot study site. We used mass-balance modeling of phosphorus (P) to calculate ACC under different scenarios of feed conversion ratio (FCR) and acceptable [P] levels, and we modeled wet seasons and dry seasons separately. The results showed that in the best scenario with acceptable phosphorus concentration ([P]) at 200 mg/m^3 and FCR at 1.8, farmers could produce 895 tons of snakehead in dry season or 467 tons in wet season. Setting acceptable [P] at 200 mg/m^3 and just varying FCR demonstrates that an FCR of 2.0 allows only 790 tons of snakehead production during the dry season and 412 tons during the wet season, whereas lowering the FCR to 1.0 will allow 1918 tons of snakehead production during the dry season and 1000 tons during the wet season (Fig. 1). Holding FCR constant at 1.8, setting acceptable [P] at 150 mg/cubic meter means that aquaculture will not be allowed in Stung Chinit; however, setting acceptable [P] at 350 mg/m^3 means that 2138 tons will allowed during the dry season and 14,448 tons during the wet season (Fig. 2). Because snakehead production takes longer than one season, we recommend using the lower of the dry season and wet season values to determine annual production levels. Using P mass-balance modeling to project acceptable snakehead production levels in Stung Chinit Reservoir provides government officials, and especially farmers (lowering FCR means more allowable fish production), to see the impacts of different scenarios on potential snakehead production in Cambodian reservoirs.

Fig. 1. Effect of FCR on aquaculture carrying capacity in Stung Chinit Reservoir

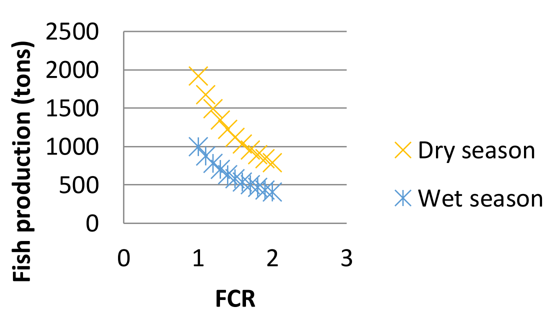
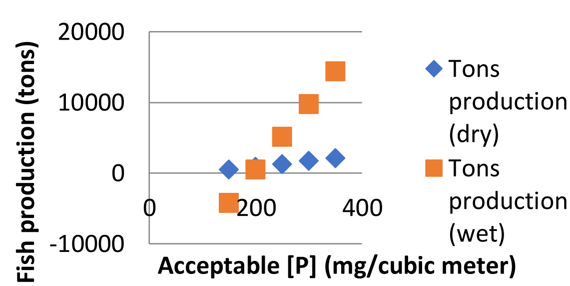


Fig. 2. Effect of phosphorus acceptability criterion on aquaculture carrying capacity in Stung Chinit Reservoir



Aquaculture Carrying Capacity of Stung Chinit Reservoir, Cambodia: A Pilot Project

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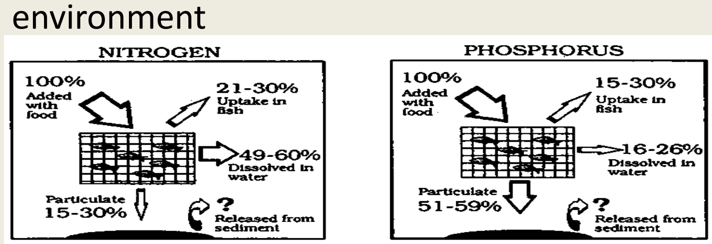
Inland Fisheries Research & Development Institute. Cambodia

A big issue for aquaculture

- Fish in cages have environmental impacts:
  - Organic deposition of feces and uneaten feed
  - Ammonia production
  - Note: Only 25-30% of feed fed to fish ends up as harvested fish tissue – the rest ends up in the environment



Ecosystem services

- The ecosystem provides services if it is not overwhelmed:
  - Primary production
  - Nitrification (ammonia → nitrate)
  - Decomposition of organic matter

Open water bodies

- Lakes, reservoirs, estuaries, bays
- Fish in cages rely on ecosystem services outside the cages via water flow
  - Remove feed and feces
  - Remove ammonia
  - Remove CO_2
  - Provide O_2

How much fish production is too much?

Many farms together may have an ecosystem-level impact

- Overwhelms the ecosystem services, not only for the farms, but for everything else

Aquaculture Carrying Capacity (ACC)

- Maximum amount of aquaculture that an environment can have:
  - Physical CC
  - Production CC
  - Ecological CC
  - Social CC

(Inglis, 2002; McKindsey et al. 2006)

Models

- We can use **models** to estimate **Production Carrying Capacity** and **Ecological Carrying Capacity**

- We still **need to develop models** to estimate **Social Carrying Capacity**

Aquaculture effects models

- Generally require knowledge of:
  - Hydrodynamics
  - Rate of input of a material to the system
  - Performance of the material in the system

Mass-balance for phosphorus (P)

- Need to know:
  - Volume of lake; inflow and outflow (turnover rate)
  - Ambient P level (P_i) in lake (before aquaculture)
  - What level of P is acceptable (P_f) (protect fish farms only or protect the ecosystem, including fisheries)
  - Potential P inputs from fish culture based on species, FCR, P retention by fish,…
- Can calculate:
  - $\Delta P = P_f - P_i$
  - The amount of fish culture allowed by ΔP (i.e., how much more P is allowed due to aquaculture)

Deciding on P_f

- Beveridge (1996) outlined the procedure for calculating ACC based on P
- One critical decision is the acceptable P (P_f)
  - To protect tilapia farms, P_f = 250 mg/m^3
  - To protect the ecosystem (capture fisheries, etc), P_f = 50 mg/m^3
  - To protect the lake for other human uses (drinking water, recreation), P_f = 10-30 mg/m^3

Critical variables

- Some critical variables in the equations can greatly affect the ACC calculated, e.g.:
  - FCR
  - P content of feed
  - Acceptable $[P]_f$

Snakehead fish in Cambodia

- One of the goals of the Aquafish Vietnam-Cambodia project is to develop the science basis for Cambodia to lift the ban on snakehead culture begun in 2005

Cambodian reservoirs

- Cambodia has reservoirs and is planning to build more. They would like to conduct aquaculture in them without exceeding ACC
- We trained IFReDI staff in P mass-balance modeling
- Then calculated ACC for Stung Chinit Reservoir (Kampong Thom province) as a pilot project
- (Also provided outreach material on ACC to fishery officers)

Stung Chinit Reservoir

Stung Chinit Reservoir

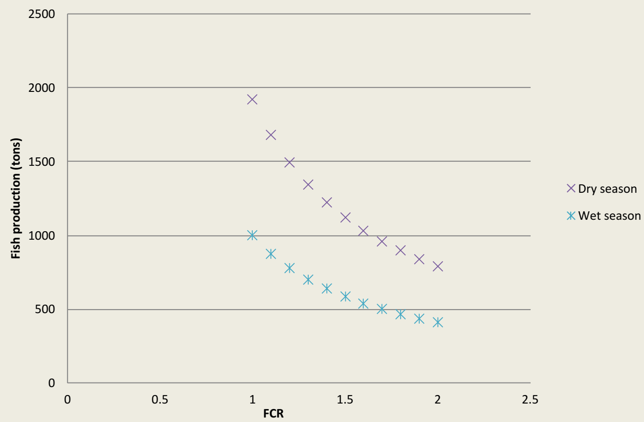
Variable	Dry Season	Wet Season
Area (m^2)	5,140,000	16,720,000
Flow (m^3/season)	460,000,000	1,586,000,000
$[P]_i$ (mg/m^3)	92	195

Strategy for ACC calculation

- Use snakehead as the species to be cultured
  - Takes about one year to raise
- Calculate ACC for wet and dry seasons separately
  - Use most conservative number for the whole year
- Vary FCR and $[P]_f$ to demonstrate how farming practices and stakeholder choices can affect ACC

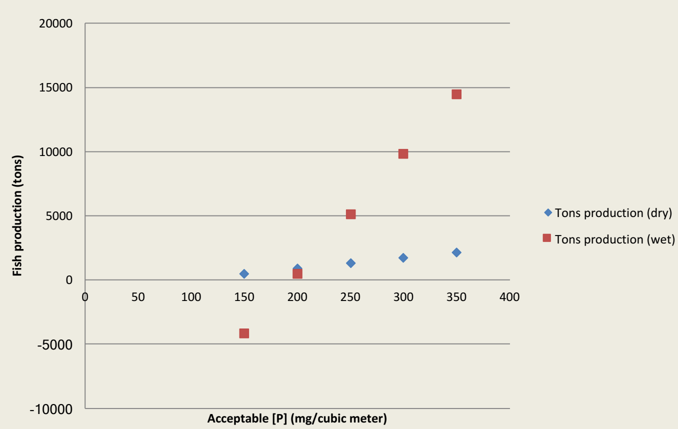
Effects of varying FCR

- (Holding $[P]_f$ constant at 200 mg/m^3)



Effects of varying $[P]_f$

- (Holding FCR constant at 1.8)



Conclusions

- With varying FCR, wet season ACC is always lower than the dry season ACC and therefore determines the year-round acceptable production
- With varying $[P]_f$, wet season ACC is higher and the dry season ACC determines the acceptable year-round production
- IFReDI scientists can now apply their knowledge of P mass-balance models to other reservoirs as needed

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AquaFish Innovation Lab

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Growth and production of carp and SIS in periphyton enhanced systems

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Role of small indigenous fish species (SIS) has been recognized for improving family nutrition in small-scale household aquaculture. An experiment was conducted at Agriculture and Forestry University (AFU), Chitwan, Nepal to compare fish production between carp-SIS polyculture and periphyton enhanced carp-SIS polyculture in order to develop a cost effective means to increase fish production. The experimental period was of 210 days from 24 August 2014 to 28 March 2015. The experiment included four treatments, T_1 (Carp+100% Supplemental feed), T_2 (Carp+SIS+100% Supplemental feed), T_3 (Carp+SIS+50% Supplemental feed + Bamboo substrate at the rate of 1 % of pond surface area) and T_4 (Carp+SIS+Bamboo substrate) each with three replicates. Silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella),* common carp *(Cyprinus carpio),* rohu *(Labeo rohita)* and naini *(Cirrhina mrigala)* were stocked at a ratio of 4:1:4:3:5 at rate of 15,000 fish/ha whereas two SIS, dedhuwa *(Esomus danricus)* and pothi *(Puntius sophore)* were stocked at a ratio of 1:1 at density of 50,000 fish/ha. Carps were fed with freshly made dough of mustard oil cake and rice bran (1:1) at 5% of body weight per day whereas Grass carp was fed with grass at 50% of body weight per day. Growth and yield of common carp was significantly? higher in T_3 than all other treatments indicating both periphyton and supplementary feed at a reduced rate produced the best growth. Growth and production of grass carp was higher in ponds without substrate. Carp yield and combined NFY was higher in T_3 due to the higher survival and growth rate of carp caused by periphyton and supplementary feed. Production of SIS was lower in substrate ponds. Gross margin was highest in T_3, intermediate in T_4 and lowest in T_2. Based on fish production and profit, supplemental feeding at 50% combined with periphyton enhancement was best among treatments.

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GROWTH AND PRODUCTION OF CARPS AND SIS IN PERIPHYTON ENHANCED SYSTEM

Sabita Jha[1], Sunila Rai[1], Madhav Shrestha[1] and James Diana[2]
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Introduction

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

Objectives

- To compare growth and yield of carps, and yield of SIS with or without periphyton enhancement
- To compare water quality among different polyculture systems
- To compare the profit among different polyculture systems

Materials and methods

- Experimental site: AFU
- Average pond size: 150.9±4.1 m^2 (117.7- 168.5 m^2)
- Duration: 210 days (24 August 2014 - 28 March 2015)
- Experimental design: CRD

Treatment	Combination	Substrate	Feeding
T1	Carp	No	100% feeding
T2	Carp+SIS	No	100% feeding
T3	Carp+SIS	Split bamboo	50% feeding
T4	Carp+SIS	Split bamboo	No feeding

Pond preparation

- Fertilization: Urea- 470 g/100 m^2 and DAP- 350g/100 m^2
- Substrate preparation: Split bamboo mat (20-35 splits, split size 4 cm x 75 cm)
- Float: Styrofoam as float at top edges of mat
- Sinker: Brick as weight at bottom edges of the mat
- Two mats per pond
- Surface area of substrate equivalent to water surface area - 1%
- Vertical positioning

Fertilization

Bamboo mat preparation and installation in pond (2 weeks later)

Stocking



SIS procurement


Stocking combination

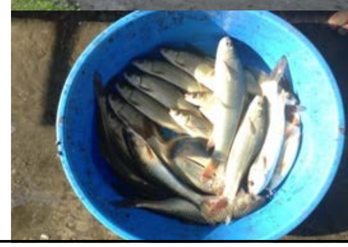
Species	T_1 Carp	T_2 Carp+SIS	T_3 Carp+SIS	T_4 Carp+SIS
Carp				
Silver carp	3000	3000	3000	3000
Bighead carp	750	750	750	750
Grass carp	2250	2250	2250	2250
Common carp	3000	3000	3000	3000
Rohu	3750	3750	3750	3750
Mrigal	2250	2250	2250	2250
Sub-total	**15000**	**15000**	**15000**	**15000**
SIS				
Pothi		25000	25000	25000
Dedhuwa		25000	25000	25000
Sub-total		**50000**	**50000**	**50000**

Feed and feeding

- Mustard oil cake and Rice bran (1:1) mixed in dough
- Fed once in the morning
- Feeding rate: 5% for initial two months and later 3% for rest experimental period
- Grass fed to Grass carp at 50% of body weight

- Partial harvesting of SIS: during monthly fish sampling

- Final harvesting: complete draining of the pond



Analytical methods

- Growth check: Monthly, Sampling at least 20% of each Carp species

- Water quality analysis: DO, pH, Temp.- fortnightly
  Transparency, Total alkalinity, TAN, SRP, Chlorophyll-a – monthly

- Periphyton analysis: Monthly, Scrapping periphyton from 1 cm^2 surface of bamboo substrate, Dry matter, Ash, Ash free dry matter

- Gross margin analysis: Gross margin

- One-way ANOVA: Water quality, growth, yield and gross margin, Student's t-test - Periphyton biomass

Results

Grass carp

Parameters	Treatments			
	T_1	T_2	T_3	T_4
Initial mean weight (g/fish)	4.9±0.5[a]	4.5±0.5[a]	5.1±0.1[a]	4.8±0.3[a]
Final mean weight (g/fish)	465.4±32.1[a]	262.4±24.8[bc]	341.8±81.9[ab]	136.0±39.0[c]
DWG (g/fish/day)	2.2±0.2[a]	1.2±0.1[bc]	1.6±0.4[ab]	0.6±0.2[c]
TWG (kg/pond)	7.0±0.0[a]	4.2±0.6[ab]	6.2±0.1[ab]	3.9±1.6[b]
Survival (%)	45.4±2.6[b]	36.7±1.5[b]	47.2±9.5[ab]	59.7±6.6[a]
NFY (t/ha/yr)	0.85±0.09[a]	0.48±0.07[b]	0.73±0.01[ab]	0.42±0.17[b]

Common carp

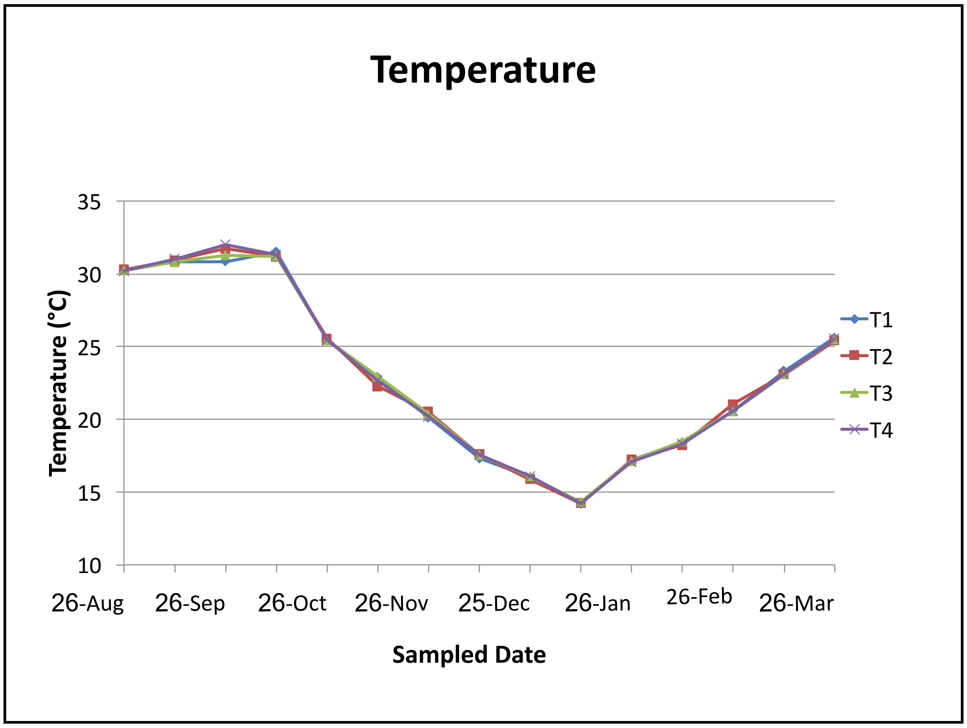
Parameters	Treatments			
	T_1	T_2	T_3	T_4
Initial mean weight (g/fish)	1.2±0.2[a]	1.1±0.1[a]	1.0±0.1[a]	1.2±0.2[a]
Final mean weight (g/fish)	1062.8±357.2[a]	666.0±191.0[a]	1167.5±120.2[a]	584.9±183.0[a]
DWG (g/fish/day)	5.1±1.7[a]	3.2±0.9[a]	5.6±0.6[a]	2.8±0.9[a]
TWG (kg/pond)	9.1±3.9[ab]	4.5±1.8[b]	15.8±1.6[a]	7.7±1.2[b]
Survival (%)	22.7±3.8[b]	18.4±2.6[b]	41.6±4.4[a]	41.4±7.0[a]
NFY (t/ha/yr)	1.01±0.41[b]	0.52±0.20[b]	1.88±0.21[a]	0.83±0.14[b]

Net fish yield

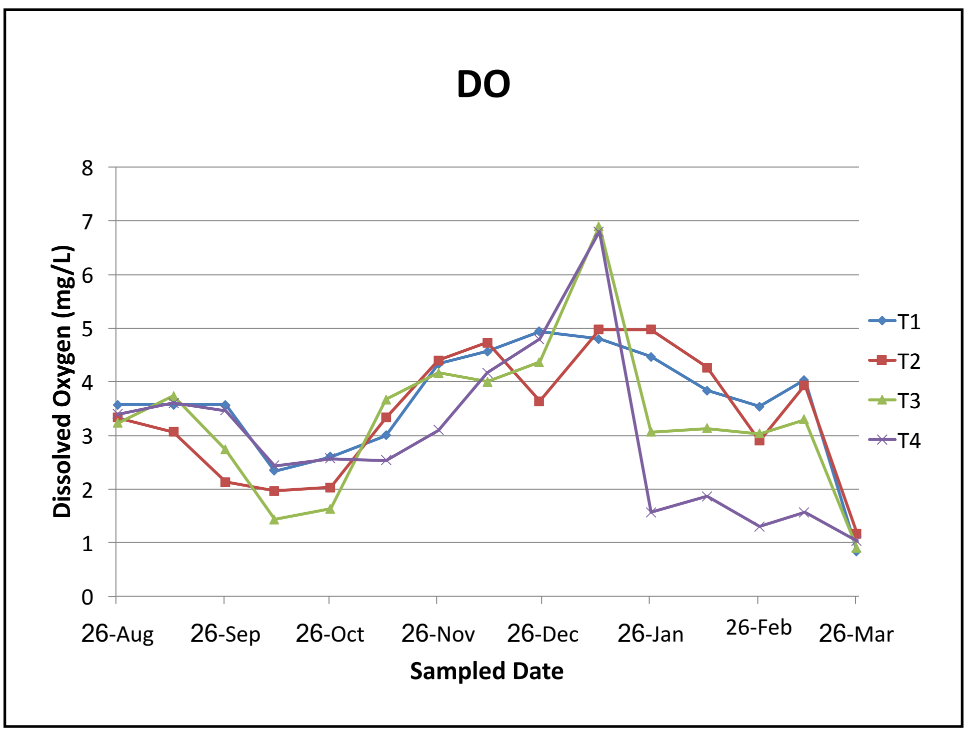
Parameters	Treatments			
	T_1	T_2	T_3	T_4
GFY Carp only (t/ha/yr)	4.48±0.47[ab]	3.62±0.43[b]	5.57±0.45[a]	4.27±0.40[ab]
NFY Carp only (t/ha/yr)	4.36±0.47[ab]	3.51±0.42[b]	5.45±0.45[a]	4.15±0.40[ab]
GFY of SIS only (t/ha/yr)	-	0.35±0.07[a]	0.19±0.02[b]	0.21±0.02[ab]
NFY of SIS only (t/ha/yr)	-	0.21±0.07[a]	0.05±0.02[b]	0.05±0.02[b]
Combined GFY (t/ha/yr)	4.48±0.47[ab]	3.97±0.37[b]	5.77±0.43[a]	4.47±0.40[ab]
Combined NFY (t/ha/yr)	4.36±0.47[ab]	3.72±0.36[b]	5.52±0.43[a]	4.20±0.41[ab]
Feed conversion ratio (FCR)	2.44±0.30[a]	2.44±0.21[a]	1.02±0.06[b]	-

Water quality

	Treatment			
Parameter	T_1	T_2	T_3	T_4
pH	6.8	6.8	6.8	6.8
Temperature (°C)	23.0±0.0[a]	23.0±0.1[a]	23.0±0.1[a]	23.0±0.1[a]
Dissolved oxygen (mg/L)	3.6±0.2[a]	3.4±0.2[a]	3.3±0.2[a]	3.0±0.1[a]
Transparency (cm)	25±5[a]	23±2[a]	21±1[a]	21±1[a]
Total alkalinity (mg/L as $CaCO_3$)	102.7±6.9[a]	98.3±1.6[a]	95.4±5.0[a]	94.5±6.7[a]
Total ammonium nitrogen (mg/L)	0.051±0.020[a]	0.031±0.008[a]	0.053±0.018[a]	0.052±0.004[a]
Soluble reactive phosphorus (mg/L)	0.030±0.011[a]	0.026±0.007[a]	0.035±0.004[a]	0.020±0.004[a]
Chlorophyll-*a* (mg/m^3)	20.5±5.8[a]	20.9±6.1[a]	21.5±1.1[a]	23.4±1.0[a]



Temperature
35
30
25
20
15
10
Temperature (°C)
26-Aug
26-Sep
26-Oct
26-Nov
25-Dec
26-Jan
26-Feb
26-Mar
Sampled Date
T1
T2
T3
T4



DO
8
7
6
5
4
3
2
1
0
Dissolved Oxygen (mg/L)
26-Aug
26-Sep
26-Oct
26-Nov
26-Dec
26-Jan
26-Feb
26-Mar
Sampled Date
T1
T2
T3
T4

Periphyton biomass

Parameters	Treatment	
	T_3	T_4
Dry Matter (mg/cm²)	3.0±0.2[a]	2.5±0.2[a]
Ash Content (%)	21.7±1.1[a]	22.0±0.2[a]
Ash free dry matter (mg/cm²)	2.3±0.1[a]	2.4±0.1[a]

Gross margin (Rs./100 m² pond)

Variables	Treatment			
	T_1	T_2	T_3	T_4
Carp Seed	498.2±4.31[a]	501.6±2.6[a]	502.7±3.1[a]	498.7±3.0[a]
SIS Seed		49.9±0.4[a]	50.2±0.2[a]	49.5±0.2[a]
Fertilizer	702.4	702.4	702.4	702.4
Bamboo			250	250
Miscellaneous	420	420	420	
Feed	1627.1±166.1[a]	1382.2±6.9[a]	871.5±47.5[b]	
Total Variable cost	3247.7±165.8[a]	3056.0±9.9[a]	2796.8±46.7[b]	1850.6±3.2[c]
Return				
Carp	6440.3±680.3[ab]	5200.6±612.6[b]	8031.1±631.2[a]	6135.9±574.3[ab]
SIS		509.5±100.9[a]	323.7±45.4[a]	382.7±29.2[ab]
Gross Return	6437.3±680.3[ab]	5710.0±525.2[b]	8354.7±612.9[a]	6518.6±563.1[ab]
Gross Margin	3192.6±622.4[bc]	2653.9±519.9[c]	5557.9±588.4[a]	4618.5±565.9[ab]

Conclusion

- Carp-SIS polyculture with 50% supplementary feeding in periphyton enhancement was best based on fish production and profit.
- This technology is suitable to rural farmers as it is cost effective and supports family nutrition and income.
- The technology needs verification trial on farm.

Funding for this research was provided by the

AQUAFISH INNOVATION LAB

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Effects of reduced feeding strategies for combined polyculture of two major carps (Rohu and Catla) with Shingh catfish *Heteropneustes fossils*

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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 or drought. Currently, production of Shing (*Heteropneustes fossilis*, stinging catfish), a high valued cultivar, is limited to monoculture systems with intensive use of commercial-grade feeds (30-35% crude protein). As feed can comprise up to 60% of total production costs, the current practices for these fish limit participation by small homesteads and therefore comprise a significant impediment to further expansion of this industry. Further, the use of high-levels of feed inputs has led to a persistent deterioration of pond water quality.

Variables	T1 (100% Feed)	T2 (100% Feed)	T3 (75% Feed)	T4 (50% Feed)
Shing Net Production (kg/ha)	623±155	457±99	555±70	614±134
Rohu Net Production (kg/ha)	-	1971±575	2064±863	1904±936
Catla Net Production (kg/ha)	-	641±198	661±157	652±220
Total Net Production (kg/ha)	623±155^{a}	3069±774^{b}	3280±853^{b}	3171±805^{b}
Benefit-Cost	0.82	1.55	1.93	2.37

An investigation was carried out to determine 1) if addition of Indian major carps (Rohu, *Labeo rohita* and Catla, *Gibelion catla*) alone can provide cost benefits for growout of Shing, and 2) if reducing feed by 50% and 75% from levels typically used by the industry to grow Shing might provide further cost savings in Shing-carp polyculture. The study was carried out for 165 days in ponds at Bangladesh Agricultural University. The experiment was consisted of four treatments (T1, T2, T3 and T4) with four replications each. The stocking density was 200 Shing/decimal, 32 Rohu/decimal and 8 Catla/decimal. All three fish species were stocked in all ponds except in the T1 group, representing the monoculture of Shing as control. Ponds under T_1 and T_2 were fed on full ration (20% - 5% body weight/day), while T_3 received feed at 75% and T_4 at 50% of full ration daily.

Growth and production of fishes did not vary significantly in the different treatments. The survival rate fish did not differ and ranged from 47 to 53% for Shing and > 89% for carps. The net productions of fish in T1, T2, T3 and T4 were 623±155, 3069±774, 3280±853 and 3171±805 kg/ha, respectively. Net return was -103,827, 294,485, 442,711 and 542,215 BDT/ha and benefit cost ratio (BCR, total returns/total costs) was 0.82, 1.55, 1.93 and 2.37 in T1, T2, T3 and T4, respectively. T4 showed the best overall FCR, SGR, BCR and fish yield followed by T3. In conclusion, the cost effectiveness of Shing growout can be substantially improved by addition of carps to the pond culture system. Moreover, reducing feed inputs by half provides additional benefits to Shing-carp polyculture. Based on these studies, farmers have the potential to enhance their income opportunities by incorporating carps and reducing feed inputs in the growout of Shing.

EFFECTS OF REDUCED FEEDING FOR COMBINED POLYCULTURE OF TWO MAJOR CARPS (ROHU AND CATLA) WITH SHINGH CATFISH (*Heteropneustes fossilis)*

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Background

- Following success of pangasius catfish aquaculture, Bangladesh has begun culture of three local air-breathing fishes, shing (*Heteropneuestes fossilis)*, magur (*Clarias batrachus*) and koi (*Anabas testudineus*) in intensive pond systems
- Culture of air-breathing fishes is advantageous due to high tolerability for harsh, low oxygen environments
- Shing recognized for its excellent taste, has high iron content, market value is very high ($6-7 at farm gate)

- Feed cost for air-breathing fishes is high due to high inputs
- This causes environmental deterioration, often leading to mass mortality and economic loss
- Farmers are looking for alternate farming options, preferably low input carp - air-breathing fish polyculture

Objectives

- Compare production of combined polyculture of two major carps (Rohu, *Labeo rohita* and Catla, *Catla catla*) with Shing catfish versus Shing monoculture
- To evaluate the effects of reduced feed ration on growth and production of major carps (*Labeo rohita* and *Catla Catla*) and stinging catfish (*Heteropneustes fossilis*) in polyculture
- Evaluate overall performance and economic returns of the improved management strategy

Research Design

Parameter	Treatment			
	T_1	T_2	T_3	T_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)
Shing *(H. fossilis)*	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)
Feed Ration	100%	100%	75%	50%
Replicates (n)	4	4	4	4

Methods

Experimental Site

Fisheries Field Laboratory Complex, Bangladesh Agricultural University, Mymensingh

Duration of the Experiment

165 days (30th May, 2014 to 11th November, 2014)

Experimental Species

Rohu *(Labeo rohita),* Catla *(Catla catla)* and Shing *(Heteropneustes fossilis)*

Culture Technique

Monoculture and polyculture

Pond Size

Area - 2.5 decimal, Depth - 1.5 m

Methods

- **Pond Preparation**
  - ✓ Drying and Re-excavation
  - ✓ Liming
  - ✓ Water Filling
  - ✓ Fertilization
- **Fingerling Collection**
  - ✓ Shing: 1.13 ± 0.98 g
  - ✓ Rohu: 21.76 ± 7.76 g
  - ✓ Catla: 27.30 ± 8.23 g

Methods – Pond Fertilization

- After watering, all ponds were fertilized initially with Urea and TSP at 28 kg N/ha (246 g Urea/decimal) and 7 kg P/ha (123 g TSP/decimal).
- Ponds for Treatments 3 and 4 were fertilized weekly to enhance natural pond productivity

Methods – Feed Application

- Formulated feed (CP, %) has been supplied at full (100%) ration (20% - 5 % of body weight of Shing) based on current practices, 75%, or 50% ration levels daily
- Feed was applied twice a day early in the morning and evening

Methods – Water Quality

- Temperature and transparency parameters measured daily or weekly
- Total Alkalinity, pH, Dissolved Oxygen, Nitrate-nitrogen, Nitrite-nitrogen, Ammonia-nitrogen, Phosphate-phosphorus and Chlorophyll-*a* measured fortnightly



Benthos and Plank Collection – Fortnightly






Sampling - Shing

- Sampling of Shing was done at 15-day intervals. Shing was caught by using one side end bamboo cylinder
- Length and weight were measured by using a scale and digital balance

Sampling - Carps

- Rohu and Catla were sampled on monthly basis
- Rohu and catla were caught by seine net
- Length and weight were measured by using a scale and digital balance

Harvesting

- After 165 days of rearing, the fish were harvested from all the ponds by repeated netting using a seine net
- Final harvesting was done by dewatering the ponds with a submerged low lift pump
- During harvest, all fishes were counted and weighed from each pond to assess the survival rate and production

Water Quality Parameters (mean ± SD)

Parameter	Treatment 1 Shing Alone 100% Feed	Treatment 2 Shing + Carps 100% Feed	Treatment 3 Shing + Carps 75% Feed + Fertilization	Treatment 4 Shing + Carps 50% Feed + Fertilization
Temperature (° C)	30.31 ± 1.59	30.33 ± 1.43	30.18 ±1.42	30.26 ± 1.44
Transparency (cm)	24.42 ± 14.44	25.31 ± 11.33	25.43 ± 10.90	27.10 ± 10.62
Total Alkalinity (mg/L)	86.61 ± 32.90	95.89 ± 36.96	89.27 ± 37.48	93.57 ± 36.56
pH	7.49 ± 0.46	7.54 ± 0.49	7.51 ± 0.48	7.53 ± 0.50
Dissolved Oxygen (mg/L)	6.31 ± 0.81	6.19 ± 0.85	6.18 ± 0.84	6.30 ± 0.83
Nitrate (mg/L)	0.08 ± 0.0[c]	0.08 ± 0.07[c]	0.25 ± 0.26[a]	0.16 ± 0.17[b]
Nitrite (mg/L)	0.08 ± 0.15	0.08 ± 0.13	0.13 ± 0.17	0.10 ± 0.15
Ammonia (mg/L)	0.26 ± 0.23[a]	0.17 ± 0.14[a]	0.32 ± 0.43[ab]	0.48 ± 0.66[b]
Phosphate (mg/L)	0.68 ± 0.43	0.75 ± 0.49	0.82 ± 0.54	0.66 ± 0.48
Chlorophyll-*a* (mg/L)	323.67 ± 266.18	243.54 ± 216.44	249.64 ± 223.71	194.63 ± 36.56

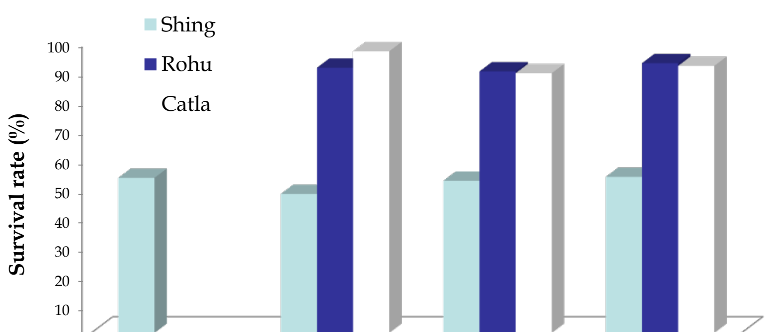
Plankton Populations
(×10³ cells/L ± SD)

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Chlorophyceae	71.27±4.67	71.25±3.03	80.72±4.14	82.90±3.89
Cyanophyceae	108.09±13.34	51.01±3.43	75.76± 8.08	57.92±4.44
Bacillariophyceae	27.90±1.77	27.90±1.64	31.58±1.87	30.90±1.65
Euglenophyceae	16.41±2.73	22.70±2.99	30.21±5.84	41.10±5.44
Rhodophyceae	3.53±0.64	4.63±0.69	4.98±0.75	5.16±0.66
Total phytoplankton	232.75±14.8	178.78±7.11	224.70±12.07	217.72±10.76
Rotifera	13.06±1.40	13±1.41	18.89±2.29	16.69±1.60
Crustacea	1.35±0.34	1.05±0.24	0.92±0.24	1.14±0.25
Cladocera	0.48±0.24	0.80±0.27	0.65±0.24	0.90±0.23
Copepoda	0.94±0.27	0.43±0.13	0.58±0.17	0.87±0.19
Total Zooplankton	16.07±1.79	16.00±1.59	21.38±2.24	20.21±1.91
Total Plankton	**248.82±1.52**	**194.78±7.55**	**246.08±1.28**	**237.95±1.11**

Benthic Organisms Identified
(10^3 cells/L)

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Oligochaeta	125 ± 90	113 ± 46	138 ± 38	90 ± 28
Chironomidae	356 ± 93	783 ± 114	979 ± 137	1057 ± 288
Mollusca	61 ± 31	48 ± 23	40 ± 15	70 ± 18
Unidentified	27 ± 50	80 ±18	83 ± 17	42 ±14
Total Benthos	**570 ± 173[a]**	**1025 ± 140[b]**	**1239 ±135[b]**	**1259 ± 294[b]**

Survival Rate



	T 1	T 2	T 3	T 4
Shing	53	47.5	52	53.35
Rohu		90.63	89.38	92.19
Catla		96.25	88.75	91.25

Production Parameters of Shing

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Level of Significance
Mean Stocking Weight (g)	1.13 ± 0.98	1.13 ± 0.98	1.13 ± 0.98	1.13 ± 0.98	NS
Mean Harvesting Weight (g)	24.73±3.45	20.62±3.50	22.70±2.34	24.44±5.09	NS
Mean Weight Gain (g)	23.60±3.45	19.49±3.50	21.57±2.34	23.31±5.09	NS
Initial Length (cm)	5.53±1.67	5.53±1.67	5.53±1.67	5.53±1.67	NS
Final Length (cm)	16.08±2.10	15.28±2.12	15.59±2.18	15.99±2.77	NS
Net Length (cm)	10.55±2.10	9.75±2.12	10.06±2.18	10.46±2.77	NS
Survival Rate (%)	53.00±6.36	47.50±5.02	52.00±2.44	53.35±2.00	NS
SGR (%)	1.83±0.08	1.72±0.10	1.78±0.06	1.82±0.13	NS
Gross Production (kg/ha)	652.21±158.42	483.65±100.90	583.71±70.80	644.23±134.30	NS
Net Production (kg/ha)	622.63±155.25	457.14±99.46	554.68±69.99	614.44±134.09	NS

Production Parameters of Catla

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Level of Significance
Mean Stocking Weight (g)	-	27.30± 8.23	27.30 ± 8.23	27.30 ± 8.23	NS
Mean Harvesting Height (g)	-	368.60±117.88	402.08±57.89	389.40±119.54	NS
Mean Weight Gain (g)	-	341.30±117.88	374.78±57.89	362.10±119.54	NS
Initial Length (cm)	-	13.05±1.36	13.05±1.36	13.05±1.36	NS
Final Length (cm)	-	29.63±2.24	30.46±1.58	29.69±3.48	NS
Net Length (cm)	-	16.58±2.24	17.41±1.58	16.64±3.48	NS
Survival Rate (%)	-	96.25±3.50	88.75±10.15	91.25±4.79	NS
SGR (%)	-	1.53±0.20	1.60±0.09	1.56±0.18	NS
Gross Production (kg/ha)	-	692.84±196.38	708.89±163.02	701.48±220.48	NS
Net Production (kg/ha)	-	640.91±197.96	661.01±157.20	652.26±220.21	NS

Production Parameters of Rohu

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Level of Significance
Mean Stocking Weight (g)	-	21.76± 7.76	21.76± 7.76	21.76± 7.76	NS
Mean Harvesting Weight (g)	-	304.81±106.6	309.63±103.26	279.92±119.29	NS
Mean Weight Gain (g)	-	283.05±106.61	287.87±103.26	258.16±119.29	NS
Initial Length (cm)	-	12.48±1.40	12.48±1.40	12.48±1.40	NS
Final Length (cm)	-	28.95±2.54	29.58±2.08	28.02±3.34	NS
Net Length (cm)	-	16.47±2.54	17.1±2.08	15.54±3.34	NS
Survival Rate (%)	-	90.63±8.92	89.38±8.75	92.19±3.73	NS
SGR (%)	-	1.54±0.22	1.55±0.21	1.48±0.27	NS
Gross Production (kg/ha)	-	2126.67±561.52	2218.06±874.12	2062.45±941.87	NS
Net Production (kg/ha)	-	1970.80±575.10	2064.34±863.13	1903.90±936.21	NS

Combined Production of All Species

Variables	T1 (100% Feed)	T2 (100% Feed)	T3 (75% Feed)	T4 (50% Feed)
Shing Net Production (kg/ha)	623±155	457±99	555±70	614±134
Rohu Net Production(kg/ha)	-	1971±575	2064±863	1904±936
Catla Net Production (kg/ha)	-	641±198	661±157	652±220
Total Net Production (kg/ha)	623±155[a]	3069±774[b]	3280±853[b]	3171±805[b]

Investment and Returns

	T 1	T 2	T 3	T 4
Gross Investment	592986.19	533712.12	478475.02	396792.12
Gross Return	489159	828197	921187	939008

Economic Analyses

Items	Treatment (BDT/ha)				Level of Significance
	T_1	T_2	T_3	T_4	
Financial Input					
Lime	2470.00	2470.00	2470.00	2470.00	NS
Urea	1033.45 ^{a}	1033.45 ^{a}	20659.08 ^{b}	20659.08 ^{b}	**
TSP	729.14 ^{a}	729.14 ^{a}	14582.88 ^{b}	14582.88 ^{b}	**
Shing	61750.00	61750.00	61750.00	61750.00	NS
Rohu	-	39520.00	39520.00	39520.00	NS
Catla	-	19760.00	19760.00	19760.00	NS
Feed	517003.60 ^{d}	398449.53 ^{c}	309733.06 ^{b}	**228050.16** ^{a}	**
Labor, Other	10000.00	10000.00	10000.00	10000.00	NS
Total Cost	592986.19 ^{d}	533712.12 ^{b}	478475.02 ^{c}	**396792.12** ^{a}	**
Financial Return					
Shing	489158.80	362738.03	437782.80	483169.05	NS
Rohu	-	361533.90	377070.20	350616.50	NS
Catla	-	103925.25	106333.50	105222.00	NS
Total Return	489158.8 ^{a}	828197.18 ^{b}	921186.5 ^{b}	**939007.55** ^{b}	**
Net Return	-103827.39 ^{a}	294484.88 ^{b}	442711.48 ^{b}	**542215.43** ^{b}	**
BCR	0.82 ^{a}	1.55 ^{b}	1.93 ^{bc}	**2.37** ^{c}	**

Summary and Conclusion

- Water quality parameters were similar among treatments except, NO_3-N and NO_2-N, and NH3 which showed only slight elevation in groups where weekly pond fertilization occurred
- Growth and production of Shing, Rohu and Catla were similar among groups
- Introduction of carps has little effect on Shing production, but enhances total fish production and benefit cost ratio
- Reducing feed ration levels by 50% from the current recommended level has little impact on fish growth, enhances overall feed efficiency and the benefit-cost ratio, and limits nutrient loading to the environment.
- Studies demonstrate that the stinging catfish (Shing) can be cultured with carps, that this polyculture management strategy likely enhances utilization of pond resources and can increase the incomes of farmers.

Thank you

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AQUAFISH
INNOVATION LAB

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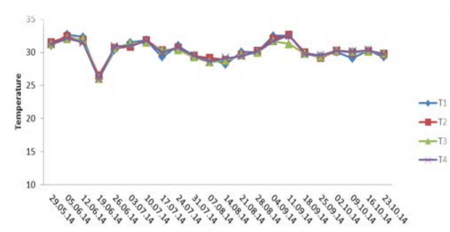
Bangladesh Agricultural University, Mymensingh
HC Lead PI of AquaFish Innovation Lab Project

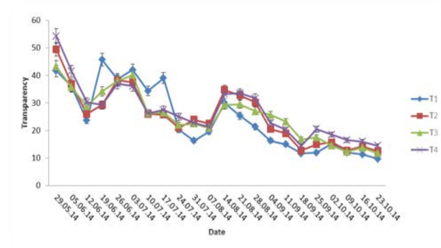
Concluding Remarks

Reductions in feed 50% and overhead costs, combined with mixed-trophic level nutrient utilization, may make semi-intensive culture of shing catfish more feasible for greater adoption among farmers while also mitigating environmental impacts associated with nutrient loading.

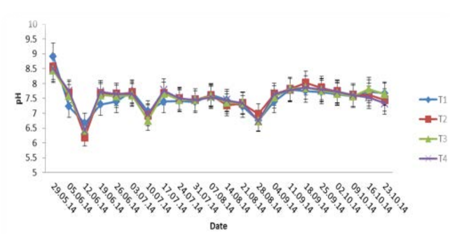
Results



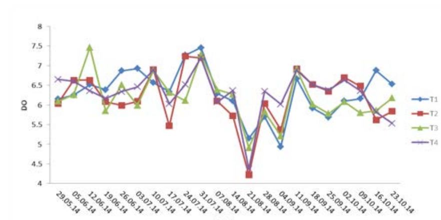
Weekly fluctuation of temperature among four treatments



Weekly fluctuation of transparency among four treatments

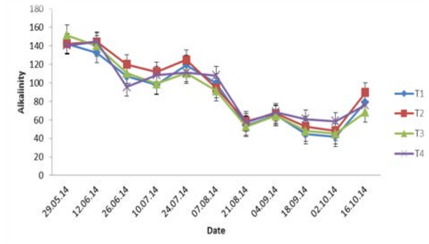


Weekly fluctuation of pH among four treatments

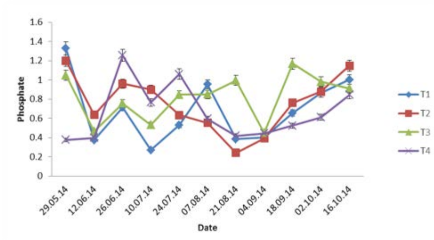


Weekly fluctuation of Dissolved Oxygen among four treatments

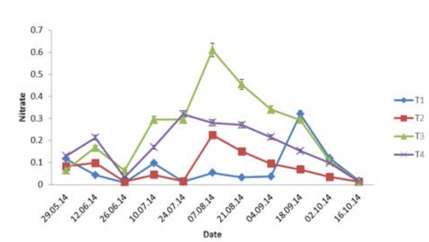
Results



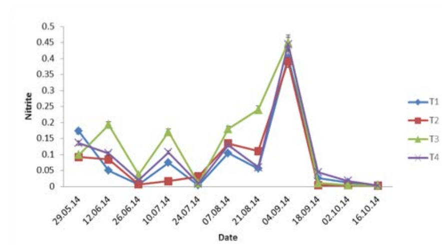
Fortnightly fluctuation of Total alkalinity among four treatments



Fortnightly fluctuation of Phosphate-phosphorus among four treatments

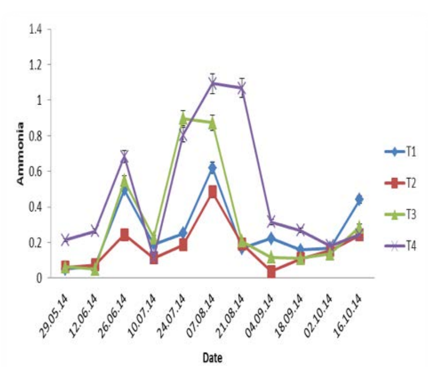


Fortnightly fluctuation of Nitrate-nitrogen among four treatments

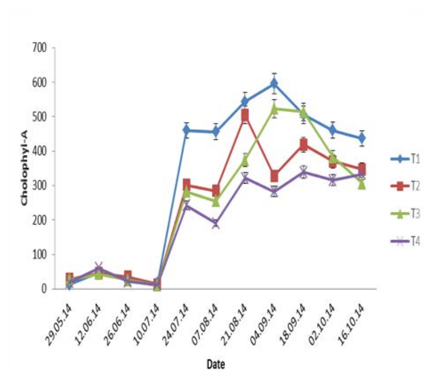


Fortnightly fluctuation of Nitrite-nitrogen among four treatments

Results

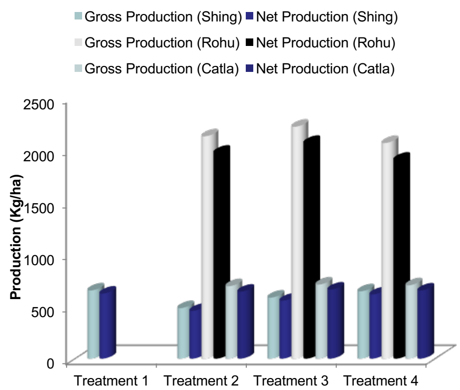


Fortnightly fluctuation of Ammonia-nitrogen among four treatments

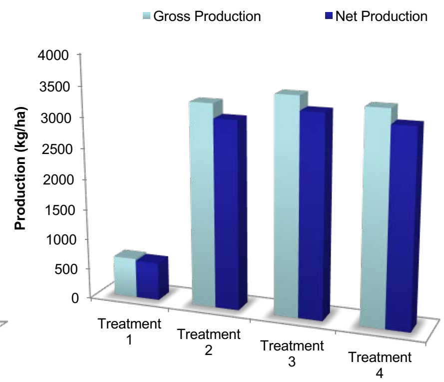


Fortnightly fluctuation of Chlorophyll-a among four treatments

Results



Gross and net production of three fish species in different treatment



Combined gross and net production of three fish species in different treatment

Growth performance outcomes for Study. Values are mean ± SD. Values with different letters are significantly different ($P < 0.05$). NA = not applicable

	Treatment 1	*Treatment 2*	*Treatment 3*	*Treatment 4*
Shing *(Heteropneustesfossilis)*				
Stocking Weight (g)	1.13 ± 0.98	1.13 ± 0.98	1.13 ± 0.98	1.13 ± 0.98
Harvesting Weight (g)	24.73±3.45	20.62±3.50	22.70±2.34	24.44±5.09
Weight Gain (g)	23.60±3.45	19.49±3.50	21.57±2.34	23.31±5.09
Initial Length (cm)	5.53±1.67	5.53±1.67	5.53±1.67	5.53±1.67
Final Length (cm)	16.08±2.10	15.28±2.12	15.59±2.18	15.99±2.77
Net Length (cm)	10.55±2.10	9.75±2.12	10.06±2.18	10.46±2.77
Survival Rate (%)	53.00±6.36	47.50±5.02	52.00±2.44	53.35±2.00
Specific Growth Rate, SGR (%)	1.83±0.08	1.72±0.10	1.78±0.06	1.82±0.13
Gross Production (kg/ha)	652.21±158.42	483.65±100.90	583.71±70.80	644.23±134.30
Net Production (kg/ha)	622.63±155.25	457.14±99.46	554.68±69.99	614.44±134.09
Rohu (*Labeorohita*)				
Stocking Weight (g)	NA	21.76± 7.76	21.76± 7.76	21.76± 7.76
Harvesting Weight (g)	NA	304.81±106.6	309.63±103.26	279.92±119.29
Weight Gain (g)	NA	283.05±106.61	287.87±103.26	258.16±119.29
Initial Length (cm)	NA	12.48±1.40	12.48±1.40	12.48±1.40
Final Length (cm)	NA	28.95±2.54	29.58±2.08	28.02±3.34
Net Length (cm)	NA	16.47±2.54	17.1±2.08	15.54±3.34
Survival Rate (%)	NA	90.63±8.92	89.38±8.75	92.19±3.73
Specific Growth Rate, SGR (%)	NA	1.54±0.22	1.55±0.21	1.48±0.27
Gross Production (kg/ha)	NA	2126.67±561.52	2218.06±874.12	2062.45±941.87
Net Production (kg/ha)	NA	1970.80±575.10	2064.34±863.13	1903.90±936.21
Catla (*Catlacatla*)				
Stocking Weight (g)	NA	27.30± 8.23	27.30 ± 8.23	27.30 ± 8.23
Harvesting Weight (g)	NA	368.60±117.88	402.08±57.89	389.40±119.54
Weight Gain (g)	NA	341.30±117.88	374.78±57.89	362.10±119.54

Results

Combined Net production

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Level of Significance
Gross Production (kg/ha)	**652.21±158.42** [a]	3303.16±825.23 [b]	**3510.66±904.85** [b]	3408.16±853.72 [b]	**
Net Production (kg/ha)	**622.63±155.25** [a]	3068.85±774.45 [b]	**3280.04±852.98** [b]	3170.60±805.46 [b]	**

Spawning response 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 of this species in the temperate region has restricted for expansion in culture as well as rehabilitation in natural waters. An experiment was conducted at the Department of Aquaculture and Fisheries, Agriculture and Forestry University, Rampur, Chitwan during August 2014 to April 2015 to explore and assess the breeding performance of sahar in the Terai region of Nepal, which has a subtropical climate. Twenty eight male (0.5-1.5 kg) and 35 female (0.8-2.5 kg) brood fish were reared in ponds at 1000 kg/ha and provided 35% supplementary feed. Maturity was observed by sampling fish and applying pressure to the abdomen to express gonads biweekly during off-season; this frequency was increased to every third day as breeding season approached. One female sahar of 3-5 years old was ready for breeding in March when the water temperature was 23.3-25.2 °C. In the same month, another female responded to injection of inducing hormone (ovaprim) at the rate of 0.5 ml/kg when the temperature was 25.3-28.7 °C. Males about 1-2 years old were expressed milt in almost all months during experiment. Ova from mature females were obtained by simple hand stripping method and fertilized with milt collected from males manually. The fertilized eggs were incubated in Atkin hatching trays. Survival and growth of the fry were high (Table 1) and maturation details were similar to fish spawned under temperate conditions. This study demonstrated that natural and induced breeding and fry rearing is possible in the Terai region of Nepal. However, further studies on synchronization of breeding time and mass seed production are recommended.

TABLE 1. Breeding performance of sahar with and without using inducing hormone

Description	Natural breeding	Induced breeding
Date	9 March 2015	27 March 2015
Temperature (°C)	23.3 -25.2	25.3-28.7
Female body wt (kg)	1.2	1.3
Male body wt (kg)	0.65 and 0.80	0.72 and 0.87
Total egg spawned	2585	4738
Egg number per kg body wt	2119	3746
Ovulated eggs per g	94	103
Fertilization rate (%)	98	99
Incubation period (hour)	96-104	80-88
Hatching rate (%)	95	97
Hatchling survival (%)	81	90
Yolk sac absorption period (days)	6	5
Time to swim up fry (days)	17	17

A
F
U

SPAWNING RESPONSE OF SAHAR *Tor putitora* IN SUB TROPICAL CLIMATE OF NEPAL

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Introduction

- Sahar *Tor putitora*, known as "Golden Mahseer" is most popular freshwater indigenous species of trans-Himalayan regions as sport fisheries
- Two species *Tor putitora* and *Tor tor* have been reported in Nepal
- Sahar comprises one of the main species of fisheries resources and sustaining livelihood of fisher.
- Sahar is carnivore in nature when it grow adult.

- This fish is economically important high value indigenous species due to its massive size and high price in the Nepalese market.
- Despite their importance, their biological diversity is being threatened by various anthropogenic factors.
- It is long migratory, migrate upward to small rivers for natural spawning and shows intermittent spawning behavior.
- Sahar is still taken in capture fisheries in lakes and rivers, but no commercial cultivation has begun.
- At present attempts to culture and conserve *Tor spp*. has been initiated in most of trans-Himalayan countries.

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 and without inducement of hormone
- To assess the growth and survival rate of fry in tropical climate

Methodology

- **Experimental setup**
  - at aquaculture farm (AFU) from 1st August 2014 to 30th April 2015
- **Brood fish collection**
  - 33 broods (28 male and 5 female) - aquaculture farm (AFU)
  - 30 female brood from FRC, Pokhara
- **Brood fish rearing**
  - cemented pond (25 m^2)
  - earthen pond (400 m^2)
  - stone pitched pond (250 m^2)
- Stocking rate 1000 kg/ha

- **Feeding and water management**
  - Fed with 35 % CP containing feed @ 4% of total biomass
  - 20 % water was replaced daily in cemented pond
- **Maturity observation**
  - Biweekly (Aug- Sept) and weekly (Oct- November)
  - Alternate day (Feb-Mar)
- **Spawning method**
  - With and without hormone use (natural and induced) spawning

Maturity observation

Brood fish hauling

Maturity observation

Induced breeding (use of hormone)

Ovaprim (Gonadotropine Releasing Hormone) was applied @ 0.5 ml/kg of female body weight

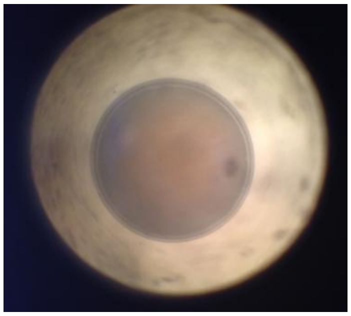
Hatchery operation

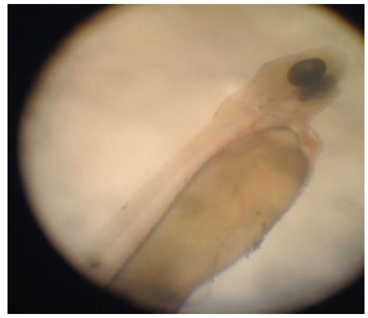



Egg incubation




Egg development





$$\text{Relative fecundity (eggs/kg)} = \frac{\text{number of eggs (estimated)}}{\text{weight of female , kg}} \text{ x 1000}$$

$$\text{Fertilization rate (\%)} = \frac{\text{Number of fertilized eggs}}{\text{Total number of eggs}} \text{ x 100}$$

$$\text{Hatching rate (\%)} = \frac{\text{Number of hatchlings}}{\text{Total number of fertilized eggs}} \text{ x 100}$$

$$\text{Survival rate (\%)} = \frac{\text{Number of fry harvested}}{\text{Number of larvae stocked}} \text{ x100}$$

Growth evaluation of fry

- **Fry stocking**
  - Sahar fry of 0.073-0.077 g body weight were stocked at 200 heads/m^2 in small happas ($1m^2$)
- **Feed and feeding of fry**
  - 35% crude protein containing commercial and farm made feed fed thrice /day at the rate 5 % of total mass.
- **Experiment was conducted for 40 days**
- **Sampling was taken -10 days interval to measure the growth and survival %**

$$\text{Daily growth rate (g/f)} = \frac{\text{Mean final weight (g)} - \text{mean initial weight (g)}}{\text{culture period(days)}}$$

$$\text{Specific growth rate (\%/day)} = \frac{\text{Mean(ln)final wt. (g)} - \text{Mean(ln)initial wt. (g)}}{\text{culture period(days)}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{Number of fry harvested}}{\text{Number of larvae stocked}} \times 100$$

Proximate composition of feed

S.N	Description	%
1	Crude Protein	35
2	Crude Fat	9
3	Ash	7
4	Fiber	8
5	NFEE*	31
6	Moisture	10

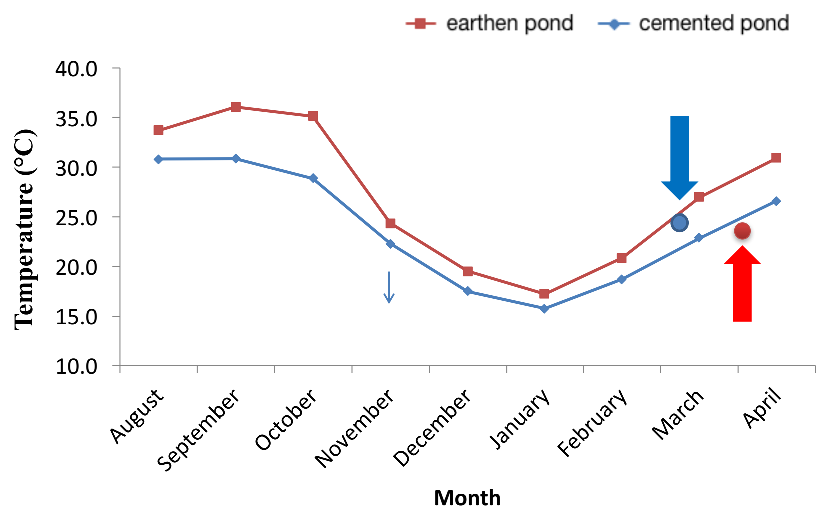
* Nitrogen free ether extract

Results and Discussion

Result of Maturity observation in different month

Date	Over matured	Spawned	Temperature (°C)
21st November 2014	1		21.2-23.0
24th November 2014	1		19.7-22.8
8th December 2014	1		18.2-21.2
21st February 2015	1		19.1-21.3
24th February 2015	2		19.4-22.0
27th February 2015	1		20.6-22.8
4th March 2015	2		22.5-26.0
7th March 2015	1		22.2-25.4
9th March 2015	1	**1**	**23.3-25.2**
27th March 2015		**1**	**25.3-28.7**

Spawning response of female broods



Breeding performance with and without inducing hormone

Description	Natural	Induced
Date	9th March 2015	27th March 2015
Temperature (°C)	23.3 -25.2	25.3-28.7
Female body wt (kg)	1.22	1.27
Male body wt (kg)	0.64, 0.80	0.72, 0.86
Total egg number	2585	4738
Egg per kg body wt	2119	3746

Breeding performance with and without inducing hormone

Description	Natural	Induced
Ovulated eggs per g	94	103
Fertilization rate (%)	98	99
Incubation period (hour)	96-104	80-88
Hatching rate (%)	95	97
Hatchling survival (%)	81	90
Yolk sac absorption period (Days)	6	5
Time to free swimming fry (Days)	17	17

Mean and Range of Egg diameter, length and weight of larvae

Parameters	Natural	Induced
Mean diameter of egg (mm)	2.9±0.2	3.1±0.3
	(2.8-3.5)	(2.8-3.3)
Mean weight of egg (mg)	12.37±0.80	12.69±0.78
	(11.57-13.17)	(11.97-13.47)
Mean length of larvae (mm)	9.4±1.2	8.9±0.7
	(8.2-10.6)	(8.2-9.6)
Mean weight of larvae (mg)	13.01±0.53	13.19±0.49
	(12.48-13.54)	(12.70-13.68)

Growth performance of fry fed on two different feeds

Parameters	Commercial	Farm made
Initial wt. (mg)	76.47±7.65[a]	71.00±3.38[a]
Final wt. (mg)	252.11±40.82[a]	330.88±39.49[a]
SGR (%/day)	2.97±0.61[a]	3.84±0.25[a]
DWG (mg/fish/day)	4.39±1.17[a]	6.50±0.94[a]
Survival (%)	98.6±2.31[a]	98.0±1.80[a]
AFCR	1.7±0.2[a]	1.2±0.1[b]

Water quality parameter during experiment

Stage	Temperature (°C)	DO (mg/L)	pH
Brood rearing	15.5-32.8	3.5-7.2	7.3
Spawning	23.3 -25.2 25.3-28.7	4.5	7.2
Egg incubation	21.0-25.8 24.0-27	6.6-7.0	7.3-7.4
Fry Rearing pond	33.5-33.7	4.8- 6.0	7.6

Results at reference site in mid hill Pokhara

Fecundity:
90-105 eggs/g

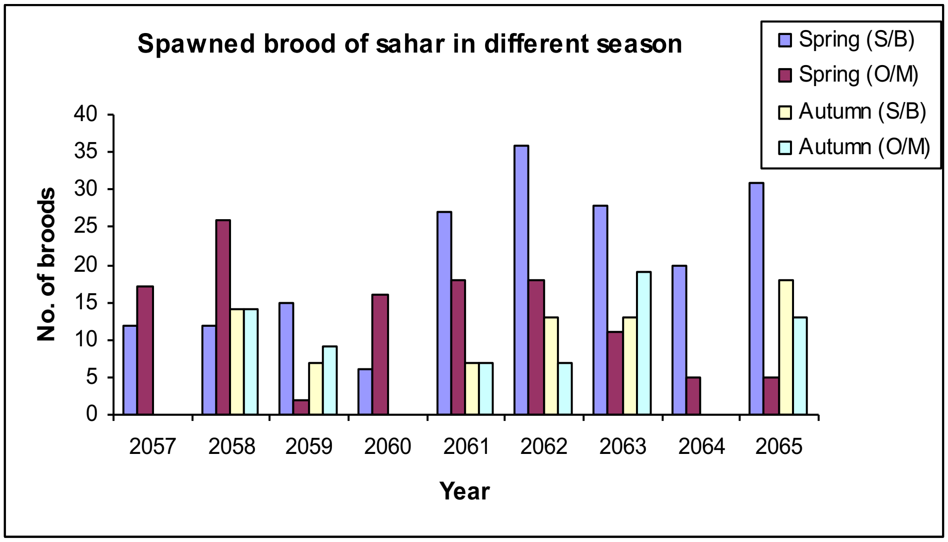
Fertility: 90-95 %

Hatchability: 75-95%.

Spawning performance at reference site

Description	Sept-Oct 2013	Feb-Mar 2014
Female, No.	100	100
Responded female, No. (%)	60 (60%)	88 (88%)
Normally spawned brood (%)	10 (10%)	46 (46%)
Over matured (%)	50 (50%)	42 (42%)
Not spawned (%)	40 (40%)	12 (12%)
Post spawning mortality (%)	0%	0%

Spawning behavior of Sahar in spring and autumn season in last few years



Growth of sahar reared in hill and Terai

Month	Hill (temperate)	Terai (tropical)
April	3.6±1.2 [a]	3.6±0.74 [a]
May	6.2±2.8 [a]	10.2±1.8 [b]
June	18.7±4.8 [a]	24.6±3.9 [b]
July	18.8±6.5 [a]	29.7±5.5 [b]
Aug	27.8±6.5 [a]	38.9±5.6 [b]
Sep	31.6±5.9 [a]	50.6±6.3 [b]
Oct	39.0±5.8 [a]	60.8±10.4 [b]
Net weight gain	32.8	50.6
Growth rate g/day	0.18	0.28

Different superscripted letters are sig. different ($P<0.05$) within row

Sahar in Cultured condition

- Tolerate wider range of temperature (13-35°C) without any adverse effect on survivability and growth.
- Survive well in all aquaculture environment (pond, raceway and cages).
- Accept artificial feed as an active feeder.
- Prefer cool and clean water for gonad development.
- Require higher level of dissolved oxygen (DO) in pond condition.

Reproductive behavior of Sahar

- Male get maturity within one year, though the size of fish even 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 (1-2days)
- No hormone injection was applied for spawning in previous study at reference site in mid hill (temperate region)
- But in this study female responded by inducing hormone.

Conclusion and Recommendation

- Pond reared Sahar breed twice in a year in two distinct season, Spring (February-March) and Autumn (September - October) and spring season which is more favorable in Nepal.
- But in natural waters it spawn during monsoon when river and rivulets are fool of flood.
- Higher spawning rate can be achieved by determining the optimum stripping time by frequent checking of female fish or by inducing hormone to avoid over maturity.
- Mass scale seed production Technology need to be develop for giving out in private hatcheries.

Funding for this research was provided by the

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THANK YOU

Understanding sex change and hermaphroditism in African lungfish *Protopterus aethiopicus* and its implication to aquaculture: Preliminary findings

John Walakira, John Kiburara, Arkanjelo Idrifua, Joseph Molnar, Eugrance Ganda, Godfrey Kityo, Cassias Aruho
National Fisheries Resources Research Institute, Uganda.
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Development of sustainable aquaculture technologies for production of African lungfish seed is still a challenge attributed to knowledge gap in its reproductive development. Its successful culture will improve household nutrition, food security and income in Uganda. To build on existing knowledge the reproductive development of 578 feral *P. aethiopicus* collected from Lakes Wamala and Bisina was investigated to obtain data for its future breeding program. The study revealed a possible sex change and hermophroditism in *P. aethiopicus* specimens based on histological analysis of gonadal samples from fish ranging 4 to 6600g. Information on naturally occurring sex change or hermaphroditism in African lungfish will greatly contribute to our understanding of factors that determine its sex, and subsequently towards development of appropriate spawning techniques for mass seed production.

UNDERSTANDING SEX CHANGE AND HERMAPHRODITISM IN AFRICAN LUNGFISH *Protopterus aethiopicus* AND ITS IMPLICATION TO AQUACULTURE: PRELIMINARY FINDINGS

John Walakira

National Fisheries Resources Research Institute

African lungfish

- Species: *Protopterus aethiopicus* (Haeckel 1851)
- Air-breathing fish
- Aestivates in drought conditio

Distribution of African lungfish

Protopterus annectans

Protopterus aethiopicus

Protopterus dolloi

Protopterus amphibius

Paugy et al. (2008); Froese and Pauly (2009); Otero, (2011).

Why lungfish?

1. Improves food nutrition & Income

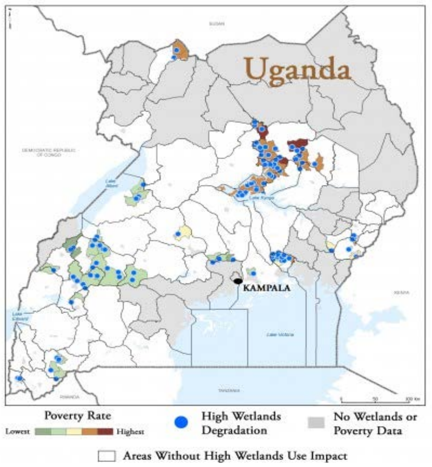
2. Natural stocks are declining (Goudswaard, al. 2002).

3. Aquaculture potential; co-cultured with farmed tilapia

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

5. Research {Largest genome 1.33 billion base pair}

Problem Statement



Source: World Resources Institute

- Climate change + anthropogenic factors
  = reduced stocks

- Sustainable strategy? Aquaculture

Challenge

i. No seed production technology

i. Sex identification of lungfish is difficult

Objective

Overall objective: Develop sustainable seed production technology for African Lungfish (*Protopterus aethiopicus*) to improve livelihoods & nutrition for vulnerable communities in Uganda

Specific objectives:

Objective 1: Understand the reproductive biology of feral African lungfish.

Objective 2: Develop a tool for sex identification of lungfish

Methods & materials

Study 1

Feral samples collected from Lakes Bisina (*N=341*) and Wamala (*N=263*) from Nov 15-Feb 16,

i) Histological analysis to verify the gonad developmental stage.

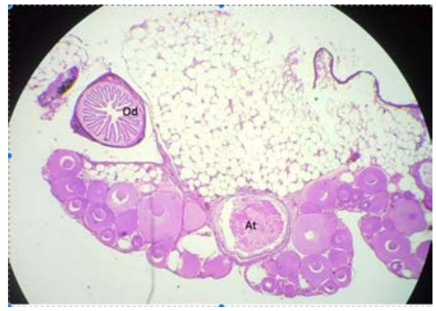
ii) Determine Length at maturity using non-linear two-parameter model (Booth 1997)

$$P = 1/\ (1+e)^{-(\alpha+\beta * L)}$$

- *α and β = regression coefficients*
- *L = length of 50% maturity fish*

iii) Sex ratio

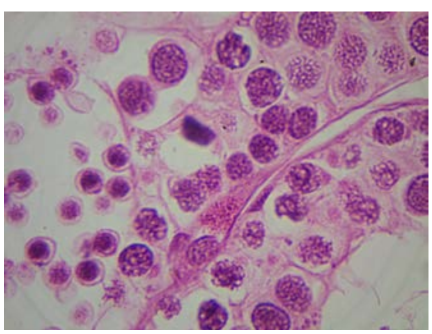
Results: No evidence of hermaphroditism!

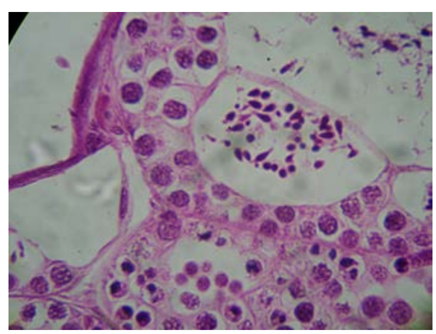


Female: Stage V

Female: Stage (I347.44 ± 50µm)

Results: Gonochorism

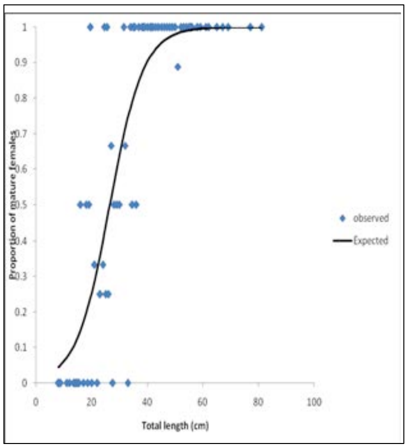




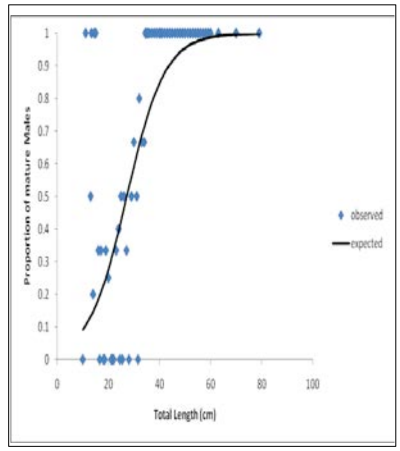
male : spermatogonia

male : Sg I

Results: Lake Bisina



Females from Lake Bisina; L_{50}=26.5



Males from Lake Bisina; L_{50}=27. 18cm

Lake Bisina vs Wamala

Lake	Males- TL (cm)	Females-TL (cm)	Sex Ratios Females: males
Wamala	20.3	24.5	0.863: 1*
Bisina	27.2	26.5	1.86: 1**

*did not deviate significantly from 1:1 ratio (χ^2 ● 3.841, p > 0.05)

Study II: Breeding trials

Artificial Breeding trial

HORMONE USED	MASS	40% VOLUME/mls 1st dose	60% VOLUME/mls 2nd dose	TOTAL VOLUME/mls	RESPONSE
LHRHA CONC. 300ug/Kg	187	0.24	0.36	0.6	None
	221	0.24	0.36	0.6	None
	354	0.32	0.48	0.8	Active
	361	0.32	0.48	0.8	Active
	480	0.4	0.6	1.0	Active
	460	0.4	0.6	1.0	Active

pH= 8.21; DO= 4.8 mg/L: Temp = 28.2^{0}C; TAN= 0.001mg/L: Nitrite= 0.0)mg/lL

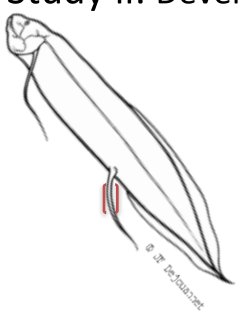
(34-45)mm

Hatchability= 87%

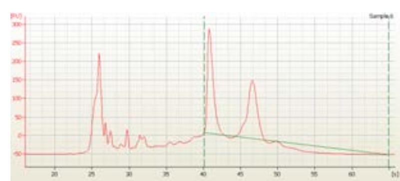
(90-120)mm

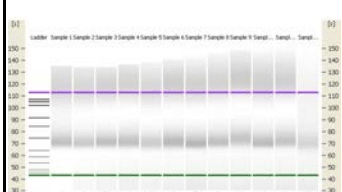
survival= 74%

Study ii: Development of SNP panel using RNA Seq



Total RNA from 30/60 : Trizol protocol

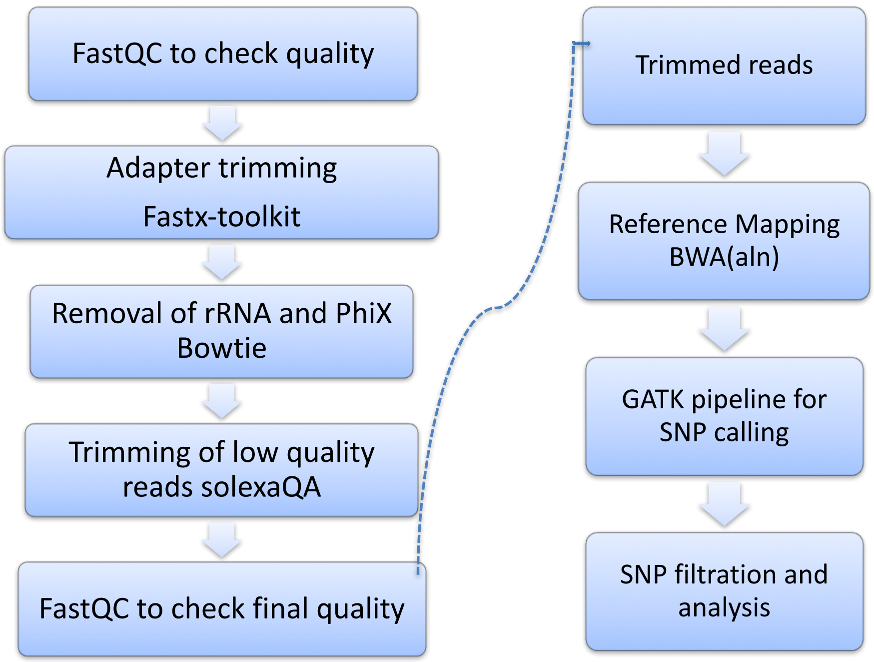




mRNA from 18 samples (3/lake); QubIt: 10.4 - 46.7, BIOANALYSER

cDNA, MiSeq platform

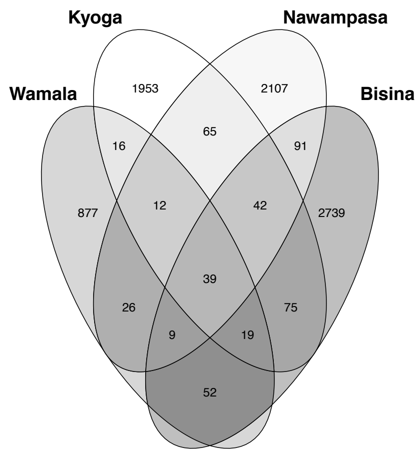
44,375,286 reads; Paired end 2X 300; 35 – 301 bp



Summary SNPs through *Denovo* pipeline

Lakes	total SNPs	Private SNPs	shared SNPs
Bisina	200106	46365	73905
Edward	118554	4217	130538
George	118924	4796	68159
Kyoga	99537	3600	33676
Nawampasa	130672	5889	17595
Wamala	153450	9038	9851
Total	**821,243**		

SNP panel



Conclusion

- No evidence of hermophroditism in lungfish from two lakes
- Lungfish breeds in tanks if induced with artificial hormones
- Sex determination is still a challenge

Generating sustainable technologies

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Climate Change Shrinking Uganda's Lakes and Fish

By Wambi Michael

Studies show that indigenous fish species in Uganda – here being caught on Lake Victoria – have shrunk in size due to an increase in water temperature as a result of climate change. Credit: Wambi Michael/IPS

KAMPALA, Aug 22 2015 (IPS) - Climate change is reducing the size of several species of fish on lakes in Uganda and its neighbouring East African countries, with a negative impa the livelihoods of millions people who depend on fishing for food and income.

Studies conducted on inland lakes in Uganda, including Lake Victoria which is shared by three East African countries, indicate that indigenous fish species have shrunk in size due t

Funding for this research was provided by the

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AquaFish Technical Session 3
Innovations in Smallholder Aquaculture Technology: AquaFish Research on Snakehead

Impacts of climate change on snakehead value chains in the Lower Mekong Basin of Cambodia and Vietnam

Navy, H., Minh, T. H. and Pomeroy, R.S
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[2] College of Aquaculture and Fisheries, Can Tho University, Cantho, Vietnam
[3] University of Connecticut-Avery Point, Department of Agricultural and Resource Economics, Goton, Connecticut, USA
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Many capture fisheries resources in the Lower Mekong basin of Cambodia and Vietnam have been largely overexploited resulting in the development of aquaculture, especially for snakehead. The snakehead value chain is affected by climate and non-climate factors (such as water development - hydropower dam development) related drivers of change, including increased temperatures, changes in rainfall patterns, changes in the hydrological regime (water levels, duration of flooding, timing of flooding), and more. This study examined the vulnerability of snakehead capture and culture value chains in the Lower Mekong Basin of Cambodia and Vietnam. One of the most frequently cited climate impacts is changing rainfall patterns resulting in severe storms and flooding. The study identified impacts and proposed adaptation strategies for various actors in the value chain. Options to assist the fish farmers and fishers across the value chain include: assisting the farmers in understanding and preparing for the impacts of climate change on their business; the actors in the value chain need to begin working together; the Government should consider reviewing the ban on snakehead aquaculture in order to provide an alternative livelihood to households as an adaptation strategy; and the Government should restrict the law on fisheries, enhance law enforcement and impose heavy fine on illegal fishing in order to prevent the mass destruction of these two fish species.

ASIAN-PACIFIC AQUACULTURE 2016

IMPACTS OF CLIMATE CHANGE ON SNAKEHEAD FISH VALUE CHAINS IN THE LOWER MEKONG BASIN OF CAMBODIA AND VIETNAM

Navy, H., Minh, T. H. and Pomeroy, R.S.

Indonesia, 26-29 April 2016

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Background

- The productive Mekong fisheries are essential to the food security and nutrition of the 60 million people of the Lower Mekong Basin (LMB).
- Freshwater fish consumption in Cambodia and Vietnam ranges up to 40 Kg/person/year, making them in the top three countries in the world.
- Fish contributes 81% of the population's protein intake in Cambodia and 70% in the case of Vietnam.
- Snakehead capture fisheries in Cambodia and aquaculture in Vietnam have been highly vulnerable to climate change.
- Adaptation is urgently needed to foster the resilience of the fisheries and aquaculture sectors.
- The presentation will focus on climate change impact on SH value chain, vulnerability and adaption of fishers and farmers.

Objectives

General Objective: To assess the vulnerability of the Snakehead capture and culture in the LMB of Cambodia and Vietnam, to predict impacts from climate change, using concept of the value chain (VC) on fish market and trade.

Specific Objectives:

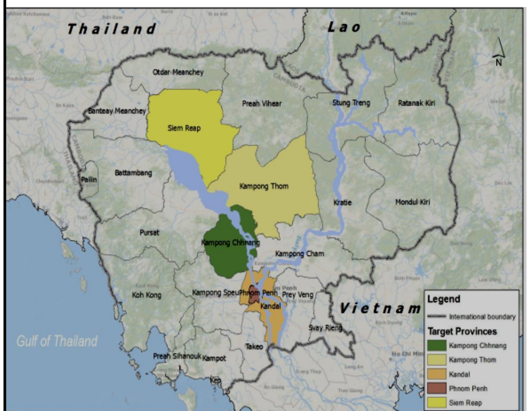
- To identify current and pathways of climate change and corresponding adaptation strategies in Snakehead VC;
- To provide recommendations in order to contribute to sustainable development of aquaculture and fisheries in the LMB.

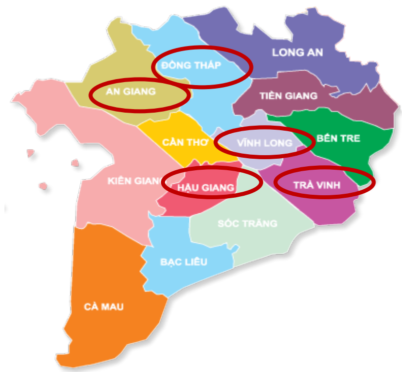
Methodology

- The study were conducted in 4 provinces and Phnom Penh city in Cambodia and 5 provinces in Vietnam
- Total sample of 216 in Cambodia and 209 in Vietnam were structurally interviewed with fishers, farmers, processors, and seed processors
- ACCESS software and EXCEL were used for database and using EXCEL and SPSS for data analyzed
- The vulnerability assessment was conducted based on data on exposure, sensitivity, potential impact, adaptive capacity and vulnerability and analyzed using two formulas (Glick, Stein and Edelson 2011):

  Potential Impact (PI) = Exposure (EX) + Sensitivity (SE)
  Vulnerability = PI + AC (Adaptive Capacity)

The study areas in Cambodia and Vietnam

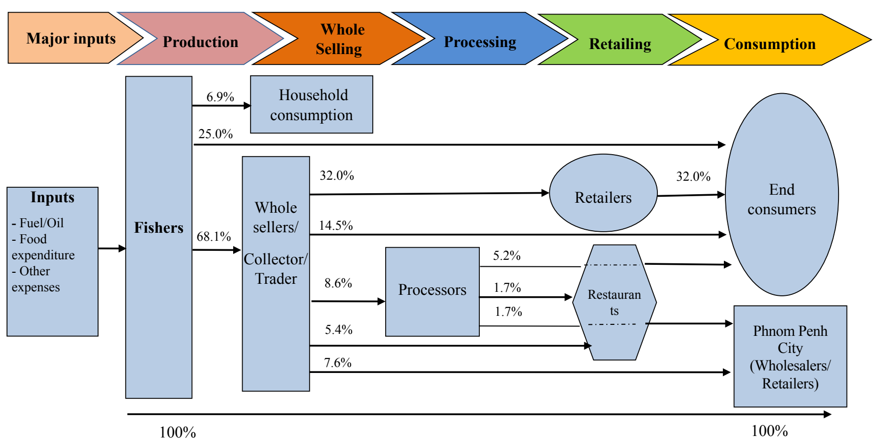




Cambodia **Vietnam**

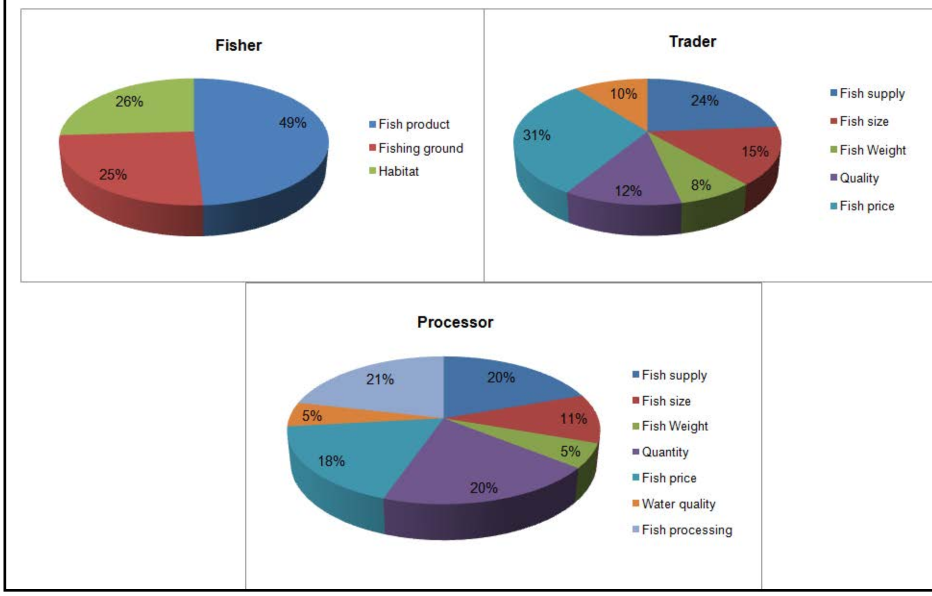
RESULTS IN CAMBODIA

Map of Capture Snakehead VC the LMB of Cambodia

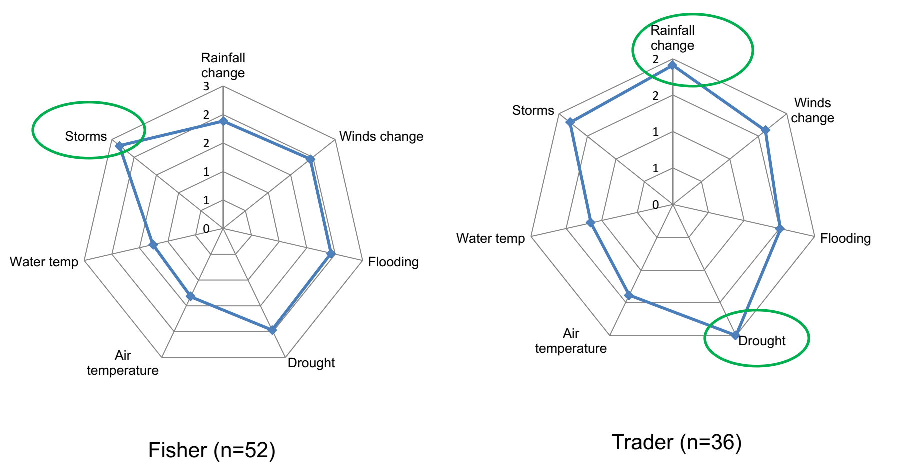


1. The total catch of captured snakeheads per fisher household in Cambodia were decreased, due to increasing of fishers, use illegal fishing gears such as electro fishing gear, mosquito net trap, dragnet etc. An average annual snakehead catch per household were 1,408 kg, in 2014.
2. Major difficulties faced by snakehead fishers included: (1) loss fishing ground, (2) decreased fish catch and fish in the natural, (3) high input costs – i.e. fuel, food, fishing gears and equipment, and (4) lack of capital.

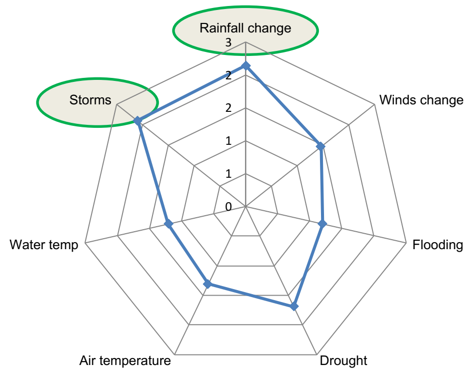
Main impacts of climate change on fisher, trader and processor in Cambodia



The Vulnerability Assessment Matrix for F and T

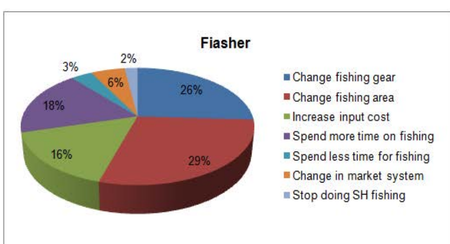


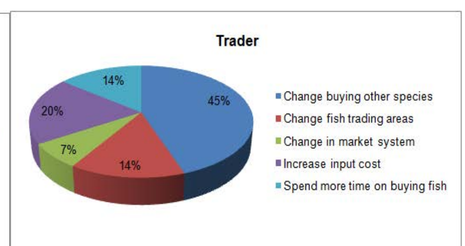
The Vulnerability Assessment Matrix for Processors

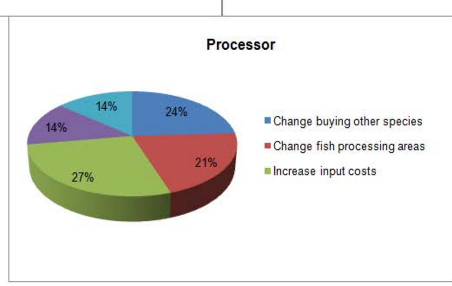


Processors (n=15)

Adaptation strategy to deal with the climate change by fisher, trader and processor in Cambodia







Adaptation Strategies of SH Value Chain Actors in Cambodia

- ✓ **Fishers:** change fishing gears, change fishing areas, increase input cost, spend more time on fishing, and stop doing snakehead fishing
- ✓ **Traders:** buy other species, change to new areas where trading is easier and more profitable, increase input cost, and spend more time buying fish
- ✓ **Processors:** buy other species, change to new areas where fish processing is easier and more profitable, increase input cost, and spend more time buying fish.

Conclusion and Recommendation in Cambodia

- ✓ Snakehead are preferred fish species for food in Cambodia.
- ✓ Snakehead production are seem to be highly vulnerable to both climate and non-climate related drivers of change such as hydropower dam development.
- ✓ The Government needs to become more active in working with the various actors in snakehead value chain to assist them in understanding and preparing for the impacts of climate change on their business.
- ✓ The actors in the value chain will need to begin working together or be organized to be able to share information and develop appropriate adaptation strategies to address the impacts of climate change on their business.
- ✓ The Government should consider reviewing the ban on snakehead aquaculture in order to provide an alternative livelihood to households as an adaptation strategy.
- ✓ The Government put high pressure and prohibit all illegal fishing gear, over fishing, or any activity done to harm all these resources in order to make sure that it is sustainable for people consumption demand.

Snakehead species and processing products in Cambodia

RESULTS IN VIETNAM

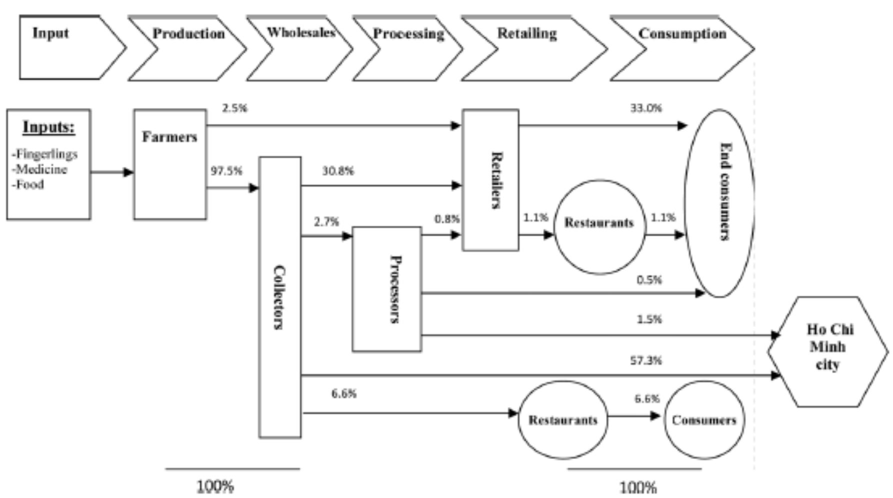
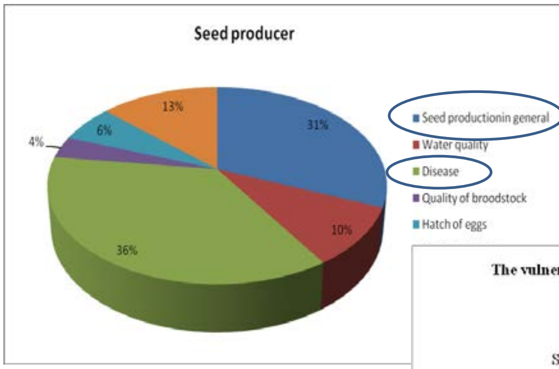
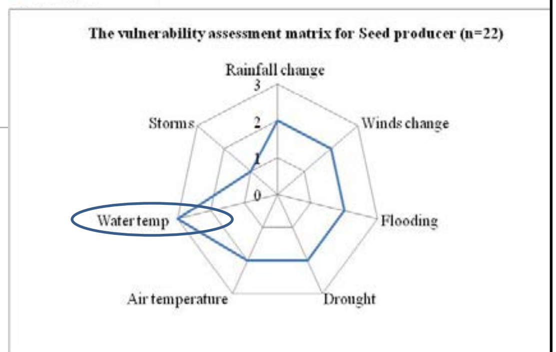


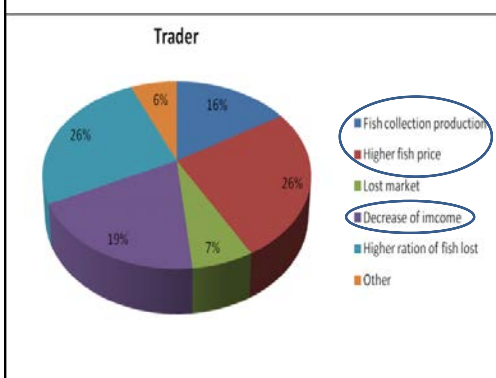
FIGURE 3 Mapping of value chain of cultured snakeheads in the LMB of Vietnam.

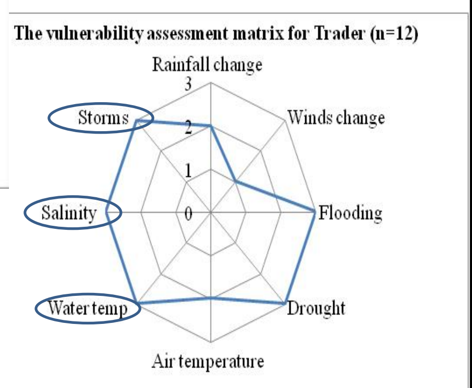
Main impacts and vulnerability of climate change on seed producer in Vietnam



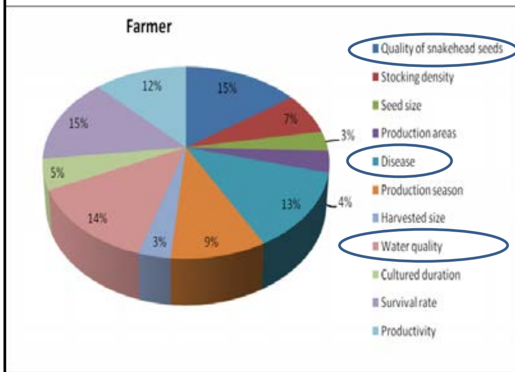


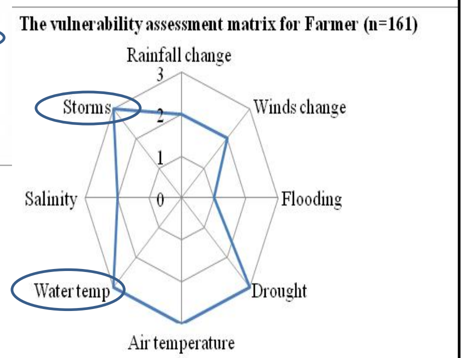
Main impacts and vulnerability of climate change on trader in Vietnam



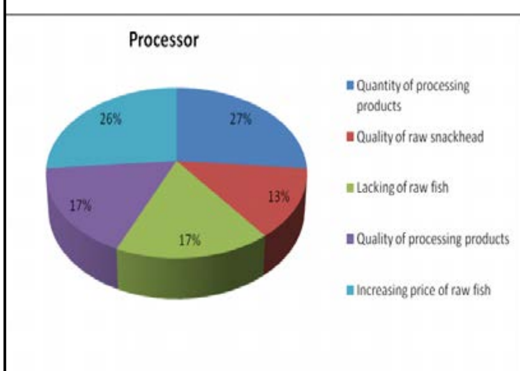


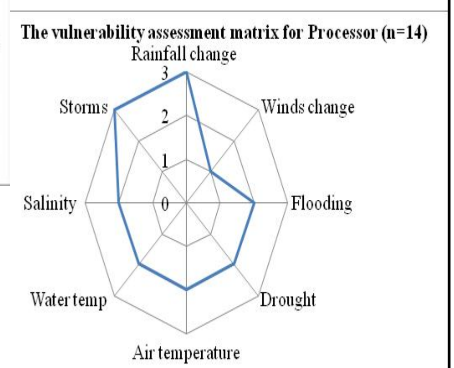
Main impacts and vulnerability of climate change on Sneakhead farmer in Vietnam





Main impacts and vulnerability of climate change on processor in Vietnam





Adaptation Strategies of SH Value Chain Actors in Vietnam

- ✓ **Adaptation**: changing in seed production scale, temporary stop seed producing, selecting better broodstocks and applying modern technology in seed production.
- ✓ **Farmers:** Changing to other culture model, stopping or changing culture technique, changing culture scale and increasing input cost in farming.
- ✓ **Trader:** choosing other fish species business, buying raw fish from other region, increasing input costs,
- ✓ **Processors:** buy other species, change to new areas where fish processing is easier and more profitable, increase input cost, and spend more time buying fish.

Conclusion and Recommendation in Vietnam

- End consumer and Ho Chi Minh markets are the major markets of sneakhead value chain in Vietnam;
- Rainfall change patterns impact negatively in sneakhead seed production and trading. Drought impact negatively to seed production, farming and trading.
- Water temperature (Temp.) is major vulnerable in seed production; storm, water temperature and drought are main vulnerable factors in sneakhead culture; storm, salinity, water temp., flooding and drought are vulnerable events to trading; storm and rainfall are vulnerable events in fish processing.

Funding for this research was provided by the

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Thank you for your attention

Thank Aquafish Innovation Lab




Evaluating growth performance and immune responses of snakehead *Channa striata* by feeding plant protein diets supplemented with mannan oligosaccharide

Thi Thanh Hien Tran , Pham Minh Duc*, Tran Minh Phu, Tran Le Cam Tu, Dang Thuy Mai Thy, and Bengtson David
[1]College of Aquaculture and Fisheries, Can Tho University, Vietnam
[2]Rhode Island University, USA
ttthien@ctu.edu.vn

The objective of this study was to evaluate the effectiveness on growth performance and immune responses of mannan oligosaccharide (MO) supplementation in both soybean meal (SBM) and soy protein concentrate (SPC) formulated feeds for snakehead (*C. striata*). The experiment included three feed groups, one using fishmeal (FM) as the only protein source, the second replacing 40% of the FM with SBM, and the third replacing 40% of FM with SPC. Each feed group was then divided into three feed treatments which added 0%, 0.2%, and 0.4% MO. The diets were 44.3-45% protein and 19.17-19.69 KJ/g energy. Eighty snakehead fingerlings (initial mean weight 7.045±0.08 g/fish) were assigned randomly to each of twenty-seven 500-L composite tanks with continuous aeration and 30% daily water exchange. MO supplementation of diets based solely on FM versus diets in which 40% of FM had been replaced by either SBM or SPC. The experiment period was 8 weeks.

The results showed that both final weight (Wf) and weight gain (Wg) were significantly affected by diet and MO supplementation, as well as the interaction between the two. In general (with some exceptions), growth performance of fish was significantly better when they were fed SPC than when they were fed SBM or FM, and MO supplementation generally improved growth of the fish. FCR, PER and survival of fish in this experiment was significantly affected by diet, but only survival was significantly affected by MO supplementation and in no case were the interactions significant. FCR was significantly improved (i.e., lower) when fish were fed the SPC diet compared to the SBM diet, but neither was significantly different from fish fed the FM diet. PER for fish fed the FM and SPC diets was significantly greater than that for fish fed the SBM diet. Survival of fish fed SPC diet was significantly lower than that of fish fed the FM and SBM diets, but supplementation with MO, especially at the level of 0.2%, significantly improved survival. Red blood cell (RBC) counts were not significantly affected by either diet, MO supplementation, or the interaction of the two, but white blood cell (WBC) counts were significantly affected by both diet and MO supplementation (although not the interaction). Fish fed the SPC diet had significantly higher WBC counts than did fish fed the FM diet, but neither group was significantly different from fish fed the SBM diet. MO supplementation at both 0.2% and 0.4% levels significantly increased WBC counts compared to the unsupplemented diets. Immunoglobulin (Ig) levels were significantly increased by MO supplementation and the interaction of MO and diet, but diet did not affect Ig levels. At the end of the feeding trial but prior to the bacterial challenge, lysozyme levels were significantly affected by diet, MO supplementation and the interaction between the two. For each diet, the greater the level of MO supplementation, the greater the level of lysozymes. Reduction of fish production costs per kg fish produced, compared to fish fed the FM unsupplemented diet as the standard, ranged from 8.7 – 15.1 % for the various other diets tested. Following a 15-d bacterial challenge with *Aeromonas hydrophila*, fish lysozyme levels were significantly increased by MO

supplementation and the interaction between MO and diet, but not by the diets themselves. Again, the greater the level of MO supplementation, the greater the lysozyme level. After the 15-d challenge, cumulative mortality was lower for fish given MO supplementation than it was for fish fed the unsupplemented diets. In general, fish fed the SBM diet, supplemented or not, had lower cumulative mortality than fish fed the FM or SPC diets.

Asia Project: Cambodia and Vietnam

Growth performance and immune responses of snakehead (*Channa striata*) fed soy diets with supplementation of mannan oligosaccharide

Tran Thi Thanh Hien, Pham Minh Duc, Tran Minh Phu, Tran Le Cam Tu and Dang Thuy Mai Thy
College of Aquaculture and Fisheries, Can Tho University, Vietnam
***David A. Bengtson**, University of Rhode Island, USA*

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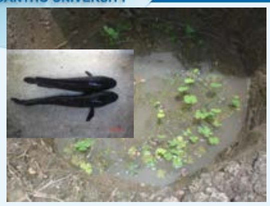
INTRODUCTION (1)




INTRODUCTION (2)

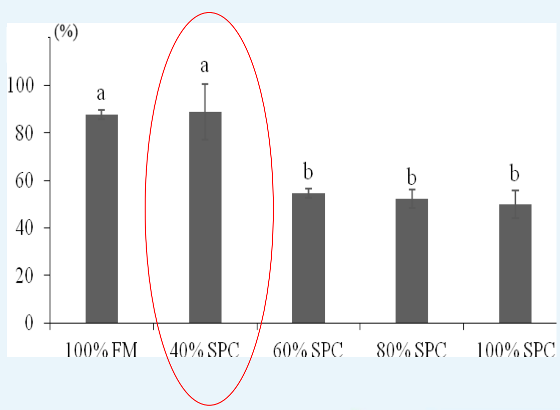


AquaFish CRSP and **AquaFish Innovation Lab** projects have contributed greatly to the success of snakehead aquaculture:

- ❑ **Domesticated breeding**;
- ❑ Protocols for the **weaning formulated feed** of hatchery-reared snakehead;
- ❑ Successful development of **pellet diets for growth out of snakehead**.

INTRODUCTION (3)

- ❑ The replacement of fishmeal by **soy protein concentrate (SPC) up to 40% in diet for snakehead in term of SURVIVAL RATE**



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INTRODUCTION (4)

Treatment	Wi (g)	Wf (g)	WG (g)	DWG (g/day)
100% FM	10.0 ± 0.13^{a}	44.4 ± 1.42^{a}	**34.8 ± 1.55^{a}**	0.83 ± 0.04^{a}
40% SPC	9.87 ± 0.12^{a}	42.7 ± 2.44^{a}	**33.1 ± 2.27^{a}**	0.79 ± 0.05^{a}
60% SPC	10.0 ± 0.18^{a}	19.3 ± 0.98^{b}	9.50 ± 1.07^{b}	0.23 ± 0.03^{b}
80% SPC	10.0 ± 0.07^{a}	18.6 ± 0.54^{b}	8.93 ± 0.64^{b}	0.21 ± 0.02^{b}
100% SPC	9.98 ± 0.20^{a}	13.4 ± 0.26^{c}	3.73 ± 0.07^{c}	0.09 ± 0.00^{c}

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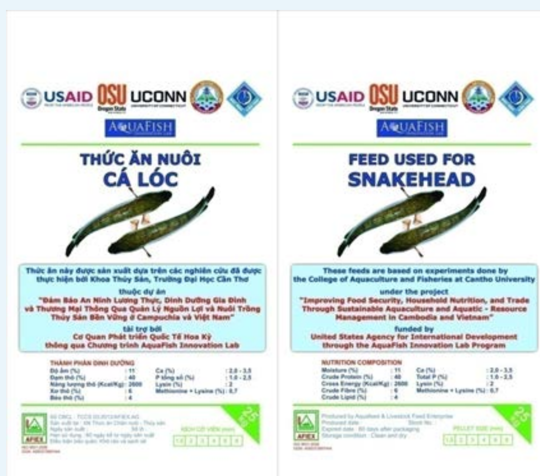
INTRODUCTION (6)

The feed formula for snakehead culture is FM protein can be replaced by SPC/SBM up to 40%



INTRODUCTION (7)

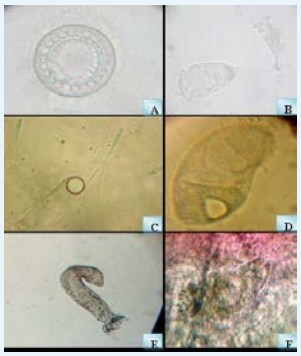


Fig. 1: Ectoparasite in snakehead:
A) *Trichodina* sp. in gill and skin;
B) *Epistylis* sp.; C) *Henneguya* sp.;...

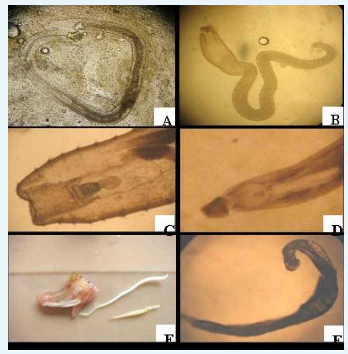
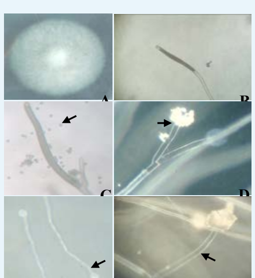
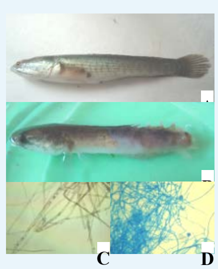
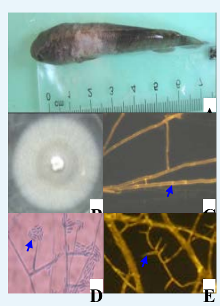


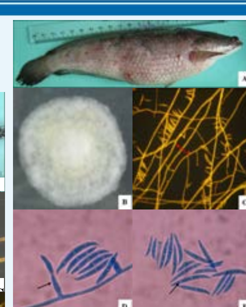
Fig. 2: Endoparasite in snakehead:
A) *Polyonchobothrium*;
B) *Proteocephalus*; C) *Spinitectus*; ...

INTRODUCTION (8)

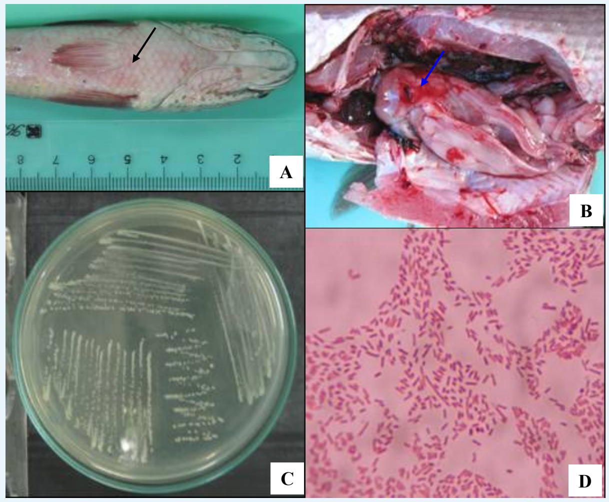








INTRODUCTION (9)



INTRODUCTION (10)

- Effects of Bio-Mos® on the performance of Tra Catfish (*P. hypophthalmus*) BioMos-GrowthTraCatfish.pdf (Hung at al., 2008);
- Effects of Bio-Mos® on the health of Tra Catfish (*P. hypophthalmus*): Response to stress and pathogen challenge BioMos-HealthTraCatfish.pdf (Hung at al., 2008);
- Bio-Mos What is Bio-Mos.pdf

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OBJECTIVE

The aim of this study was to determine whether MO supplementation in diets containing 40% replacement of FM with SBM or SPC improves the growth and immune response of snakehead

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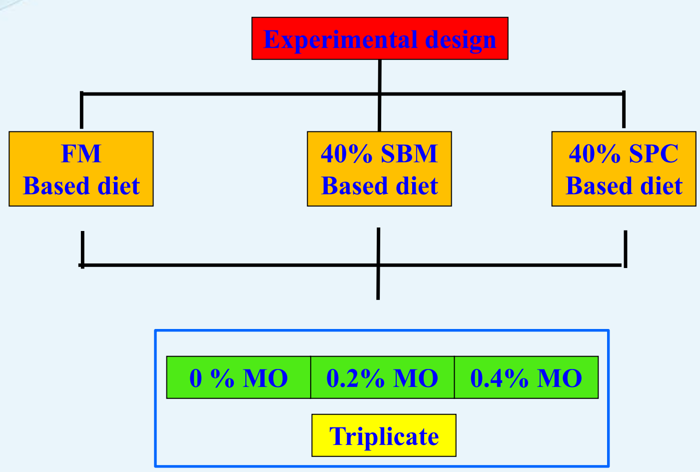
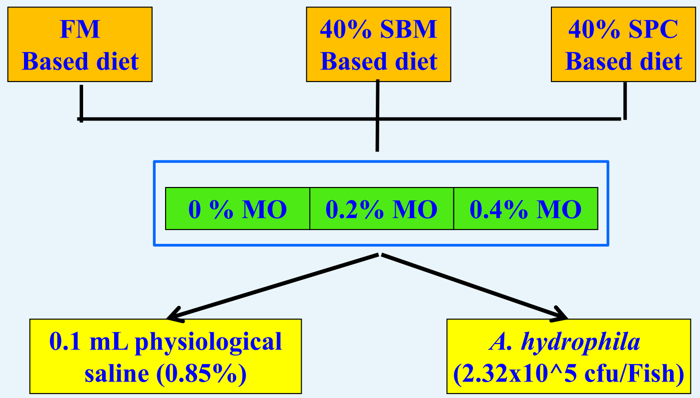
Experiment 1: Growth performance



Experiment 2: Bacterial challenge



Growth performance and immune response parameters

- **Growth performance**: Weight Gain; Food Conversion Rate (FCR); Protein Efficiency Ratio (PER); and Survival Rate (SR)
- **Immune response parameters**: Erythrocytes (RBC) Leukocytes (WBC); Lysozymes; and total immunoglobulin (Ig)
- **Bacterial challenge:** To determine the snakehead's disease resistance to *Aeromonas hydrophila* CT1403, recorded daily moribund fish, clinical signs, leasions

RESULTS: Growth performance (1)

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Treatment	W_i (g)	W_f (g)	WG (g)
FM	7.00±0.14	47.7±0.6^{d}	40.7±0.5^{f}
FM 0.2MO	7.05±0.03	52.5±1.2^{b}	**45.5±1.2^{b}**
FM 0.4MO	7.01±0.05	52.1±0.2^{b}	**45.0±0.2^{b}**
SBM	7.08±0.11	50.5±2.1^{bc}	43.4±2.0^{bd}
SBM 0.2MO	7.08±0.10	57.7±1.7^{a}	**50.6±1.6^{a}**
SBM 0.4MO	7.05±0.06	57.4±1.5^{a}	**50.3±1.5^{a}**
SPC	7.23±0.36	49.4±0.6^{cd}	42.2±0.4^{cf}
SPC 0.2MO	7.00±0.03	51.3±1.2^{bc}	**44.3±1.3^{bc}**
SPC 0.4MO	7.06±0.05	48.9±1.8^{cd}	**41.9±1.8^{df}**
P values			
Diets	-	*0.000*	*0.000*
MO	-	*0.000*	*0.000*
Diets*MO	**-**	***0.003***	***0.003***

RESULTS: Growth performance (2)

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Treatment	Growth parameters		
	FCR	**PER**	**SR (%)**
Diet sources			
FM	0.97±0.09^{ab}	2.56±0.28^{a}	76.2±3.3^{a}
SBM	**1.05±0.08^{a}**	**2.20±0.24^{b}**	**78.1±3.9^{a}**
SPC	**0.93±0.09^{b}**	**2.67±0.24^{a}**	66.6±5.3^{b}
MO levels (%)			
0	1.03±0.20^{a}	2.35±0.57^{b}	67.9±12.4^{b}
0.20	**0.94±0.23^{a}**	**2.53±0.66^{a}**	**78.8±0.2^{a}**
0.40	**0.98±0.35^{a}**	**2.54±0.52^{a}**	**74.2±9.9^{ab}**
P values			
Diets	*0.037*	*0.004*	*0.000*
MO	*0.167*	*0.260*	*0.000*
Diets*MO	***0.843***	***0.800***	***0.217***

RESULTS: Growth performance (3)

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Treatments	FC (USD/kg feed)	FPC (USD/kg fish gain)	Reduction in fish production cost (%)
FM	1.063	1.117	0.0
FM 0.2MO	1.072	0.964	13.4
FM 0.4MO	1.085	1.018	8.7
SBM	0.933	1.013	8.9
SBM 0.2MO	0.946	0.955	14.4
SBM 0.4MO	0.955	1.009	9.1
SPC	1.027	0.978	12.3
SPC 0.2MO	1.040	0.946	15.1
SPC 0.4MO	1.049	0.987	11.4

RESULTS: Immune response (4)

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Treatment	Blood parameters	
	RBC (10^6 cells/mm^3)	WBC (10^3 cells/mm^3)
Diet sources		
FM	2.17 ± 0.18^a	60.9 ± 5.9^b
SBM	2.18 ± 0.33^a	**66.3 ± 7.1^{ab}**
SPC	2.20 ± 0.17^a	**74.6 ± 3.4^a**
MO levels (%)		
0	2.17 ± 0.87^a	58.6 ± 2.7^b
0.20	2.26 ± 0.66^a	**71.8 ± 1.8^a**
0.40	2.14 ± 0.52^a	**71.4 ± 19.8^a**
P values		
Diets	*0.973*	*0.001*
MO	*0.567*	*0.000*
Diets*MO	***0.273***	***0.081***

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RESULTS: Immune response (5)

Treatment	Ig (mg/ml)	Pre-challenge lysozyme (µg/ml)	Post-challenge lysozyme (µg/ml)
FM	9.09±0.85[c]	263±6[df]	459±3[df]
FM 0.2MO	10.10±0.57[bc]	276±13[d]	503±11[bc]
FM 0.4MO	12.90±0.83[a]	**346±15[b]**	**536±27[a]**
SBM	9.08±0.49[c]	248±23[f]	479±6[cd]
SBM 0.2MO	9.42±0.50[c]	283±3[d]	485±7[c]
SBM 0.4MO	12.00±0.69[a]	**308±14[c]**	**529±24[a]**
SPC	8.75±1.36[c]	271±14[df]	443±4[f]
SPC 0.2MO	11.60±0.69[ab]	323±12[bc]	524±7[ab]
SPC 0.4MO	10.20±1.27[bc]	**371±11[a]**	487±3[c]
P values			
Diets	*0.383*	*0.000*	*0.069*
MO	*0.000*	*0.000*	*0.000*
Diets*MO	***0.000***	***0.023***	***0.003***

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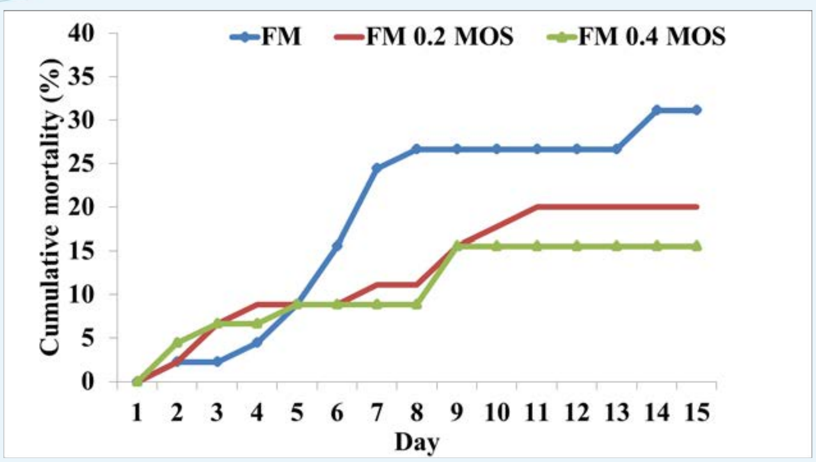
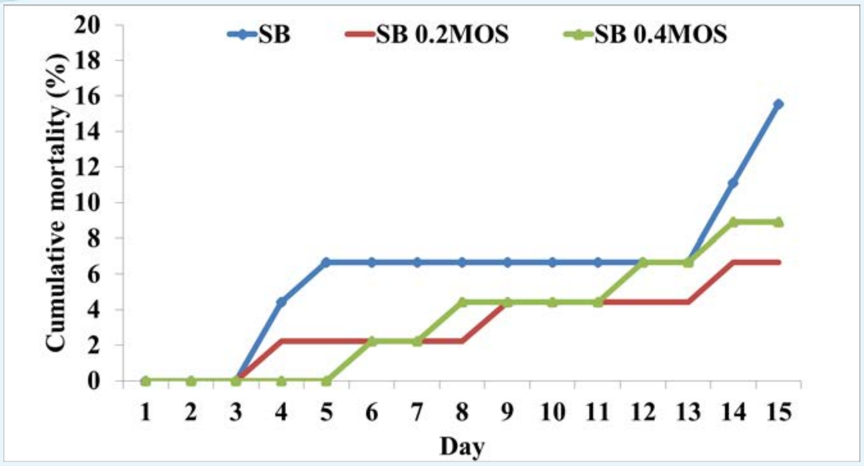
RESULTS: Bacterial challenge (6)



RESULTS: Bacterial challenge (7)



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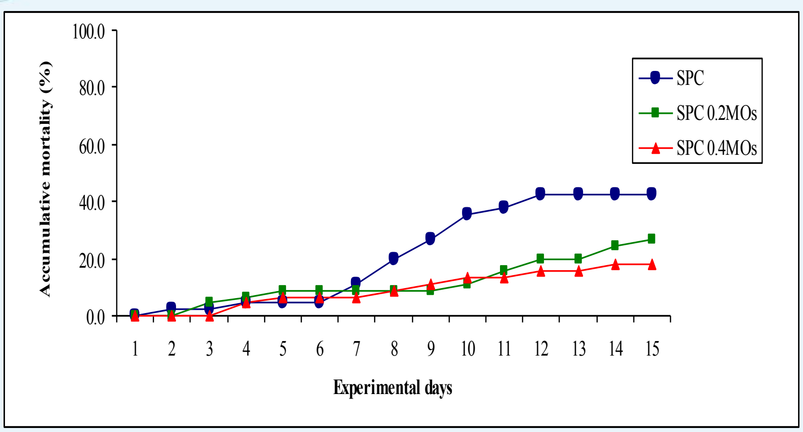
RESULTS: Bacterial challenge (8)



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CONCLUSIONS

- **Addition of MO to soy-based diets for snakehead significantly improves their growth and immune responses;**
- **Survival rate in each feed group showing less mortality with MO addition;**
- **Addition of MO to snakehead diets may improve its performance on commercial farms.**

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THANK FOR YOUR ATTENTIONS !

Assessment on the current status of snakehead seed production in the Mekong Delta, Vietnam

Truong Hoang Minh, Tran Ngoc Hai and Robert Pomeroy
College of Aquaculture and Fisheries
University of Connecticut-Avery Point, Department of Agricultural and Resource Economics, Goton, Connecticut, USA

The study on "*Assessment on the current status snakehead seed production the Mekong Delta*" was conducted from April 2014 to June 2015 by directly interviewing 65 snakehead seed production hatcheries, which of 22 hatcheries in Dong Thap province, 33 hatcheries in An Giang province and 10 hatcheries in Hau Giang province. The result showed that there were two kinds of seed production systems which consist of earthen pond and hapa in earthen pond. The experience of earthen pond and hapa in earthen pond hatcheries owners were around 12.1 years and 9.26 years, respectively. Broodstock productivity in earthen pond and hapa in earthen pond were 8,375 larvae/kg and 7,954 larvae/kg of female, respectively. Snakehead seed nursing density in earthen pond years was 553 individual/m^3, whereas hapa in earthen pond year was 2,108 individual/m^3, Food conversion ratio of earthen ponds was lower than that of hapa in earthen ponds; and the survival rates were 56.2% and 61.9% respectively. The productivity of the hapa in earthen pond was 1,299 individual/m^3, whereas earthen pond was 311 individual/m^3. Total cost of earthen was 47 VND thousand/m^3/production cycle) was lower than that of hapa in earthen pond (206 VND thousand/m^3/production cycle). The total income of the earthen pond was (97.7 VND thousand VND/m^2) lower than that of hapa in earthen pond (404 VND thousand/m^2). The profit of earthen pond system was (49.8 VND thousand/m^3) lower than that of hapa in pond 196 thousand VND/m^3. Fingerlings consuming source of earthen pond system was mainly in the studied provinces (78.9%) and other provinces (13.21%), the rest (7.89%) was kept to culture by the producers. While the hapa in earthen pond system sold to snakehead seed wholesalers in the studied provinces accounted for 74.6% and consumers outside the provinces (8.8%), the rest (17.6%) was kept for farming by the seed producers.

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Asia Project: Cambodia and Vietnam

AN ASSESSMENT ON THE CURRENT STATUS OF SNEAKHEAD SEED PRODUCTION IN THE MEKONG DELTA, VIETNAM

Minh, T. H.[1], Hai, T.N[1] and Robert S. Pomeroy

(1) College of Aquaculture and Fishieries, Can Tho Univeristy

(2) Connecticut University, USA, Aquafish Innovation Lab

27-29 April, 2016

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1. INTRODUCTION

- ✓ In 2014, the total aquaculture area was 830,000 ha with the production of 2.97 million tons of the Mekong Delta (MKD). It accounted at 87.6% of Vietnam
- ✓ Main freshwater cultured fish species in the MKD: catfish, sneakhead,… In 2015, the production of sneakhead reached 50,000 tons
- ✓ In recent years, snakehead culture has encountered several obstacles.

→ "An assessment on the current status of sneakhead seed production in the Mekong, Vietnam" was conducted.

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2. OBJECTIVES

Overal objective

✓To propose solutions for improvimg efficiency, seed quality and consumption of snakehead to sustain snakehead culture in Mekong Delta

Specific objectives

✓ To analyze technical and economic aspects of snakehead seed production in the Mekong Delta of Vietnam;

✓To address advantages and disadvantages of snakehead seed production in the Mekong Delta of Vietnam

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3. METHODOLOGY

Time of the study

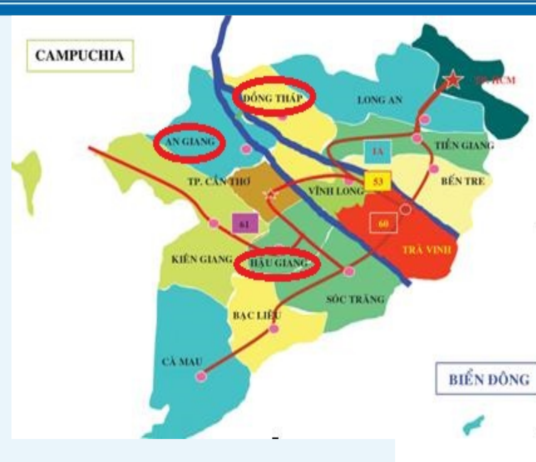
✓4/2014-6/2015

Site of the study

✓An Giang: 33 households

✓Dong Thap: 22 households

✓Hau Giang: 10 households



Mekong delta map

Nguồn www.google.com

www.ctu.edu.vn

3. METHODOLOGY

Primary data:

✓Interview 65 snakehead seed producers

Main data

✓Technical and economic aspects

✓Advantages and disadvantages

Data analysis

✓Description statistics

✓Comparison (T-test)

✓Multivariate regression

4. RESULTS AND DISCUSSION
Technical aspects

Seed producing systems

Earthen pond | Happa in pond

4.1. TECHNICAL ASPECTS

Variables	Earthen pond	Hapa
Hatchery area (m^2)	1,177±1,304	1,635±1,862
Area for spawning (m^2)	425±272	744±526
Nursing area (m^2)	425±272[a]	212±218[b]
Average area for spawning of 1 couple & nursing	11.6±1.55	12.1±1.55
Depth (spawning & nursing)	1.2-1.5	

4.1. TECHNICAL ASPECTS

Process

✓Semi-natural: naturally spawn (stimulated by exchange water without stimulants)

Season

✓Main season: rainy season (May-October)

✓Sub-season: the other months

Water source & environment

✓Rarely do water treatment

✓Environmental factors: pay little attention

4.1. TECHNICAL ASPECTS

Source and manipulate broodstock

Variables	Earthen pond	Hapa
Broodstock source		
✓ *Self-supply*	*28.9*	*33.3*
✓ *Buy from the province*	*57.9*	*44.4*
✓ *Buy from other provinces*	*13.2*	*22.2*
Spawning times (times/year)	9.16±1.31	8.74±1.87
Number of broodstocks (couple/year)	36±21.5	61.1±44
Size (gram)	1,006±88.6	1,025±105

4.1. TECHNICAL ASPECTS

Feeding snakehead fry

Variables	Earthen pond	Hapa
Total feed for fry (kg/m^2/year)	3.83±0.72[a]	18.4±6.88[b]
✓ Moina (%)	78.9	35.2
✓ Trash fish (%)	21.1	64.8

4.1. TECHNICAL ASPECTS

Variables	Earthen pond	Hapa
No. of fry *(ind/couple)*	8,351±1,263[a]	8,089±1,064[b]
Total seed *(',000 ind./cycle/HH)*	295±160[a]	499±373[b]
Nursing density *(ind/m²)*	733±160[a]	2.881±1047[b]
Survival rate *(%)*	56.2±2,55[a]	61,9±5,3[b]
Yield *(ind./m²)*	412±92.1[a]	1,773±630[b]
Selling price *(USD/ind.)*	11.02±0.75	10.7±0.001
Thinning ratio *(%)*	7.89	81.48
Consumption (%)		
✓ *Culture*	7.89	17.6
✓ *Selling within the province*	78.9	74.6
✓ *Selling to other provinces*	13.2	8.8

4.2. THE ECONOMIC ASPECTS

Variables	Earthen pond	Hapa
Fixed costs (USD/m²)	0.3	0.25
✓ Construction depreciation	*41%*	*36%*
✓ Machinery depreciation	*59%*	*64%*
The variable costs (USD/m²)	***27.5***	***126.7***
✓ Feed for broodstock	*2.2*[a]	*9.1*[b]
✓ Broodstock	*0.8*[b]	*3.1*[a]
✓ Feed for fry	*16.5*[a]	*78.6*[b]
✓ Chemicals	7.7[a]	35.1[b]
✓ Energy	0,34[a]	0.83[b]

4.2. THE ECONOMICAL ASPECTS

Variables	Earthen pond	Hapa
Total cost (USD/m^2)	27.8±9.1[a]	127±65,5[b]
Revenue (USD/m^2)	48.8±11.3[a]	202,0±66.5[b]
Net income (USD/m^2)	19.5±10.1[a]	54.5±39.5[b]
Cost profit ratio (times)	0.74±0.36[a]	0.46±0.32[b]
Percentage losses (%)	5.2	7.4

4.3. ADVANTAGES & DISADVANTAGES

Advantages

✓ Simple and easy to do which does not require high technical skills

✓ Taking advantage from household labor and land

✓ The main species with high productivity and natural food sources utilization

✓ Low investment costs, capital turnaround time

✓The traditionally cultured species with highly experienced and high quality broodstock available.

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4.3. ADVANTAGES & DISADVANTAGES

Disadvantages

✓ Depend highly on weather

✓ Influence of the surrounding agricultural water

✓ Production remains in small scales, non-integrated between seed producers and traders

✓ Fish is easy to get diseases that unknown causes and treatment that leads to high wastage rate.

✓ The quantities and quality of the seed is unstable.

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5. CONCLUSION AND RECOMMENDATION

CONCLUSION

✓There are kinds of 2 hatcheries: earthen pond and hapa. Both of them are natural reproduction (un-used hormones).

✓ Seed production is mainly based on personal experience.

✓Number of seed production cycle is 8-9 cycles/year; Seed production period is 30 days/cycle.

✓Consumption: the majority is sold to traders in the province.

5. CONCLUSION AND RECOMMENDATION

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RECOMMENDATION

✓Selection of good quality broodstock and complete the process of artificial breeding to make high quality seed that following by the quality and quantity will be available.

www.ctu.edu.vn

Funding for this research was provided by the

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Sustainable snakehead aquaculture development in the Lower Mekong Basin of Cambodia

Phanna Nen, Nam So, Seang Hay Pheng, Robert Pomeroy
Fisheries Administration, Phnom Penh, Cambodia; phannanen@gmail.com

Farming snakehead is prohibited in Cambodia due to its dependence on freshwater small-sized fish (FSF) for sourcing key dietary nutrient inputs and seed collected from the wild, while lack of technologies on developing of snakehead hatcheries through breeding, weaning and grow-out on formulated or pelleted diets. This study was conducted to investigate weaning and grow-out performance of the wild indigenous *Channa striata* (non-domesticated) in Cambodia compared to those of domesticated snakehead imported from Vietnamese hatcheries on formulated or pelleted feed (FF or PF) and to assess economic efficiency and product quality of the two types of snakehead fed on different diets at the end of experimental grow-out. In the experiment 1 (weaning): 3 day-old larvae of both types of both *C. striata* were stocked in 50 L-tank at a density of 5 fish L-1 and fed on Moina, FSF and FF (45% CP) to satiation four times daily for 45 days. In experiment 2 (grow-out): the experiment was conducted in 18 hapa-nets (1.8m x 2.5 m x 1.8 m) placed in 3 earthen ponds (300 m2 each) at a density of 100 fingerlings hapa-1 (3 replicated hapas for domesticated fingerling and 3 replicated for non-domesticated). Snakehead fingerlings (12-13 g fish-1) were fed on three diets: 1) FSF (Pond 1); 2) PF (40% CP, Pond 2); and 3) 50:50 mixtures of FSF and PF (Mix, Pond 3). The fish was fed to satiation twice daily for 6 months. The results of the study showed that weaning of non-domesticated and domesticated *C. striata* larvae on FF can start at 17 days after hatch with replacement ratio 10% FF day-1 for substituting FSF. Feed intake (107 mg fish-1 day-1) and final weight (170 mg) of domesticated snakehead was higher than the ones (85 mg fish-1 day-1 and 146 mg, respectively) of non-domesticated snakehead, while survival rate (29%) and Cannibalistic rate (47%) of the domesticated was lower than the ones (36% and 51%, respectively) of the non-domesticated. In grow-out experiment, both snakeheads can accept formulated or pelleted feed. However, the domesticated snakehead showed higher survival rate (75%), better growth performance (final body weight 367 g fish-1), higher feed intake (3 g fish-1 day-1) and food conversion ratio (FCR; 1.5) than the non-domesticated snakehead (69% and 233 g fish-1, 2 g fish-1 day-1 and 1.7, respectively) since the domesticated hatchery snakehead has been gone through more than two-decade domestication. Considering economic efficiency, replacing freshwater small-sized fish by pelleted feed up to 100% is possible and profitable for both snakeheads. However, the domesticated snakehead (about US$ 0.35/kg fish produced) showed higher profit than the non-domesticated snakehead (US$ 0.25/kg fish produced). In regards to product quality, pelleted feed does not significantly affect the fillet quality of both cultured snakeheads compared to a diet of FSF and a mixture.

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

Weaning and Grow-out of Striped Snakehead *Channa striata*

Nen Phanna, So Nam, Pheng Seang Hay and Robert Pomeroy

2016 AquaFish Technical Meeting
Asian-Pacific Aquaculture Conference
Surabaya, Indonesia
27-28 April 2016
Grand City Convention Center

Content

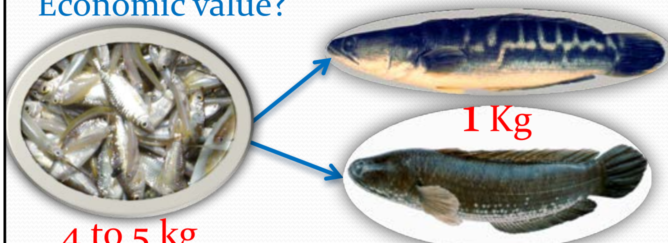
- Introduction
- Objectives
- Brooder condition and induced spawning
- Weaning experiment of Snakehead
- Grow-out experiment of Snakehead
- Conclusion

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

Does it have a balance? In term of Biomass, Nutrition and Economic value?



Objectives:

- To compare performance of domesticated (Vietnamese) vs. non-domesticated(Cambodian) snakehead *C. striata* with regard to weaning performance and grow-out on pellet feed.
- To assess economic efficiency of experimental grow-out of the two types of snakehead on different diets
- To assess product quality of the two types of snakehead.

Brooder conditioning

Induced spawning

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)

- Feed preparation (wet)

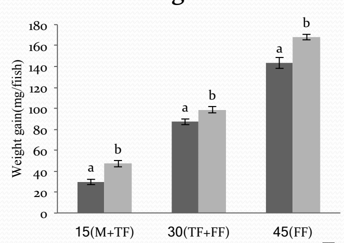
- Feed formulation (about 45% Crude Protein)

Main ingredients	**(g)**
Fish meal	570
Soy bean meal	140
Rice bran	100
Cassava meal	130
Vitamin C	2
Premix mineral-vitamin	15
Fish oil	25
Phytase	0.2
Binder	17.8
Total	1000

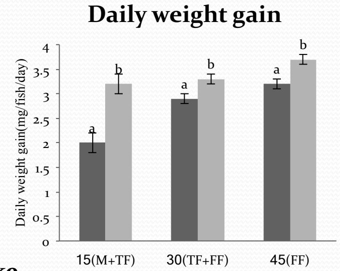
Result

- Growth and feed intake

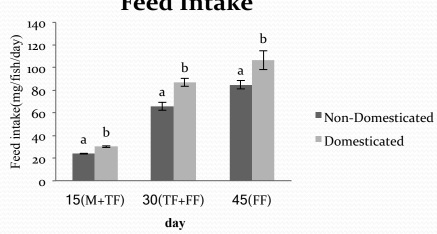
Larval growth



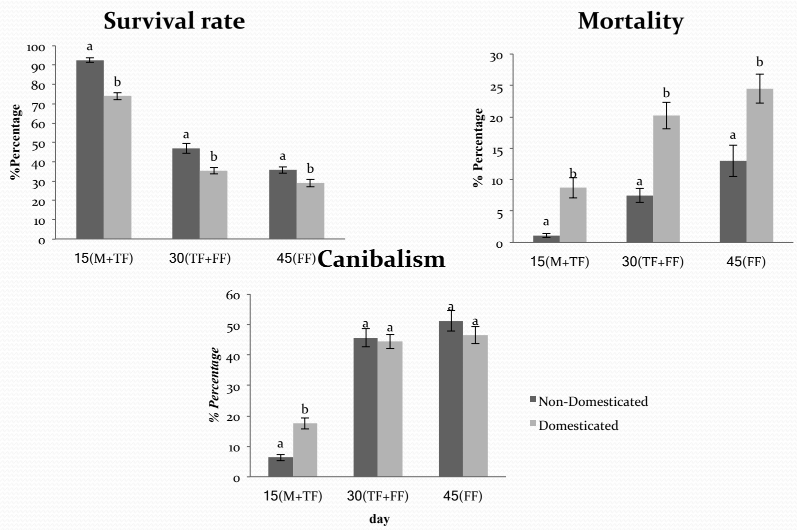
Daily weight gain



Feed Intake

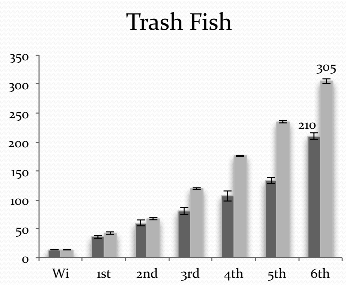


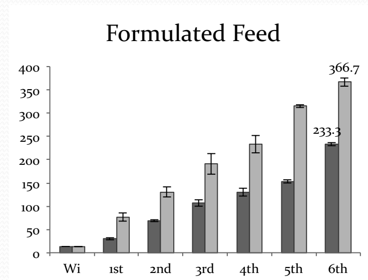
- Survival, mortality, and cannibalism

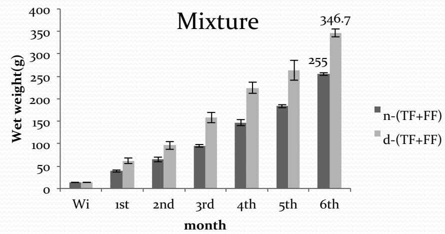


Grow-out

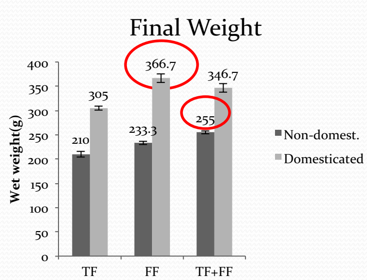
Result

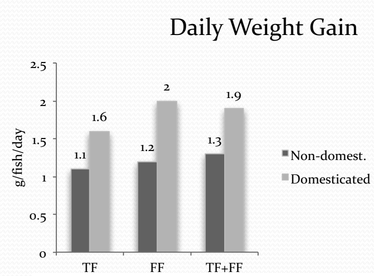


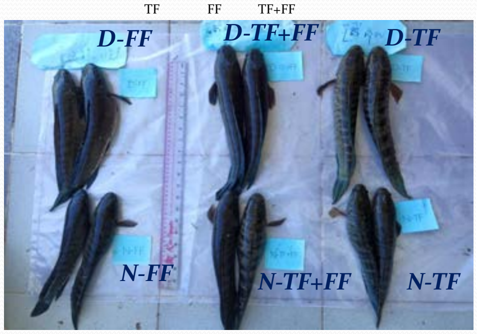


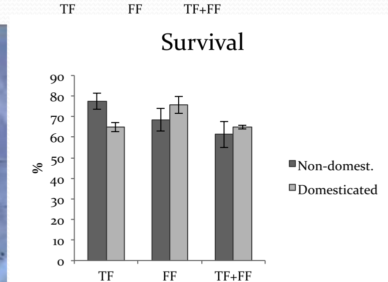


- Growth and survival

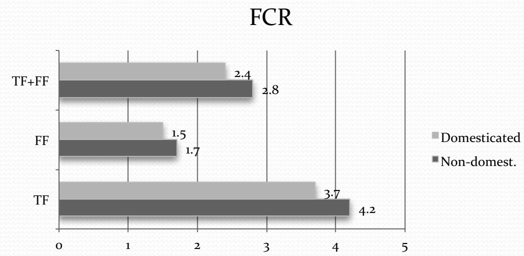








- Food Conversion Ratio and Economic Conversion Ratio



Treatments	Total cost (feed) (thousand KHR/Kg fish)	Total income (thousand KHR/Kg fish)	Profit (thousand KHR/Kg fish)
n-FSF	8.5±0.1^{a}	8.0±0.0	-0.5 ±0.1^{a}
n-PF	7.1±0.3^{b}	8.0± 0.0	0.9± 0.3^{b}
n-Mix	8.8 ±0.3^{a}	8.0 ±0.0	-0.8 ±0.3^{c}
d-FSF	7.4±0.03^{c}	8.0± 0.0	0.6 ±0.03^{d}
d-PF	6.7 ±0.2^{d}	8.0± 0.0	1.3 ± 0.2^{e}
d-Mix	7.5±0.4^{e}	8.0± 0.0	0.9 ± 0.4^{f}

Conclusion

- 1. Both strains of snakehead accept formulated feed, with similar product quality; however, domesticated snakehead show higher, growth rate survival and profit than non-domesticated one.
- 2. Considering economic efficiency, replacing FSF by formulated feed up to100% is possible the both strains.
- 3. Using formulated feed for snakehead provides significantly better growth performance, FCR and higher profit than using FSF or Mixture.
- Feeding formulated feed does not significantly affect the product quality of the both strains as compared to FSF or mixture feeding.

Thank you

Funding for this research was provided by the

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AquaFish Technical Session 4
Innovations in Smallholder Aquaculture Technology: AquaFish Economics and Marketing Research

Impact of stocking density and feeds on yield of Pangasius catfish *Pangasius hypophthalmus* in hyposaline waters

M. Lokman Ali*, S. Mahean Haque, M. A. Wahab and Russell Borski
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& University of Malaya, Malaysia,
lokman.fri@gmail.com

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 tones produced annually. The fish is cultured in freshwater. The aim of this investigation was to findout the best stocking density and feed for expanding the culture of *Pangasius* catfish to hyposaline waters in Southern Bangladesh. This region is severely impacted by overfishing, and is underutilized due to increasing susceptibility to rising sea levels linked to global climate change, and remains underutilized for fish. If *Pangasius* culture can be introduced to coastal regions of Bangladesh, it may significantly improve food security and the economic viability of its communities.

A research was undertaken in 12 ponds to assess the effect of commercial and formulated feed with the consideration of stocking density on growth of Thai pangus (*Pangasius hypophthalmus*) for a period of 6 months from 1 May to 28 October, 2015 in the coastal Patuakhali district of Bangladesh. In T_1 and T_2 formulated (28% CP) and commercial feed (Mega floating feed, 28% CP) were used at same stocking density (2/m^2). In T_2 and T_3 different stocking densities (2/m^2 and 3/m^2) were used but feed was same (commercial feed). Fish were fed with commercial feed (28% CP) and formulated feed (28% CP) at an initial rate of 10% body weight (bw)/day down to 3% bw/day. Feed was provided twice daily at 09:00 and 14:00 h.

Production parameters of *Pangasius* in hyposaline water

Parameters	T_1	T_2	T_3
Initial weight (g)	65.56 ± 4.53	65.56 ± 4.53	65.56 ± 4.53
Final weight (g)	786.34 ± 45.21^a	790.62± 45.21^a	784.89±51.80^a
Survival rate (%)	95.71±3.64^a	95.45±3.12^a	95.12±2.85^a
Weight gain(g)	720.78±36.41^a	725.06±35.64^a	719.33±37.21^a
FCR	1.63±0.26^a	1.62±0.28^a	1.64±0.39^a
Yield (kg/ha)	15,538 ±1293^a	15,622±1374^a	23,264 ±1347^b
Net Profit	11,438 US$^{a}	8,275 US$^{b}	12,104 US$^{c}
BCR	1.91	1.53	1.51

No significant differences ($P>0.05$) were observed in survival rate, weight gain, SGR, feed conversion ratio (FCR), yield, and benefit cost ratio (BCR) among the treatments. Significantly ($P>0.05$) higher production were observed in T_3 (23,264 kg/ha) followed by T_1 (15,538 kg/ha) and T_2 (15,622 kg/ha). Significantly higher ($P>0.05$) net profit was found in T_1 (11,438

US$/hec.) than in T_2 (8,275 US$/hec.). Total cost was higher in T_3 than in T_2 but higher net profit was observe in T_3 (12,104 US$/hec) than in T_2 (8,275 US$/hec). But the cost of formulated feed is lower than commercial feed as net profit is in formulated feed, so formulated feed is best for better economic benefit. Due to higher net profit in high stocking density ($3/m^2$) than low stocking ($2/m^2$), high stocking density with formulated feed is recommended for profitable pangas culture. Adoption of *Pangasius* culture in coastal regions can provide an alternative livelihood for communities impacted by water salinization resulting from global warming.

Welcome
To
My Presentation

'IMPACT OF STOCKING DENSITY AND FEEDS ON YIELD OF PANGASIUS CATFISH, *Pangasius hypophthalmus* IN HYPOSALINE WATERS

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

Investigaors/Affiliation

1. Dr. Md. Lokman Ali, HC Co-PI, Patuakhali University of Science and Technology, Patuakhali, Bangladesh Prof.

2. Prof. Dr. Shahroz Mahean Haque, HC Lead PI, BAU, Mymensingh, Bangladesh

3. Dr. Md. Abdul Wahab, HC Lead PI, BAU, Mymensingh, Bangladesh

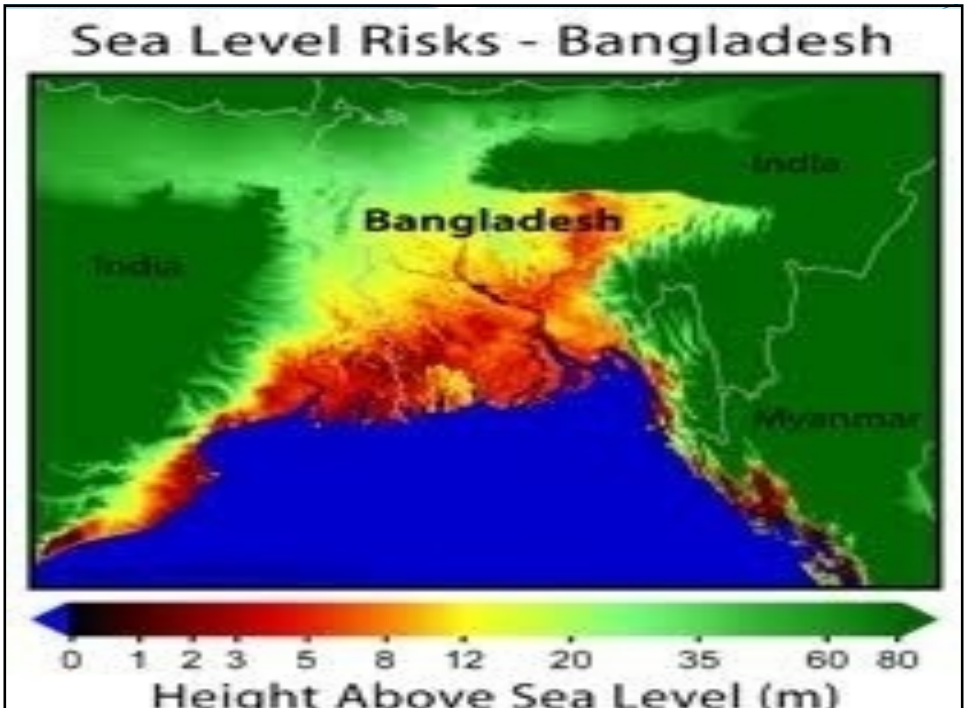
4. Prof. Dr. Russell Borski, US Lead PI, Department of Biology, North Carolina State University (NCSU) Raleigh, NC, USA

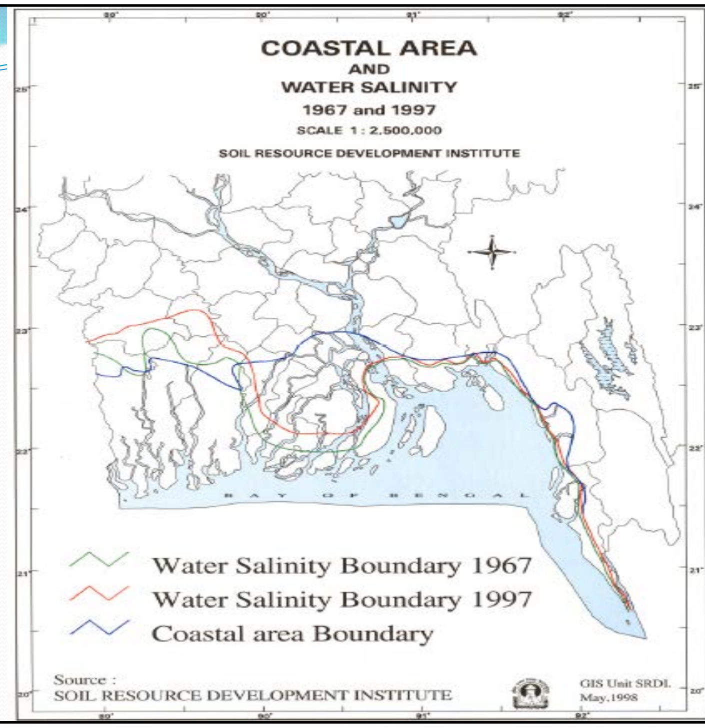
Background

- The river catfish (*Pangasius hypopthalamus*) was introduced to Bangladesh in 1990's, and since then it has become a thriving aquaculture industry with over 30,0000 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.

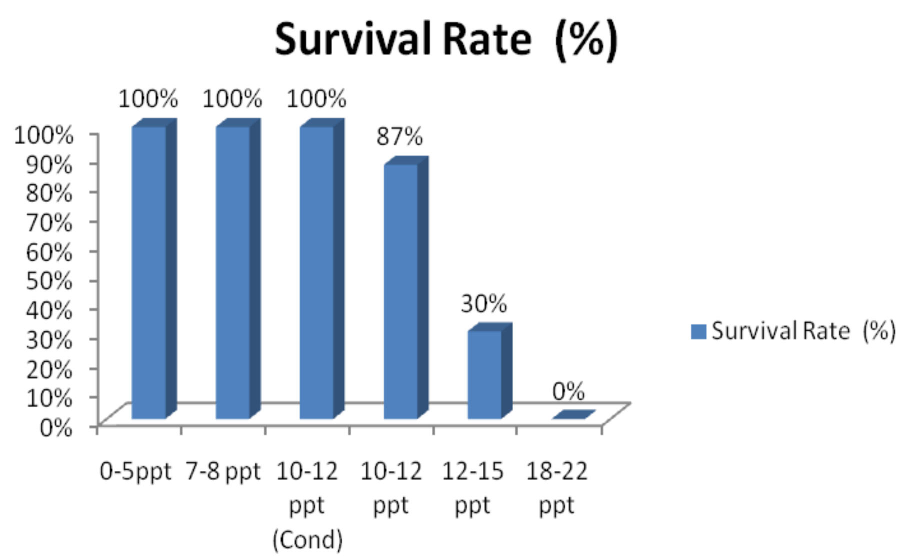
Background

- 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 (60,0000 metric tones), thus may significantly impact the diet and economic viability of coastal communities.





Effects of salinity on survival rate of Thai Pangas



OBJECTIVES

- Optimozation of stocking density of *Pangasius* catfish in hyposaline water
- Evaluate potential economic impacts for formulated and commercial diet in *Pangasius* culture at hyposaline water.

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METHODOLOGY:

1. Study area:

The proposed research was conducted for 5 months during 1 May, 2015 to 31, September, 2015, at Kuakata of Patuakhali district.

Table-1: Research Design

Treatment	Replications	Pond No	Stocking density	Feed
T_1	R_1	01	80/decimal	Formulated feed
	R_2	02	80/decimal	Formulated feed
	R_3	03	80/decimal	Formulated feed
	R_4	04	80/decimal	Formulated feed
T_2	R_1	05	80/decimal	Commercial feed
	R_2	06	80/decimal	Commercial feed
	R_3	07	80/decimal	Commercial feed
	R_4	08	80/decimal	Commercial feed
T_3	R_1	09	120/ decimal	Commercial feed
	R_2	10	120/ decimal	Commercial feed
	R_3	11	120/ decimal	Commercial feed
	[illegible]	[illegible]	[illegible]	[illegible]

Pond Preparation :

Pond Drying: All ponds were completely dried and all unwanted species were removed from pond prior to the start of experiment.

Liming: Liming was done at a standard rate of 1 kg per decimal on 21 April, 2015. Lime was mixed with water and kept overnight and distributed on the pond surface early in the morning.

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 26th Aril, 2015 with Urea and Triple Super Phosphate (TSP) at the rates of urea 150 g/decimal and TSP- 75 g/decimal.

Fingerlings collection:

Over wintered fingerlings of Thai Pangas (~65g) were collected from World Fish supported fish nursery, Kuakata, Patuakhali, Bangladesh at Morning on 01 May, 2015 and stocked in 12 ponds as experimental design.


AquaFish Innovation Lab, USAID
Pangas Culture at Hyposaline Water
Farmer's Name: Kulsum Begum
Kuakata, Patuakhali
Implemented By:
Patuakhali Science and Technology University and
WorldFish
AQUAFISH INNOVATION LAB


sh Innovation Lab, USAID
Culture at Hyposaline Water
Farmer's Name: Tan Nan (Rakhain)
Kuakata, Patuakhali
Implemented By:
Patuakhali Science and Technology University and
WorldFish
USAID

Feeding :

Fish were fed with formulated feed – Mega feed in T_2 and T_3 at 10-3% of body weight. In treatment 1 formulated feed were fed at same rate. Feeding rates was adjusted accordingly based on this biweekly sampling of fish. The quantity of feed to be applied daily was recorded in the record sheet.

Low cost Feed formulation

Name of the ingredients	% in feed	Amount of protein (%) in the ingredient	Protein contribution in the feed
Fish meal	30%	60%	18 %
Mustard oil cake	20%	32%	6.4%
Rice bran	20%	7.5%	1.50%
Wheat bran	15%	11%	1.65%
Wheat flower	3%	15%	0.45%
Molasses	2.5%	-	
Vitamin mineral premix	0.5%	-	
Total	100%		28%

Proximate composition analysis of commercial and formulated feed

Proximate composition%	Feed (Means ±SE)	
	Mega feed	Fresh feed
Moisture	15.56±0.030	15.26±0.185
Crude lipid	4.04±0.045	4.321±0.387
Crude protein	28.06±0.170	28.10±0.164
Ash	16.08±0.305	15.34±0.232
Crude fibre	5.66±0.100	5.96±0.145[c]

Sampling of fish:

Before stocking, 50 Pangas fingerlings were randomly collected to measure length and weight of individual fingerling. Growth parameters (length and weight) are monitoring at 2-week intervals. Feeding rates adjusted accordingly based on the biweekly sampling.

Water quality parameters :

Water quality parameters such as water temperature, dissolved oxygen, pH, alkalinity, ammonia, nitrite and transparency were recorded regularly.

Harvesting


Pangas Culture at Hyposaline Water
USAID

AquaFish Innovation Lab. USAID
Pangas Culture at Hyposaline Water
Farmer's Name: Md. Basir
Kuakata, Patuakhali
Implemented By:
Patuakhali Science and Technology University and
WorldFish
USAID


Pangas Culture at
Farmer's Name
Patuakhali Science and

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Water Quality Parameters

Parameters	T_1	T_2	T_3
Water Temperature (°C)	29.50 ± 0.42 °C	29.50 ± 0.42°C	29.50 ± 0.42°C
Dissolved Oxygen (mg/L)	5.17 ±0.12	5.20 ±0.13	5.23 ±0.12
pH	7.81 ± 0.32	7.82 ± 0.29	7.75± 0.34
Alkalinity (mg/L)	152.5±2.12	155.3±2.61	158.7±2.15
Ammonia (mg/L)	0.05 ± 0.02	0.04 ± 0.03	0.05 ± 0.03
Nitrite (NO_2) (mg/L)	0.06 ± 0.02	0.05 ± 0.01	0.05 ± 0.01
Salinity (PPT)	9.6± 0.7	9.4± 0.6	9.7± 0.6

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Comparison of yields parameters (Mean ± Sd)

Yield parameters	T_1 (Formul.+ 2/m²)	T_2 (Comm.+ 2/m²)	T_3 (Comm+ 3/m²)
Mean initial weight (g)	65.56 ± 4.53	65.56 ± 4.53	65.56 ± 4.53
Initial length (cm)	21.18 ± 1.68	21.18 ± 1.68	21.18 ± 1.68
Mean final weight (g)	**786.34 ± 45.21[a]**	**790.62± 45.21 [a]**	**784.89±51.80 [a]**
Final length (cm)	42.87 ±5.31	43.10±5.23	41.96±6.22
Survival Rate (%)	**95.71±3.64 [a]**	**95.45±3.12 [a]**	**95.12±2.85 [a]**
Mean weight gain(g)	720.78±36.41 [a]	725.06±35.64 [a]	719.33±37.21 [a]
FCR	1.63±0.26 [a]	1.62±0.28 [a]	1.64±0.39 [a]
Yield (kg/ha)	**15,538 ±1293 [a]**	**15,622±1374 [a]**	**23,264 ±1347 [b]**

$T_{1=}$ Formulated feed & stocking 2/m², T_2= commercial feed & stocking 2/m², T_3= commercial feed & stocking 3/m²

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Economic analysis of the research

Investment	T_1 (Formul.+ 2/m²)	T_2(Comm.+ 2/m²)	T_3 (Comm+ 3/m²)
Pond Preparation	80 US$	80 US$	80 US$
Fingerling	2,026 US$	2,026 US$	3,040 US$
Total feed used	25327 kg	25327 kg	38,152 kg
Feed cost	10,384 US$	13,676 US$	20,602 US$
Total cost	12,490 US$[a]	15,782 US$[b]	23,722 US$[c]
Fish production/hector	15,538 kg[a]	15,622 kg[a]	23,264 kg[b]
Retail price of fish/kg	1.54 US$	1.54 US$	1.54 US$
Gross income (from fish sale)	23,928 US$[a]	24,057 US$[a]	35,826 US$[b]
Net Profit/hactor	11,438 US$[a]	8,275 US$[b]	12,104 US$[c]
Benefit-Cost Ratio (BCR)	**1.91**	**1.53**	**1.51**

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Training of Farmers


Training on
Pangas Culture at Hyposaline Water
স্বল্প লবনাক্ত পানিতে পাঙ্গাস চাষ শীর্ষক
প্রশিক্ষণ কর্মসূচী
স্থানঃ কুয়াকাটা, পটুয়াখালী ।
অর্থায়নেঃ AquaFish Innovation Lab, USAID
আয়োজনে ঃ পটুয়াখালী বিজ্ঞান ও প্রযুক্তি বিশ্ববিদ্যালয়
USAID


Training on
Pangas Culture at Hyposaline Water
স্বল্প লবনাক্ত পানিতে পাঙ্গাস চাষ শীর্ষক
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আয়োজনে
বিজ্ঞান ও প্রযুক্তি বিশ্ববিদ্যালয়
USAID

Conclusion:

❖ Due to low cost and higher net profit , formulated feed is best for better economic benefit.

❖ High stocking density (3/m^2)is better than low stocking (2/m^2),

❖ So high stocking density with formulated feed is recommended for profitable pangas culture in hyposaline water.

❖ Adoption of *Pangasius* culture in coastal regions can provide an alternative livelihood for communities impacted by water salinization resulting from global warming.

Funding for this research was provided by the

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.

Thank You All

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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.

Price volatility in the African catfish reseller markets in Uganda

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The paper examines price volatility in the African catfish (Clarias gariepinus) markets in Uganda. An understanding of the structure of price volatility is of great interest since this is a major contributor to economic risk in the fisheries industry. Well-functioning markets transmit price signals, which allow changes in demand to be met by supply. When demand is greater than supply, producers increase production in response to price signals, and this increased production, in turn, helps to stabilize prices. By transmitting information in this way, markets help to reduce price volatility. The volatility process in catfish prices was analyzed based on monthly data from January 2006 to August 2013.

The analysis draws on price data for ex-vessel, wholesale and retail market channels. The ex-vessel prices were collected at different landing sites along Lake Victoria while corresponding retail and wholesale prices were gathered from fish markets in the central region. The GARCH model, which is widely used in various branches of econometrics, is used to estimate the volatility parameters. The model can be represented as $\varepsilon_t = v_t\sqrt{h_t}$ where v_t is a white noise term and $h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-1}^2 + \sum_{i=1}^{p}\beta_i h_{t-1}$ defines the conditional variance. The model is estimated with a one-month lag in the ARCH and GARCH terms.

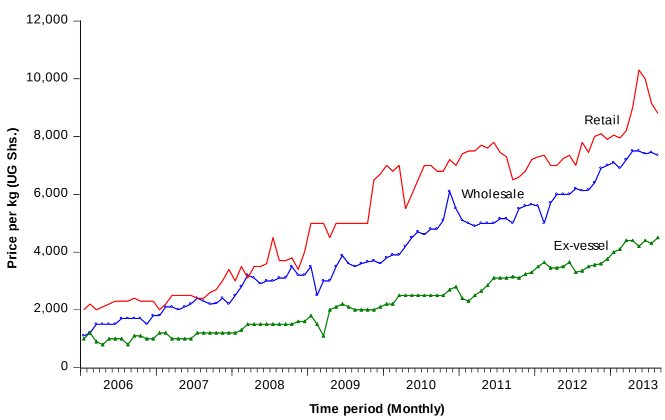

FIGURE 1. Catfish prices in the Reseller Markets

Figure 1 presents a plot of the series indicating increasing trends over the study period. Descriptive statistics reveal that ex-vessel and wholesale prices are moderately skewed to the right, indicating that the series have longer right tails than left tails while retail price are approximately symmetric. All series have kurtosis values lower than 3, and the Jarque-Bera statistics shows non-normal distribution for all series.

In a GARCH (1,1) model, the sum ($\alpha_1 + \beta_1$) measures the degree of volatility persistence in the market. Thus it reveals the degree of efficiency in the market, where the intuition is that if a market is completely efficient it should immediately correct to any shock. The results reveal evidence for volatility persistence estimated to 0.91, 0.62 and 0.90 for ex-vessel, wholesale and retail markets, respectively. The results suggest that the wholesale market displays a larger degree of efficiency than the ex-vessel and retail markets. Similar findings have been reported is previous fisheries studies. For instance, Buguk et al. (2003) found volatility persistence value for catfish equal to 0.98 while Oglend (2008) reported persistence value for salmon equal to 0.81.

The estimated degree of persistence in the respective markets was used to estimate the half-life of a volatility shock. The half-life estimates $[\log(0.5)/\log(\propto_1 + \beta_1)]$ measures the time it takes for a shock to fall to half of its initial value. In this study, the results show half-life time of 7 months for the ex-vessel market, 1.4 months for the wholesale market and 6.5 months for the retail market. Based on the overall findings, catfish prices in Uganda exhibit substantial volatility.

Model	Variable	Coefficient	Std. Error	z-Statistic	Prob.	Volatility
Ex-vessel	RESID(-1)^2	0.522749	0.174017	3.004011	0.0027	0.9058
	GARCH(-1)	0.383073	0.078879	4.856455	0.0000	
Wholesale	RESID(-1)^2	0.486276	0.218619	2.224304	0.0261	0.6158
	GARCH(-1)	0.129483	0.296313	0.436981	0.6621	
Retail	RESID(-1)^2	0.112550	0.067168	1.675665	0.0938	0.8986
	GARCH(-1)	0.786065	0.093091	8.444077	0.0000	

TABLE 1. GARCH Estimation Results for Catfish Markets

PRICE VOLATILITY IN THE CATFISH RESELLER MARKETS IN UGANDA

James O. Bukenya

Alabama A&M University

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Presentation Outline

Introduction | Objectives | Methodology | Results

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Introduction

- **Fish production is a risky venture**
  - Price variability is a significant risk component
- Few studies on fish-price volatility, relative to other agricultural commodities
  - Data availability
  - *Single species volatility studies* (e.g. Oglend & Sikveland, 2008; Oglend, 2013, Sollibakken, 2012; Buguk et. al. 2003)
  - *Forecasting studies* (e.g. Guttormsen, 1999; Vukina & Anderson, 1994; Gu & Anderson, 1995).

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Introduction ctn.

- Understanding the structure of price volatility is of great interest:
  - ✓ Well-functioning markets transmit price signals, which allow changes in demand to be met by supply.
  - ✓ When demand is greater than supply, producers increase production in response to price signals, and this increased production, in turn, helps to stabilize prices.

Thus, by transmitting information…, markets help to reduce **price volatility**.

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Assumptions behind price expectation and volatility

- ✓Producers are rational in the sense that they have adaptive expectations about price levels and volatility (Muth, 1961; Nerlove, 1969; Nerlove and Bachman, 1960).
- ✓The expectations that determine supply decisions are conditional on information available at the time resources are committed to production.
- ✓As a result, supply response is based on the hypothesis that quantity produced depends on input prices and producers' expectation of output price.
- ✓Because of production lag, there is a lag in the information set—production at time (t) is the result of decision made at time (t-1).

Cost structure

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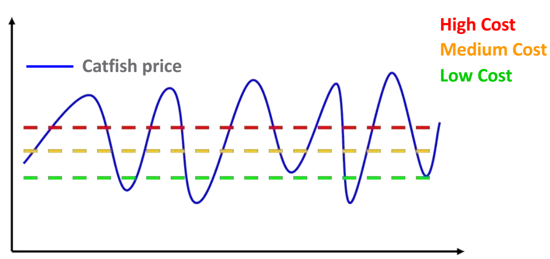
Coping with Volatility



High cost:	Competitiveness problem
Medium cost:	Needs to manage price risk
Low cost:	Can ride out the volatility

Response to price volatility will depend on current cost structure of the farm or business

Managing price volatility

- Improve cost control
- Build cash reserve
- Increase/reduce capital spending
- Appropriate finance for expansion
- Develop a cash flow budget

Other risks

- Weather
- Disease and predators
- Interest rates
- Increased debt

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Objectives

- The objective of this research is to investigate price volatility response in a rational expectation context for aggregate producers' supply response in the catfish reseller markets.
  - ✓ Determine the degree of volatility persistence in the ex-vessel, retail and wholesale market channels.
  - ✓ Determine the time required for the persistence of shocks in volatility to move half way back towards its unconditional mean.

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Methodology

Time Series Data:

- The volatility process in catfish prices is analyzed based on monthly data from Jan. 2006 – Aug. 2013.
- Ex-vessel prices from landing sites on Lake Victoria:
  - ✓ Kikondo (Buikwe district), Masese (Jinja district) and Ggaba (Kampala).
- Retail and wholesale prices from selected fish markets:
  - ✓ Nateete, Busega, Luzira, Mukono, Kalerwe, Nakawa and Owino.
- Prices (UG Shs.) are deflated using CPI to account for inflation
  - ✓ CPI for food stuff drawn from UBS (used 2005/06 as base year).

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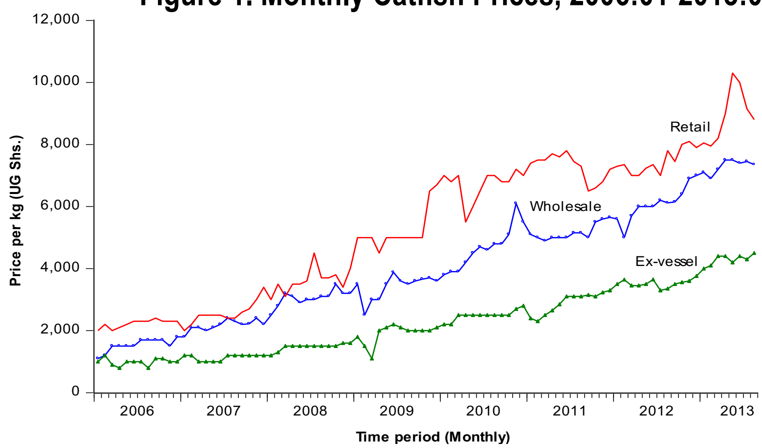
Figure 1. Monthly Catfish Prices, 2006:01-2013:08



Source: Aquaculture Management Consultant (AMC, 2013).

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Ordinary Regression vs GARCH Model

Ordinary regression model assumed homoscedasticity (errors have same variance throughout).

$$Y_t = X_t\beta + u_t$$

- Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model addresses this weakness.

Proposed by Engle in 1982

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GARCH (1,1) Model:

$$u_t = \sqrt{h_t \varepsilon_t}$$
$$h_t = k + \alpha h_{t-1}\varepsilon_{t-1}^2 + \beta h_{t-1}$$
$$= k + \alpha u_{t-1}^2 + \beta h_{t-1}$$

h is conditional variance of catfish price, ***ε*** is the residual squared; while ***k***, ***α*** and ***β*** are empirical parameters determined by maximum likelihood estimation.

- The variance of u_t is a weighted average of three components:
  - ✓a constant or unconditional variance.
  - ✓yesterday's information.
  - ✓past forecast variance.

Measures of Persistence:

$$u_t = \sqrt{h_t \varepsilon_t}$$
$$h_t = k + \alpha h_{t-1}\varepsilon_{t-1}^2 + \beta h_{t-1}$$
$$= k + \alpha u_{t-1}^2 + \beta h_{t-1}$$

1. Determine the degree of volatility persistence in the catfish market channels

$$Volatility = (\alpha + \beta)$$

2. Determine the time required for the volatility to move half way back towards its unconditional mean:

$$Half - life\ estimation = [Log(0.5)/Log(\alpha + \beta)]$$

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Table 1. GARCH Estimation Results

Model	Variable	Coefficient	Std. Error	z-Statistic	Prob.
Ex-vessel	RESID(-1)^2	0.522749	0.174017	3.004011	0.0027
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GARCH [1,1]

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	GARCH(-1)	0.786065	0.093091	8.444077	0.0000

RESID: Suggests there is evidence of the presence of volatility clustering

GARCH [1,1]

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Table 1. GARCH Estimation Results

Model	Variable	Coefficient	Std. Error	z-Statistic	Prob.	Volatility
Ex-vessel	RESID(-1)^2	0.522749	0.174017	3.004011	0.0027	**0.9058**
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	GARCH(-1)	0.129483	0.296313	0.436981	0.6621	
Retail	RESID(-1)^2	0.112550	0.067168	1.675665	0.0938	**0.8986**
	GARCH(-1)	0.786065	0.093091	8.444077	0.0000	

Note: the sum $(\alpha_1 + \beta_1)$ measures the degree of volatility persistence in the market.

Comparable Studies:

- Buguk, et al. (2003) arrive at the degree of volatility persistence of **0.98** for the US catfish markets.
- Oglend and Sikeland (2008) estimate the degree of volatility persistence in the Norwegia salmon market at **0.81**.
- Marvasti (2014) report the degree of volatility persistence of **0.99** for the Gulf of Mexico red snapper.

Table 2. Half-Life Estimation Results

Model	Variable	Coefficients	Half-Life Estimate
Ex-vessel	log(0.5)	-0.69315	**7 months**
	$\log(\propto_1+\beta_1)$	-0.09891	
Wholesale	log(0.5)	-0.69315	1.4 months
	$\log(\propto_1+\beta_1)$	-0.48490	
Retail	log(0.5)	-0.69315	**6.5 months**
	$\log(\propto_1+\beta_1)$	-0.10690	

Note: The half-life estimates $[\log(0.5)/\log(\propto_1+\beta_1)]$ measures the time it takes for a shock to fall to half of its initial value.

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Summary and Conclusion

- The estimated volatility coefficients are closer to one indicating that there are long persistence of shocks in volatility in the markets.
- Ex-vessel and retail market channels show longer persistence of shocks in volatility compared to the wholesale market channel.
- The half life of volatility spikes in the ex-vessel and retail market channels is almost 4 times that of the wholesale market channel.
  - ✓ It meant that any bad or good news did have a long lasting and significant impact on the volatility of the prices over the studied period.
- Overall, the results suggest a great deal of uncertainty and risk in the catfish reseller markets.

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Implementing mobile marketing and technical support for fish farmers: Uganda grower experiences and aspirations

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International Center for Aquaculture & Aquatic Environments
Auburn University
Auburn, AL 36849-5406
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Improving fish culture productivity is one of the most pressing issues for African aquaculture. The widespread availability of mobile phones and improving coverage over wide areas position the technology as a necessary component of sustainable improvements in farm practice. Coupled with corresponding innovation in existing social and institutional arrangements, mobile phones have the potential to make significant contributions to increase income for small-scale fish farmers. As mobile phones converge with other mobile devices such as netbooks and tablets, the opportunities proliferate. Affordability will remain an issue, but cell phone capability and market penetration grow. Old style extension approaches must be supplanted (or at least supplemented) by mechanisms that provide for widespread dissemination of technical information to stimulate and support the adoption of productivity increasing practices. Technical guidance, product assembly, and price discovery are but three of the many fundamental applications of cell phones in aquaculture. Fishers and farmers use cell phones to get market prices to know where to sell products. Fish farmers use them for extension support and to arrange for feed and seed.

The presentation considers the process of implementing cell-based marketing, input supply, and technical support services for fish farmers in Uganda. Baseline information about the needs and interests of fish farmers was developed through focused group interviews conducted in five Uganda districts: Masaka, Mukono, Mpigi, Bushenyi and Kalungu in May, June, July and August 2014. Data were obtained from 48 Ugandan fish farmers (14 women). The main findings reveal that cell phone use is common among fish farmers, but that intermediary farmers play an important role in connecting producers to markets and suppliers. Sustainable systems will feature a business model that recovers covers costs in a minimal way, while responding to farmer needs and interests in a flexible way. Public agencies, nongovernmental organizations, and cellular service providers must work together to advance the use of cell phones guide, coordinate, and instruct fish farmers. Public agencies will be challenged to provide timely and technically correct information to producers.

Implementing Mobile Phone Marketing and Technical Support for Fish Famers: Uganda Grower Experiences and Aspirations

Joseph Molnar, Moureen Matuha, Gertrude Atukunda, John Walakira, Jeffrey Terhune, James Bukenya, Shamim Naigaga
Auburn University
Auburn, Alabama USA

Fish Species Cultured in Uganda

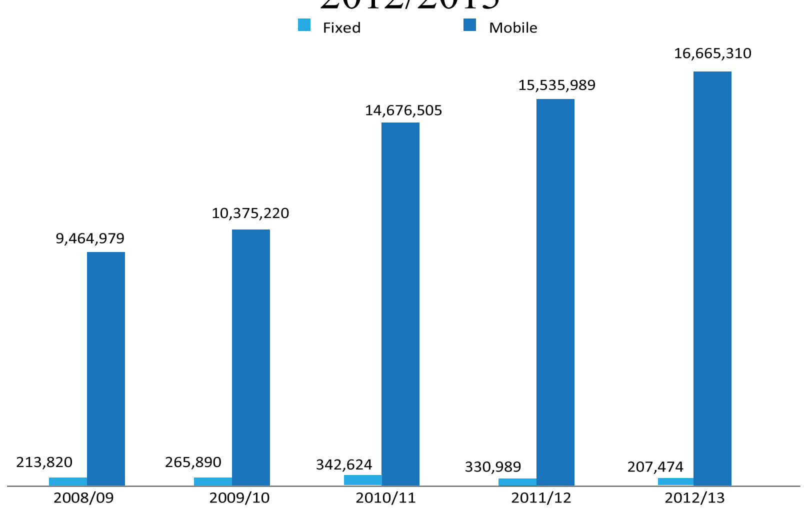
- Nile tilapia (*Oreochromis niloticus*)
- African catfish (*Clarias gariepinus*)
- Common carp (*Cyprinus carpio*)



Objectives

- Examine mobile phones as means for reaching and supporting fish farmers
- Outline possibilities for Uganda
- Consider current path for implementation

FIXED AND MOBILE PENETRATION 2012/2013



Source: UCC, post and Telecommunications Annual Market Review 2012/2013

POPULATION COVERED BY MOBILE CELLULAR NETWORKS IN UGANDA(%)

Source: Trading Economics.com

Mobile Money

- Mobile payments
  - Receive or make payments
  - Transfer and save money

Fish Farmer's Ponds

Marketing & Inputs

- Price discovery
  - Prior to negotiations
  - Before travel
- Purchase of inputs
  - Fingerlings
  - Feed
  - Nets
- Locating services
  - Transport
  - Pond construction
  - Harvesting

Mobile Support Applications

- No miracles
- Facilitate existing processes
- Several possibilities
- Farmers helping farmers
- Marketing first target application
  - Private sector vendor manager
  - Technical advisory committee
  - Content from NaFIRRI, AquaFish, others

Business Models

- Several possibilities, none fixed
- USAID & GOU support for start-up
- Farmers pay
  - Subscriptions & use costs
  - Text costs
- Management entity
  - Recovers costs through vendors and subscribers
  - Vendors and buyers pay transaction fee (NOT farmers)
  - Minimizing costs, maximizing benefits

Technical Leader(s)

- Interface with farmers
- Several different models
- Leading farmer
  - One or more leading farmers per district?
    - Android phone
    - Support colleagues
- Technical specialist
  - Full-time
    - Community Knowledge Worker CKW
    - Ambassador Farmer
    - Other names
  - One per district
  - Mediator, organizer, promoter, facilitator

Implementation

- Identify technical leader
- Implement in first target district
- Put marketing application to work
- Advance technical modules
- Business model

Technical Assistance

- Contact fellow fish farmers for guidance
- Gain knowledge on crops, livestock
- Extension officers not always available to help

Farmer's own words

- *"Through mobile phones, I have been able to to call fellow fish farmers that have been in the business or contact the middle men to locate for market…"*
- "*Mobile money helps us to save small amounts of money, receive payments quickly in times of need and pay for agricultural inputs, make mobile payments, replace costly traditional transfer services and reduce the need to travel long distances to collect funds. Before the introduction of mobile-money, we used to waste too much time moving to financial institutions to make payments or to receive money. However the costs and taxes associated with it are high"*
- "*We have more than 100 fish farmers in our district but we have only one district Fisheries Officer to serve both fish farmers and fishermen –yet, farmers have diverse questions which an Officer may not handle even if he reached them since he is not a trained personnel"*

Mobile Use by Farmers in Aquaculture

- Reducing coordination costs
  - Arrange for fish farming inputs
  - Receive information from other fish farmers
  - Provide monetary savings

Next steps

- Identify technical service provider
- Select model for supporting farmers
- Implement in first target district (s)
- Put marketing application to work
- Advance technical modules

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Background

- Aquaculture is largely a non-traditional form of agriculture in Uganda.
- Fish farming was introduced in early 1940's due to unreliable and unsustainable use of natural waters for capture fisheries.
- Scientific, technological and managerial skills need to be improved in order to optimize production in fish farming.
- The major problem faced by Ugandan fish farmers is lack of information on best management fish farming and marketing practices.
- Mobile phones could play an important role by providing timely information to fish farmers.

Focused Group Interviewers with Farmers

Conducted to understand use of mobiles in fish farming:

- Five Districts of Uganda: Masaka, Mukono, Mpigi, Bushenyi and Kalungu.
- 48 small- to medium-size farm holders .
- Digitally recorded and transcribed in English.
- Semi-structured questionnaires were used.
- Fish farmers were recruited for their participation was voluntary through the help of Grameen Field Officers and Community Knowledge Workers (CKWs).

Location of Focused Group Interviews

Method

- Respondents were asked, against pre-identified challenges, to indicate their extent using a 4-point rating scale: 1= not at all, 2= low, 3= medium 4= high
- Responses were computed and ranked by developing a Problem Facing Index (PFI).
- Responses were measured using the following formula:

  Problem Facing Index (PFI) = (PH×3) + (PM×2) + (PL×1) + (PN×0)
- Thus, PFI of an item could range from 0 to144, where 0 indicated no problem at all and 144 indicated high extent problem faced.

Findings

Table 1: Problems faced by fish farmers using mobile phones

Problems in using mobile phones	score	Rank
High calling rates	144	1
Lack of adequate calling credit	135	2
Poor battery systems	96	3
Poor network	70	4
Poor battery systems	62	5
High maintenance costs	48	6
lack of internet applications	33	7
Lack of adequate knowledge on mobile use applications	16	8

Findings

Table 2: Interests and needs of fish farmers

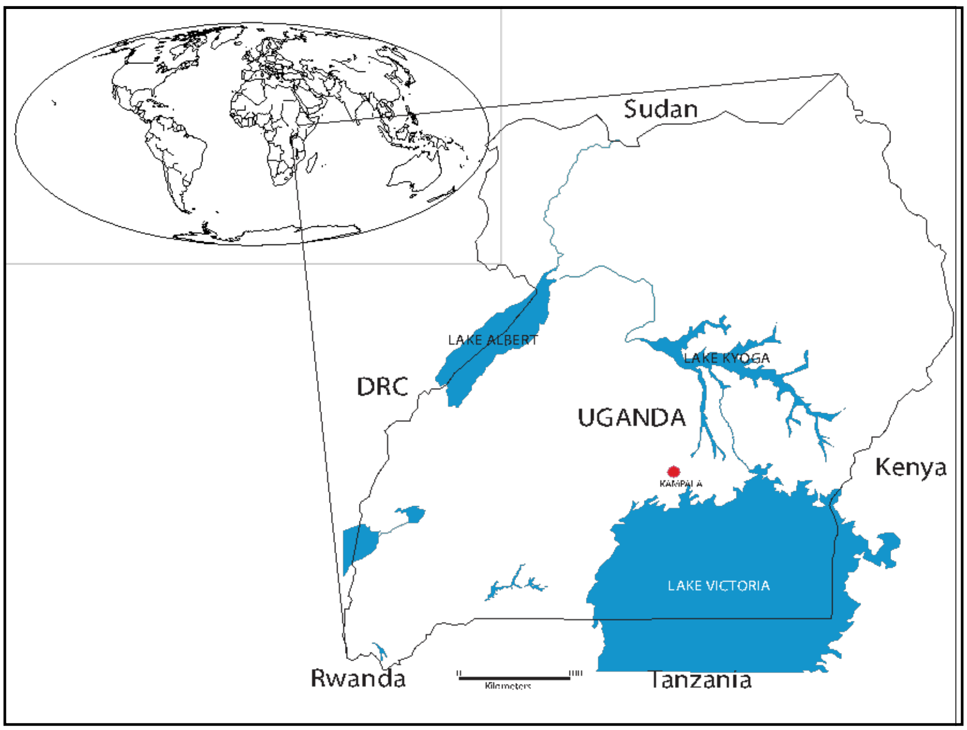
Farmer's needs	**Rank order**
Market information	1
Feeding procedures	2
Pond management	3
Water quality management	4
Fish health information	6
Breeding information	7
Fertilizer application	8
Brood stock management	9

Method

- Responses were coded using thematic analysis:
- Marketing information
- Coordination
- Mobile payments
- Technical assistance

Discussion

- Cell phone use is common among fish farmers in Uganda
- Government fisheries officers and aquaculturalists are unable to meet the needs of all fish farmers.
- Intermediary farmers play an important role:
  - Connecting producers to markets and suppliers.
  - Providing information regarding fish farming
- Farmers are anxious to use mobile phone applications
- Market information, quality seeds, feeding procedures, pond management, fish diseases, breeding, water quality management and predator control are most needed by fish farmers.



An assessment of household food security in fish farming communities in Ghana

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Fish is an important source of protein and essential micronutrients for many African households. Therefore, participation in aquaculture could have food security implications both directly through fish consumption, and indirectly through income effects. Food security can be assessed at different levels, i.e., nationally, regionally, and at the household levels. This study looked at the household level where food security can be characterized by nutritional adequacy and dietary diversity. Given the importance of fish in the Ghanaian diet, this study examined the impact of fish farming on household food security. The objectives of the study were to (1) measure household food security (dietary diversity and nutrient adequacy) using WFP's Food Consumption Score (FCS), and (2) assess the determinants of household food security. Data was collected from two regions in Ghana, i.e., Ashanti and Brong-Ahafo. The FCS was measured as a sum of the weighted frequencies of various food groups consumed in a week. The food groups included cereals and tubers, pulses, vegetables and fruits, meats and fish, sugar, milk, and condiments.

The study evaluated households engaged in fish farming as well as non-fish farming households (control group). The average FCS value for fish farming households was 72 while that of non-fish farming households was 69 but the difference is not statistically significant. A two stage least squares regression (2SLS) estimation method was used to assess the determinants of *FCS*, which included *fish farming participation*, *location* (*peri-urban vs rural*), *farming experience, number of years of mother's education*, *number of children at home,* and *household wealth* (*proxy for household income*). *Technical support* was used as instrument to control for endogeneity of the *fish farming participation* variable. Results from the 2SLS estimation showed that *fish farming participation, peri-urban location, mother's education, and number of children at home* are very strong predictors of household nutritional adequacy and dietary diversity in fish farming communities. The impact of fish farming could be attributed to both fish consumption and the income effect. An educated mother probably uses her knowledge of nutritional foods to purchase the right kinds of foods for the household, while households located in peri-urban areas have better opportunities in terms of income generating activities, larger markets and food delivery systems than rural areas.

To assess any differences in household wealth on food security, the study tested for potential non-linear relationships by adding a quadratic household wealth variable. The variable was found to have a positive relationship with food security. This appears to suggest that wealthier households, usually the middle to higher income class in the fish farming communities, make better dietary quality decisions for the household compared to households in the low income class.

FOOD SECURITY IN FISH FARMING COMMUNITIES IN GHANA

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Food Security & Nutrition

- Agricultural-related development projects presumed to accomplish some combination of improving household food security and nutrition
- But how do we measure these outcomes?
  - ✓ Access to adequate food
  - ✓ Food distribution within household
  - ✓ Dietary intake
  - ✓ Dietary diversity
  - ✓ etc

Food Security & MDGs

- UN Millennium Dev't Goals applicable to food security:
  - ✓ Eradication of extreme hunger & poverty
  - ✓ Reduction in child mortality
  - ✓ Improve maternal health
- Aquaculture being adopted by developing countries to achieve above goals
- 2015 MDG report suggests Ghana is food secure but only in selected staple crops.

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Empirical Questions

- Does fish farming improve the nutritional quality of a household?
- Are rural-based fish farming households more food secure than urban-based fish farming households?
- Does household wealth determine food security?

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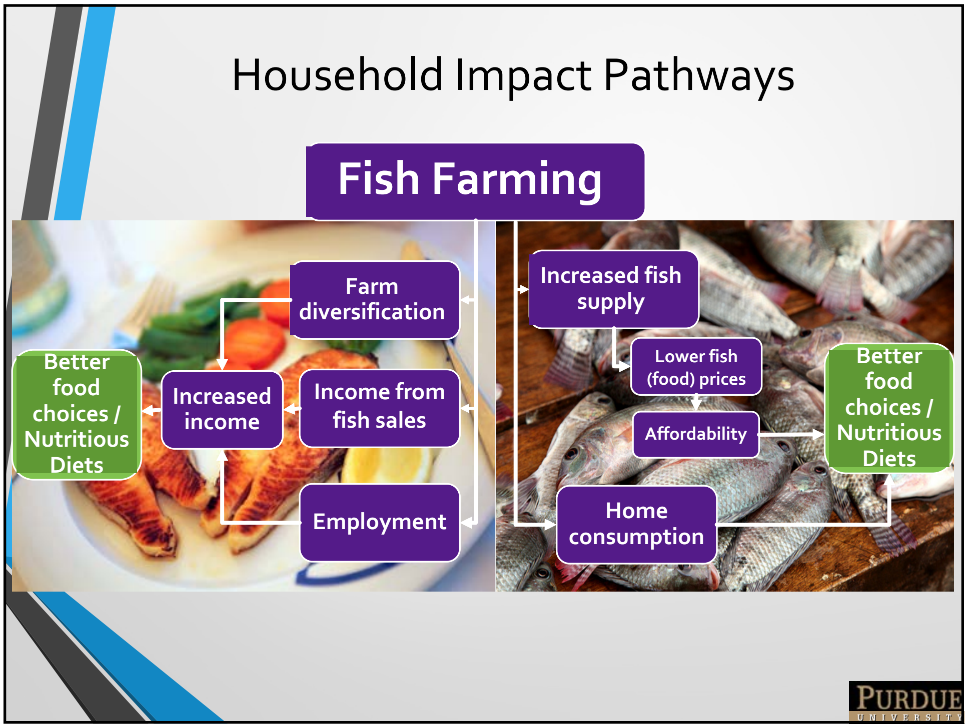
Household Impact Pathways
Fish Farming
Farm diversification
Increased income
Income from fish sales
Employment
Better food choices / Nutritious Diets
Increased fish supply
Lower fish (food) prices
Affordability
Home consumption
Better food choices / Nutritious Diets
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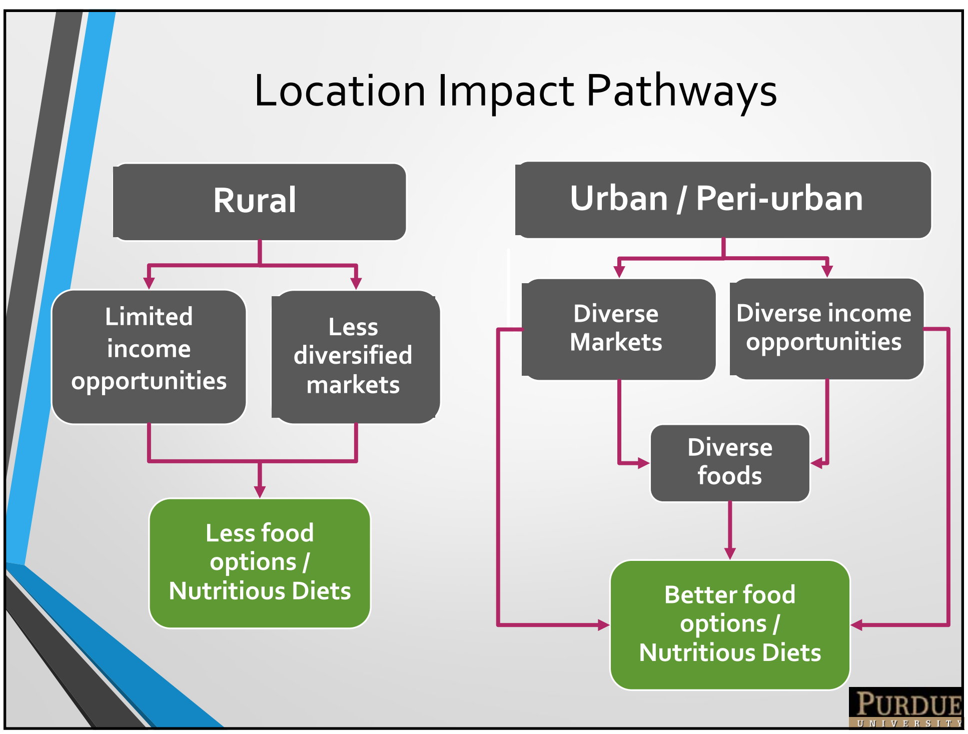
Location Impact Pathways
Rural
Limited income opportunities
Less diversified markets
Less food options / Nutritious Diets
Urban / Peri-urban
Diverse Markets
Diverse income opportunities
Diverse foods
Better food options / Nutritious Diets
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Study Objectives

1. Measure food security using dietary diversity indicators of aquaculture households
2. Evaluate the effect of selected socio-economic factors on household food security
3. Suggest some policy recommendations

Food Security Measures

- Coping Strategies Index (CSI)
- Reduced Coping Strategies Index (rCSI)
- Household Food Insecurity and Access Scale (HFIAS)
- Household Hunger Scale (HHS)
- Food Consumption Score (FCS)
- Household Dietary Diversity Scale (HDDS)
- Self-assessed measure of food security (SAFS)

Data / Methodology

- Household face-to-face interview in Ashanti & Brong-Ahafo regions (June - August 2014)
- Information on assets, demographics, health, 24hr food consumption recall, & food consumption frequency and patterns
- Data collected from both fish farming and non-fish farming households

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Respondents

- 158 households - 54 fish farming households & 104 non-fish farming households.
  - ✓ Targeted AquaFish supported farmers
  - ✓ Non-fish farming group based on proximity to target group and used as a comparison group.
- 99% women - targeted the caregivers of the households
- Age range: 19 - 76 years

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Food Security Indicator

Food Consumption Score (FCS): Sum of the weighted frequencies of the various food groups consumed:

$$FCS = \sum w_i f_i$$

w_i = weight or the nutritional value of food group *i.*

f_i = frequency of food consumption of food group *i* (number of days in a week the food group is consumed).

'*i*' = food groups - cereals and tubers, pulses, vegetables and fruits, meats and fish, sugar, milk, & condiments.

WFP Food Groups and Weights

Food Items	Food Groups	Weights
Maize, maize porridge, rice, sorghum, millet, pasta, bread, other cereals, Cassava, potatoes and sweet potatoes	Cereals and Tubers	2
Beans, peas, groundnuts, cashew nuts and other nuts	Pulses	3
Vegetables, leave and fruits	Vegies and fruits	1
Red meat, poultry, eggs, fish	Meat and fish	4
Milk, yoghurt and other dairy products	Milk	4
Sugar and sugar products	Sugar	0.5
Oils, fat and butter	Oil	0.5
Condiments	Condiments	0

FCSs

- WFP thresholds:
  - ✓ Poor Food Security: FCS of 0 – 21
  - ✓ Borderline Food Security: FCS of 21.5 – 35
  - ✓ Acceptable Food Security: FCS above 35
- Threshold with oil & sugar eaten on daily basis (~7 days/week)
  - ✓ 0 - 28
  - ✓ 28.5 – 42
  - ✓ >42

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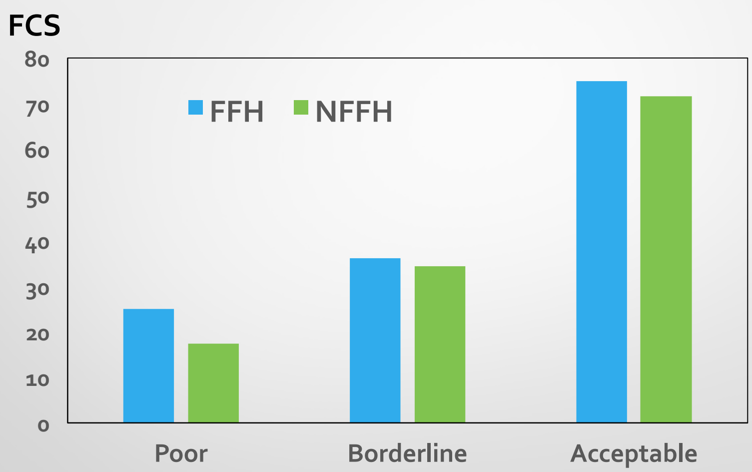
Results

Fish farming households (FFH) vs non-fish farming households (NFFH)]



Mean FCS FFH (72); NFFH (69)

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2SLS Regression

- FCS = *f* (fish farming, location, farming experience, mother's education, # of children, household wealth)
  - ✓ Instrumental var was technical assistance.

2SLS Regression

	Coeff	Std. Er	*t*	95% C I	
Fish Farm	0.514	0.056	9.15	0.404	0.624
Peri-Urban	0.341	0.058	5.87	0.227	0.454
Experience	-0.08	0.008	-0.98	-0.025	0.008
Mother's Ed	0.042	0.006	7.26	0.030	0.053
# of children	0.104	0.016	6.42	0.073	0.136
Wealth Index	0.008	0.009	0.93	-0.009	0.025

2SLS Regression

	Coeff	Std. Er	*t*	95% C I	
Fish Farm	0.562	0.058	9.67	0.448	0.676
Peri-Urban	0.299	0.059	5.08	0.184	0.415
Experience	-0.018	0.009	-1.99	-0.037	0.000
Mother's Ed	0.040	0.006	7.07	0.029	0.051
# of children	0.098	0.016	6.10	0.067	0.130
Wealth Index	0.003	0.009	0.29	-0.015	0.020
WI squared	0.016	0.006	2.58	0.004	0.028

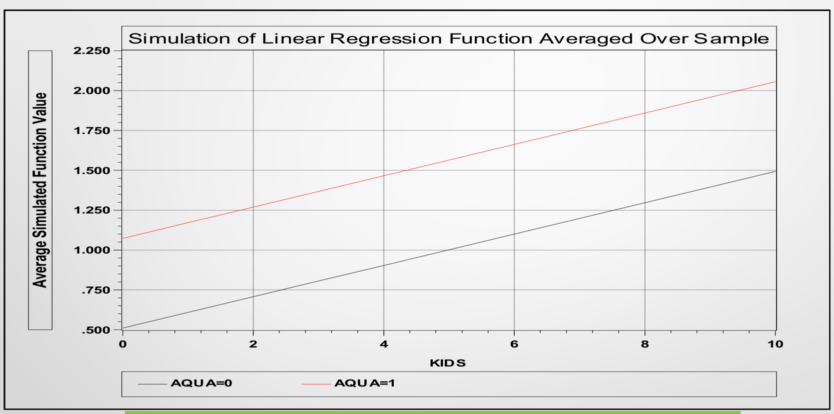
Pathways

- Fish Farming:
  - ✓ Direct fish consumption and Indirect income effects
- Location:
  - ✓ Peri-urban areas have better opportunities in terms of income generating activities, larger markets and food delivery systems than rural areas.
- # of children:
  - ✓ It is assumed that with more children in the household, the better food choices, quality and diversity of the food consumed.
- Mother's education:
  - ✓ An educated woman as a household caregiver is able to make informed and independent decisions when it comes to the choice of food the household should consume.
- Wealth:
  - ✓ Household income is an indication of the household's economic status. Wealthier households - middle to higher income class make better dietary quality decisions compared to households in low income households.

Summary of Results

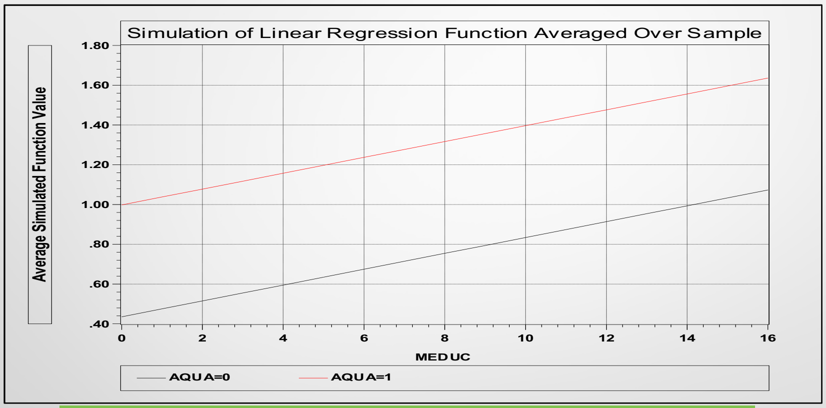
- Based on the magnitude of effects, the positive impact on food security in descending order:
  1. Fish farming
  2. Peri-urban
  3. # of children
  4. Mother's education
  5. Wealth

Effect of fish farming over no. of children



Food security increases with number of children; and also for households engaged in fish farming.

Effect of fish farming over mother's education



Food security increases with increased number of years of mother's education; and also for households engaged in fish farming.

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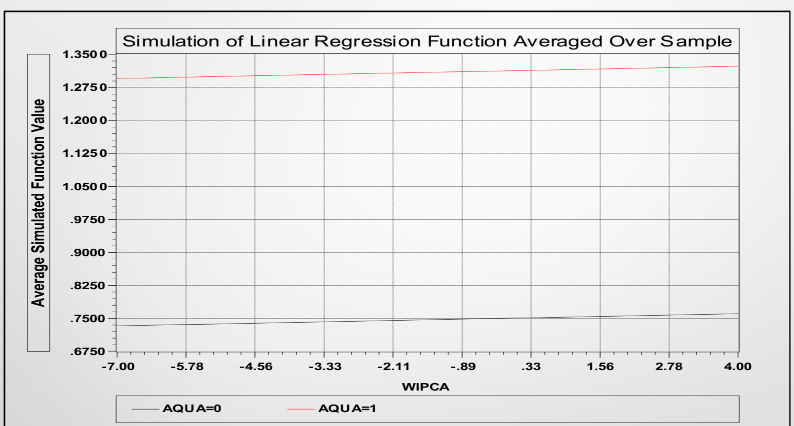
Effect of fish farming over household wealth



Food security slightly increases with increased wealth; and also slightly for households engaged in fish farming.

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Policy Recommendations

- Aquaculture is having household food security outcomes. Policies should also be directed at improving farm household welfare and not only economic development.
- Need for production & promotion of diverse aquaculture products to enhance human consumption.
- Development and use of efficient technology suitable for small-scale aquaculture.
- Technology to connect small-scale fish farmers to urban fish markets to reduce information asymmetry.

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Production and economic benefits of reduced feed inputs and addition of Indian carp (Rohu) on Nile tilapia growout in ponds

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The aim of these studies was to determine if reductions in feed inputs and introduction of a native Indian carp, *Rohu* (*Labeo rohita*), can increase economic benefits of tilapia culture in earthen ponds in Bangladesh. An on-station pond trial was carried out for 150 days at the Fisheries Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh. 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. Pond water temperature, transparency, dissolved oxygen, nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_3-N), phosphate-phosphorus (PO_4-P) and chlorophyll-a did not vary among treatments, while pH was slightly lower in T1 than the other treatments, but well within the suitable range for tilapia growth. A total of 27 genera of phytoplankton and 12 genera of zooplankton were identified from the pond water samples. Total phytoplankton levels were highest in the T4 and T3 groups. The survival rates (%) of tilapia were 81.06 ± 1.03, 76.89 ± 1.28, 76.24 ± 2.06 and 75.29 ± 2.45 in T4, T3, T2, and T1 groups, respectively. The specific growth rate (% day^{-1}) 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 ($p < 0.05$) with feed conversion ratios of 0.49 ± 0.03, 0.47 ± 0.03, 1.13 ± 0.11 and 1.23 ± 0.16, for the T4, T3, T2, and T1 groups, respectively. Gross production of tilapia was higher in the T4 (5,385.23 ± 276.98^a kg ha^{-1}) followed by T3 (5,340.62± 156.47^a kg ha^{-1}), T2 (4440.99± 440.04^b kg ha^{-1}) and T1 (4089.83± 518.46^b) groups, respectively. Rohu gross production was similar among the T2 and T4 groups. A significantly higher net return (BDT 743,977 ha^{-1} with benefit cost ratio of 2.92) was found in T3 followed by T4 (BDT 673,750 with benefit cost ratio of 2.72), T2 (BDT 286,469 ha^{-1} with benefit cost ratio of 1.49) and T1 (BDT 226,675 ha^{-1} with benefit cost ratio of 1.37) groups, respectively. Based on the higher net return and benefit-cost ratio, it may be concluded that fertilization with half feeding was substantially more cost effective over standard full feeding for growout of tilapia. Moreover, tilapia growth was little impacted by reducing feed by half. It would also appear that addition of Rohu had little impact on growth of tilapia, but could provide an additional source of income for tilapia farmers.

Production and economic benefits of reduced feed inputs and addition of Indian carp (ROHU) on Nile tilapia growout in ponds

Mst. Kaniz Fatema*, Md. Abdul Wahab, S. A. S. A. Tahmid, Amit Pandit, S. M. Masud Rana, Shahroz Mahean Haque, and Russell J. Borski

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Introduction

- Pond production of fish constitutes almost 85% of total aquaculture output in Bangladesh, with 60% coming from indigenous Indian major carps, *Catla* (*Catla Catla)* and *Rohu (Labeo rohita)*, and 17% from exotic Chinese carps (DOF, 2010; Belton *et al*., 2011).

- The appropriate amounts of feed (semi-intensive) can enhance aquaculture production by fourfold, and apart from this promotion of semi-intensive farming practices is a prime issue for increasing personal household income and fish consumption, and greater food security for impoverished farmers in Bangladesh.

Introduction

- A significant hurdle for the implementation of semi-intensive farming is **the cost of feed, comprising up to 50-70% of total costs**. Further, as local feed formulations often have low protein content, farmers compensate by overfeeding their fish, leading to poor water quality.

- Tilapia-carp farming under reduced feeding will hopefully produce **greater production yields with less cost,** thereby significantly increasing economic profitability for this endeavor.

- This investigation directly targets the improvement of household income for small-scale tilapia farmers by generating meaningful cost savings in feed.

Objectives

Evaluate production parameters and potential economic and environmental benefits of introducing rui in tilapia culture and of reduced feed ration in tilapia- Rui carp polyculture systems.

Research Design

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Rohu (*L. rohita*)	0	25 (0.25/m^2)	0	25 (0.25/m^2)
Tilapia (*O niloticus*)	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
Pond Numbers	12, 13, 15, 27	10, 11, 16, 26	17, 21, 23, 24	14, 18,22, 25

Study Area:

- Fisheries Field Laboratory Complex, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh-2202

Pond Size:

- The average size of all ponds was 151 m^2 (3.78 decimal) with an average water depth of 1.5 meter.

Research Methodology

Pre-stocking Activities

Pond preparation:

- Pond Drying
- Excavation
- Liming
- Water Filling
- Fertilization

Fingerlings Collection:

- Fingerlings collection
- Fingerlings rearing
- Sampling of fish

Feeding

- Formulated feed (30% CP) were supplied initially at 100% level for treatment 1 and 2 (see table below) and 50% level for treatment 3 and 4 every day according to the schedule below:

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

	Production system	
Fish weight (g)	Intensive	Semi-intensive
0-15	15.0	10.0
15-60	8.0	5.0
60-100	5.0	3.0
100-200	3.0	2.0
200-300	2.25	1.5
300-500	2.0	1.4
500 +	1.6	1.3

Source: Aquanutro 2002.

Pond Fertilization:

- Except Treatment-1 and 2, all ponds of treatments 3 and 4 were fertilized with urea and triple super phosphate (TSP) at the rates of 4:1 as N: P.

Sampling for water quality:

- Water Sample Collection
- Plankton Sample Collection
- Benthos Sample collection

Fish Sample Collection

- Growth parameters (length and weight) were monitored at 2-weeks interval. Feeding rate was adjusted accordingly based on the biweekly sampling.



Harvesting

- After 150 days of culture periods, all fishes were harvested from all ponds.






Analysis of Production Parameters:

The following production parameters were collected for further economic analysis:

i. Specific Growth Rates (SGR).

ii. Feed Conversion Ratio (FCR).

iii. Total fish yield (kg/ha).

iv. Water quality for all treatments were tested for significant differences using analysis of variance.

v. A marginal cost-economic return were performed for all treatments using production, labor, feed, fertilizer and other input costs.

Results

Table: Water quality analysis

Parameters	Treatment				Level of significance
	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Dissolved Oxygen (mg/l)	6.31±0.40	6.49±0.28	6.73±0.42	6.53±0.46	NS
Temperature (°C)	23.82±0.03	23.88±0.03	23.83±0.03	23.86±0.05	NS
pH	8.04±0.11b	8.19±0.02ab	8.26±0.10a	8.27±0.10a	*
Transparency (cm)	12.06±2.33	11.44±0.58	10.67±0.96	10.94±1.32	NS
Total Alkalinity (mg/l)	140.00±24.57	142.52±10.45	143.64±5.46	143.73±6.24	NS
TDS (mg/l)	132.18±26.32	135.34±17.79	134.75±4.74	126.88±11.01	NS
Chlorophyll-a (µg/l)	100.28±25.43	104.27±32.71	143.32±33.36	130.86±33.24	NS
Ammonia(mg/l)	0.626±0.152	0.507±0.058	0.523±0.089	0.582±0.090	NS
Phosphate (mg/l)	1.357±0.184	1.282±0.106	1.215±0.064	1.434±0.200	NS
Nitrite(mg/l)	0.036±0.008	0.052±0.025	0.038±0.016	0.041±0.006	NS
Nitrate(mg/l)	0.310±0.009	0.327±0.022	0.297±0.055	0.346±0.026	NS

Table: Mean abundance ($\times 10^3$ cells L^{-1}) of plankton population recorded from the ponds among four treatments

Variables	Treatments				Level of significance
	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	
Plankton ($\times 10^3$ cells L^{-1})					
Bacillariophyceae	21.14 ± 4.36^b	22.86 ± 4.42^b	28.72 ± 5.94^a	27.28 ± 5.95^a	*
Chlorophyceae	27.47 ± 3.86^c	29.17 ± 3.63^b	34.31 ± 3.09^a	33.17 ± 2.98^a	**
Cyanophyceae	5.58 ± 0.88^c	8.53 ± 0.88^a	6.97 ± 1.17^b	7.17 ± 0.84^{ab}	**
Euglenophyceae	6.72 ± 1.62^b	7.86 ± 1.04^a	6.53 ± 0.85^b	5.53 ± 1.28^c	**
Rhodophyceae	1.94 ± 0.62^a	1.39 ± 0.33^b	1.17 ± 0.38^c	1.44 ± 0.30^b	**
Total Phytoplankton	61.14 ± 7.21^c	64.47 ± 4.52^c	73.39 ± 5.87^b	85.94 ± 6.70^a	**
Copepoda	5.64±0.67	6.31±0.74	5.94±1.01	5.81±0.86	NS
Rotifera	9.39±2.36	10.06±2.36	12.72±4.26	11.19±1.88	NS
Cladocera	2.44±1.07	1.92±0.78	1.97±1.19	2.08±0.98	NS
Protozoan	0.61 ± 0.25^a	0.28 ± 0.15^c	0.67 ± 0.41^a	0.39 ± 0.28^b	*
Total Zooplankton	15.28±1.22	16.58±0.86	20.39±2.32	25.17±3.68	NS
Total Plankton	76.42±7.87	81.06±5.00	93.78±7.96	111.11±9.76	NS

Table: Abundance of Benthos in Different Treatments during the Experimental Period

Group of Benthos	No. of Benthos in Different Treatments (no./m²)				Level of Significance
	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Oligochaeta	217.28±45.80	206.58±36.14	195.06±42.03	188.89±39.28	NS
Chironomid Larvae	386.83±77.06a	316.87±56.96b	257.61±50.24c	261.73±73.66c	**
Mollusks	69.68±27.76	56.79±14.70	70.78±20.49	53.91±26.13	NS
Unidentified	22.50±15.24	21.81±12.76	17.70±18.41	9.05±9.09	NS

Growth and Production of Tilapia

Variables	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	Level of significance
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Mean Stocking Weight (g)	8.34 ±1.85	8.34 ±1.85	8.34 ± 1.85	8.34 ± 1.85	NS
Mean Harvesting Weight(g)	108.96 ± 9.82 ^{b}	116.99 ± 9.04^b	137.69 ± 2.04^a	132.57 ± 5.42^a	**
Mean Weight Gain (g)	100.62 ± 9.82 ^{b}	108.64 ± 9.04 ^{b}	129.35 ± 2.04 ^{a}	124.23 ± 5.43 ^{a}	**
Survival Rate (%)	75.29 ± 2.45 ^{b}	76.2 4 ± 2.06 ^{b}	76.89 ± 1.28 ^{b}	81.06 ± 1.03^a	*
Specific Growth Rate, SGR	1.71 ± 0.06^b	1.76 ± 0.05^b	1.87 ± 0.00^a	1.85 ± 0.03^a	*
Gross Production (kg ha^{-1})	4089.83 ± 518.46^b	4440.9 9± 440.04^b	5340.62 ± 156.47^a	5385.23 ± 276.98^a	*
Net Production (kg ha^{-1})	3777.52 ± 52^b	4124.6 7± 431.38^b	5017.16 ± 151.46^a	5046.53 ± 272.30^a	*

Table: FCR (Feed Conversion Ratio) of Tilapia

Treatments	T_1 (100% feed no fertilization, No Rui)	T_2 (100%feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	Level of significance
Feed Conversion Ratio, FCR	1.23±0.16[a]	1.13±0.11[a]	0.47±0.03[b]	0.49±0.03[b]	**

Growth and Production of Rui

Variables	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	Level of significance
		Mean±SD		Mean±SD	
Mean Stocking Weight (g)	-	26.6 ± 8.5	-	26.6 ± 8.5	NS
Mean Harvesting Weight(g)	-	61.6 ± 13.76	-	59.93 ± 2.04	NS
Mean Weight Gain (g)	-	35 ± 13.76	-	33.33 ± 2.04	NS
Survival Rate (%)	-	80.56± 18.44		77.29 ± 22.94	NS
Gross Production (kg ha^{-1})	-	126.502 ±52.63	-	116.107 ± 35.13	NS
Net Production (kg ha^{-1})	-	73.12 ± 42.14	-	64.78 ± 20.75	NS
Specific Growth Rate, SGR	-	0.55 ± 0.14	-	0.54 ± 0.02	NS

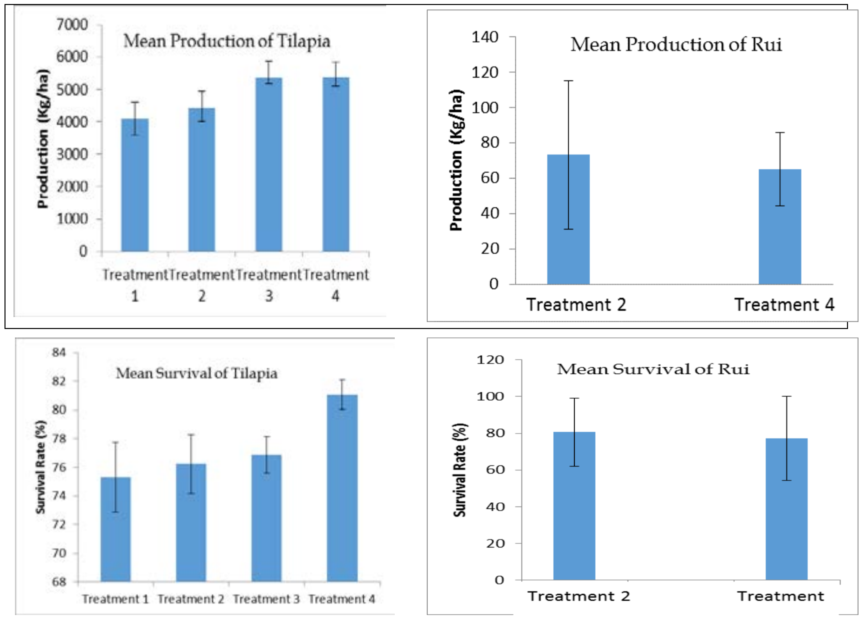


Table: Economic Analysis of Tilapia and rui Production

Expenditure(Tk $pond^{-1}$)	T_1 (100% feed no fertilization, No Rui)	T_2 (100% feed no fertilization, plus Rui)	T_3 (50% feed plus fertilization, No Rui)	T_4 (50% feed plus fertilization, Plus Rui)	Level of significance
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Fingerlings cost (Tk ha^{-1})	99,505.71± 1,411.43^{b}	1,11943.93 ±1,587.86 ^{a}	1,00917.14±1,411.43^{b}	1,12737.86±1,833.50^{a}	**
Feed cost (Tk ha^{-1})	1,18210.1421±4,309.44^{a}	1,18210.1421±4,309.44 ^{a}	62,777.92± 1,074.71^{b}	60,407.64± 981.23^{b}	**
Lime Cost (Tk ha^{-1})	1,885.58±935.91	1,389.38±1273.01	1,896.61±1784.02	2,172.28±1457.26	NS
Fertilizers cost (Tk ha^{-1})	_	_	6,661.74± 93.55^{a}	6,614.97± 108.02^{a}	**
Operational cost (Tk ha^{-1})	42,664.53±568.91^{a}	43,560.18±555.06^{a}	26,948.17±431.08^{b}	27,244.54±747.29^{b}	**
Total Expenditure (Tk ha^{-1})	6,11,524.94±8154.32^{a}	6,24,362.60±7955.90^{a}	3,86,257.17±6178.87^{b}	3,90,505.00±10711.16^{b}	**
Gross return (Tk ha^{-1})	8,38,200.68±1,16,951.37^{c}	9,32,932.67±77,451.22^{bc}	11,30,234.07±86,477.25^{a}	10,64,254.63±89,098.58^{ab}	NS
Net return (Tk ha^{-1})	2,26,675.58±110128.31 ^{b}	2,86,469.43±95884.41^{b}	7,43,976.95±80584.80^{a}	6,73,749.64±79583.97^{a}	**
BCR (Benefit Cost Ratio) (Tk ha^{-1})	1.37±0.17 ^{b}	1.49±0.11 ^{b}	2.92±0.18 ^{a}	2.72±0.17 ^{a}	**

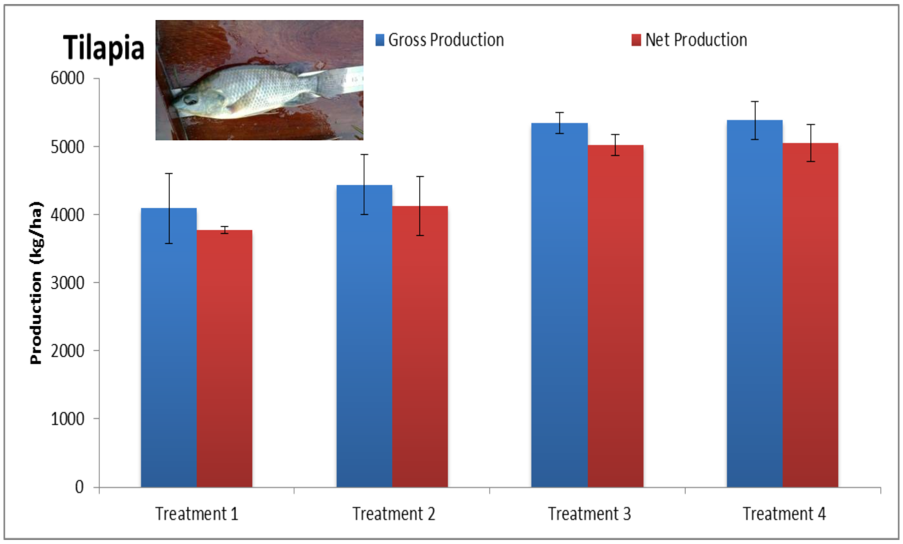


Figure 1: Gross production of Tilapia

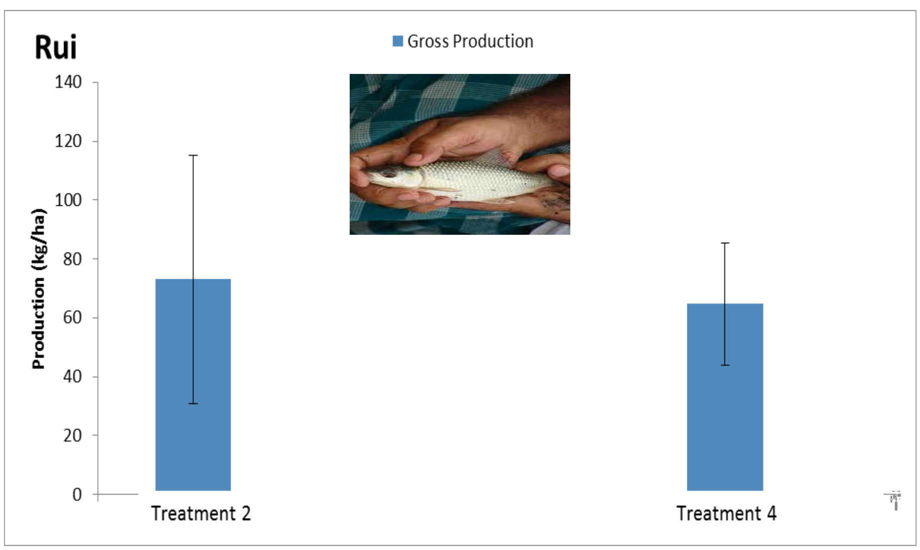


Figure 2: Gross production of Rui

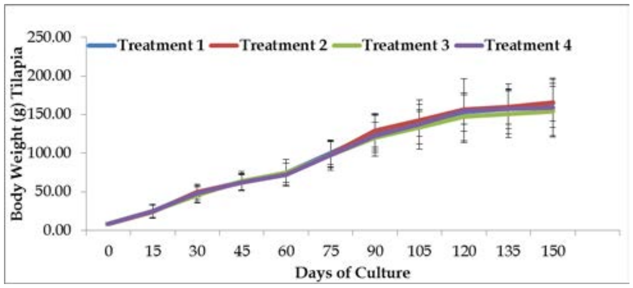


Figure: 3

Body Weight of Tilapia

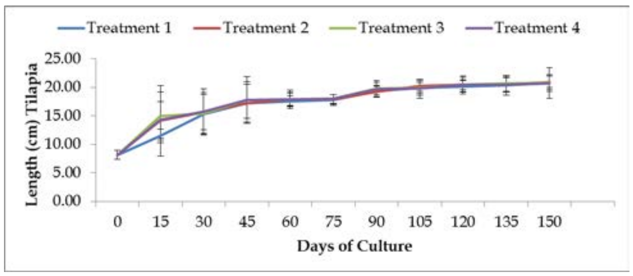


Figure: 4

Body length of Tilapia

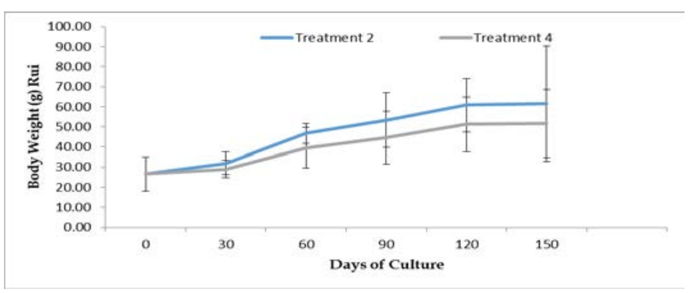


Figure: 5

Body Weight of Rui

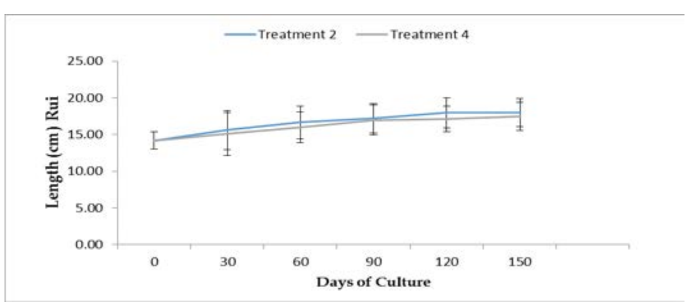


Figure: 6

Body Length of Rui

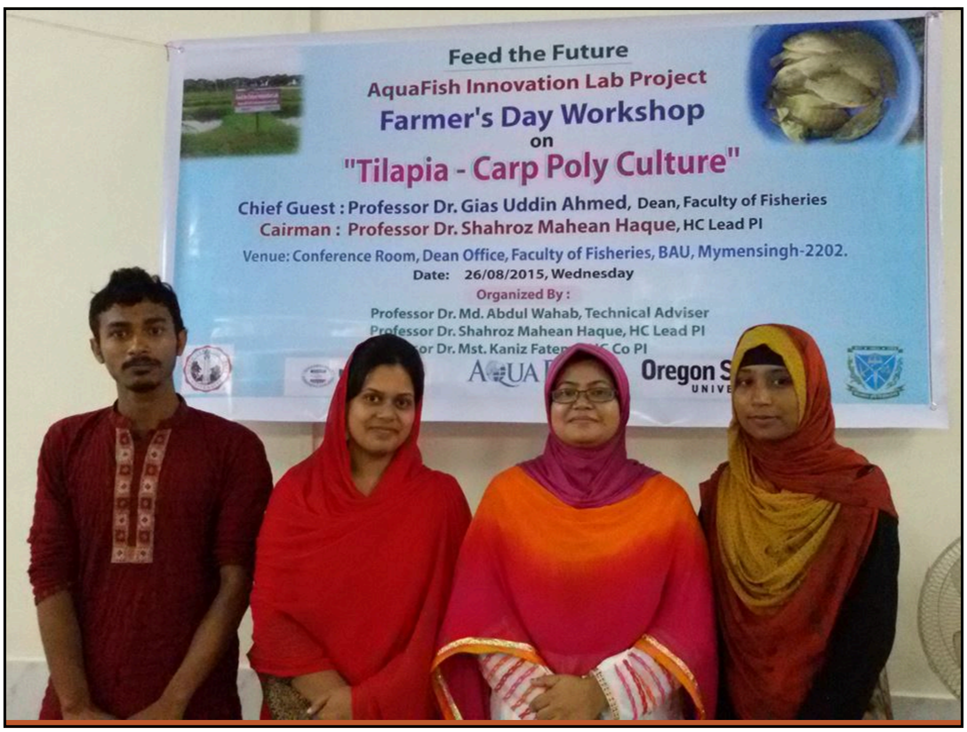
Conclusion

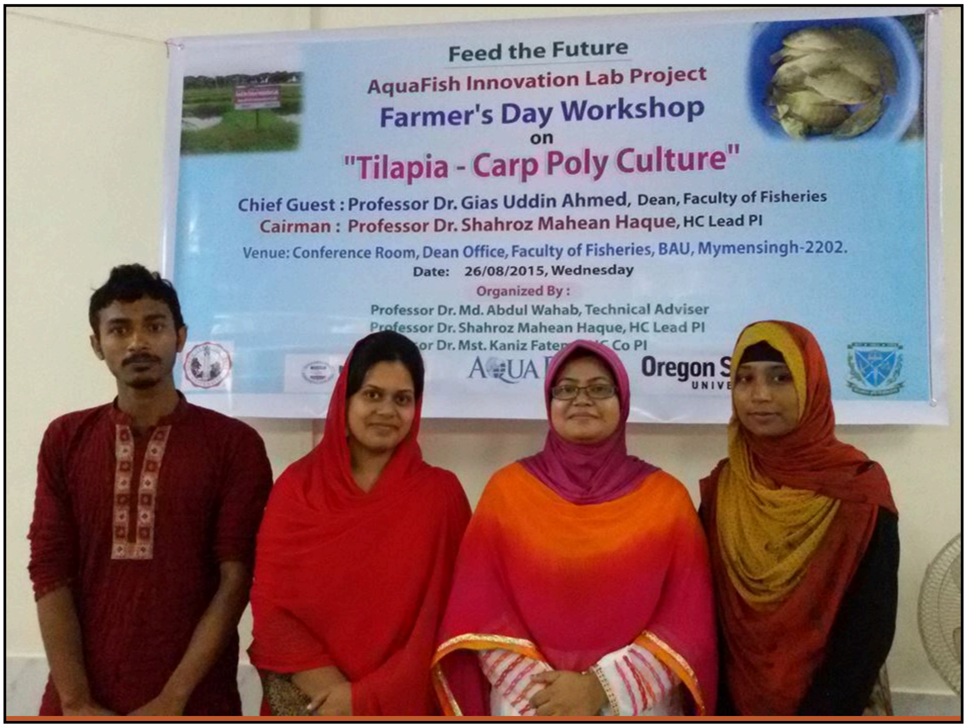
- The production, the highest net return and gross return were recorded highest in treatment 4 and 3 (daily feeding 50% level and input pond fertilization).

- BCR (benefit-cost ratio) were highest at treatment 3 (also daily feeding 50% satiation level and input fertilization).

- Based on the higher net return and benefit-cost ratio, it may be concluded that fertilization with half feeding was suitable option for Tilapia and Rui polyculture where Rui could provide an additional source of income for tilapia farmers.




Feed the Future
AquaFish Innovation Lab Project
Farmer's Day Workshop
on
"Tilapia - Carp Poly Culture"
Chief Guest : Professor Dr. Gias Uddin Ahmed, Dean, Faculty of Fisheries
Cairman : Professor Dr. Shahroz Mahean Haque, HC Lead PI
Venue: Conference Room, Dean Office, Faculty of Fisheries, BAU, Mymensingh-2202.
Date: 26/08/2015, Wednesday
Organized By :
Professor Dr. Md. Abdul Wahab, Technical Adviser
Professor Dr. Shahroz Mahean Haque, HC Lead PI

Farmers Day Workshop news published in different national online newspapers in Bangladesh

agrilife24.com
news & views for life

বাকৃবিতে কম খরচে মাছ চাষের কর্মশালা

Details 26 Aug 2015
ঢাকা, মঙ্গলবার ২৫ এপ্রিল ২০১৬, ১৩ বৈশাখ ১৪২৩

আবুল বাশার মিরাজ,বাকৃবি প্রতিনিধিঃ বাংলাদেশ কৃষি বিশ্ববিদ্যালয়ে (বাকৃবি) মাৎস্যবিজ্ঞান অনুষদে মিশ্র পদ্ধতিতে কম খরচে মাছ চাষের বিভিন্ন কলাকৌশল বিষয়ে আগামীর জন্য খাদ্য প্রকল্পের আয়তায় অ্যাকুয়া ফিস ইনোভেশন ল্যাব প্রজেক্টের অধীনে প্রান্তিক ও ক্ষুদ্র মৎস্যচাষীদের নিয়ে দিনব্যাপী কর্মশালা অনুষ্ঠিত হয়েছে। বুধবার সকাল ১০টা থেকে মাৎস্যবিজ্ঞান অনুষদীয় সম্মেলন কক্ষে ওই কর্মশালা শুরু হয়। বর্তমান মাছের খাদ্যের উচ্চমূল্যের বিপরীতে অনেক কম মাছ বিক্রি করতে হচ্ছে চাষীদের। এককেজি তেলাপিয়া উৎপাদনে ১০০-১২০ টাকা খরচ হলেও চাষীদের বিক্রি করতে হয় ১০৫-১১০ টাকায়। ফলে অনেক চাষীরা লোকসানের সম্মুখীন হচ্ছে। স্বল্প খাদ্য দিয়ে মিশ্র চাষ পদ্ধতিতে মাছের উৎপাদন কিভাবে বৃদ্ধি করা যায় এ লক্ষে গবেষণা পরিচালনা করছেন বাকৃবির মাৎস্যবিজ্ঞান অনুষদের বিজ্ঞানীরা। ইউএসএআইডি(টেঝঅওউ) এর অর্থায়নে অ্যাকুয়া ফিস ও বাংলাদেশ কৃষি বিশ্ববিদ্যালয়ের সহায়তায় মিশ্র পদ্ধতিতে ৫০ শতাংশ কম খাদ্য দিয়ে তেলাপিয়া-কার্প জাতীয় রুই, কাতলা মাছ এবং কই-শিং মিশ্র চাষ বিষয়ে অ্যাকুয়া ফিস ইনোভেশন ল্যাব প্রজেক্টের অধীনে গত প্রায় তিন বছর থেকে গবেষণা পরিচালনা করছেন মাৎস্যবিজ্ঞান অনুষদের ম্যানেজমেন্ট বিভাগের অধ্যাপক প্রফেসর ড. শাহরোজ মাহেন হক। তার সাথে সহযোগী গবেষক হিসেবে রয়েছেন একই বিভাগের প্রফেসর ড. মোছা.কানিজ ফাতেমা। গবেষণার প্রযুক্তিগত উপদেষ্টা হিসেবে ছিলেন সাবেক মাৎস্যবিজ্ঞান অনুষদের ডিন ও একই বিভাগের প্রফেসর ড. আবদুল ওহাব। গবেষণার বিভিন্ন বিষয় নিয়ে প্রান্তিক ও ক্ষুদ্র মৎস্যচাষীদের সাথে মত বিনিময়, চাষীদের বিভিন্ন সমস্যা নিয়ে দিনব্যাপী কর্মশালা অনুষ্ঠিত হয়। কর্মশালায় প্রধান অতিথি ছিলেন মাৎস্যবিজ্ঞান অনুষদের ডিন প্রফেসর ড. গিয়াস উদ্দিন আহমেদ। সম্মানীত অতিথি হিসেবে উপস্থিত ছিলেন একুয়াকালচার বিভাগের বিভাগীয় প্রধান প্রফেসর ড. এম এ সালাম। কর্মশালায় দুটি সেশনে তেলাপিয়ার সাথে কাপর্ জাতীয় মাছ এবং কই-শিং মিশ্র চাষ বিষয়ে প্রবন্ধ উপস্থাপনা এবং চাষীদের নিয়ে গবেষণা পুকুর পরিদর্শণ করা হয়। কর্মশালায় ময়মনসিংহের ৪০ জন প্রান্তিক মৎস্যচাষী, গবেষণার সাথে যুক্ত মাস্টার্স শিক্ষার্থীরা উপস্থিত ছিলেন।দেশের উপজেলা ও গ্রামের প্রান্তিক মৎস্যচাষীদের মাঝে তেলাপিয়া-রুই মাছের মিশ্রচাষে স্বল্প খাবার ব্যবহারের কলাকৌশল,কম খরচে বেশি মাছ উৎপাদন, মৎস্যচাষীদের জীবনমান ও অবকাঠামো উন্নয়নের উদ্দেশ্যে এই প্রশিক্ষণ এবং মাছ চাষের ফলে পরিবেশের উপর প্রভাব বিষয়ে আলোচনা করাহয়। জাতীয় পর্যায়ে পুরষ্কার প্রাপ্ত(২বার) মুক্তাগাছার মৎস্যচাষী মাহবুবুল হক শাহীন বলেন, বর্তমান দেশে মাছের উৎপাদন অনেক বেড়েছে। দেশে হিমাগারের অভাবে মাছ যথাযথভাবে সংরক্ষণ করা যাচ্ছে না। দেশের প্রান্তিক মৎস্যচাষীদের জন্য প্রতিটি জেলায় মাছের হিমাগারের স্থাপনের সংশ্লিষ্ট কতৃপক্ষের নিকট জোর দাবি জানাচ্ছি।

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Feed the future

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Funding for this research was provided by the

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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.

Thanks

Treatment 2

The contribution of tilapia alone - 96.3% from gross return.
The contribution of tilapia alone - 313.54% from net return.

&

The contribution of Rui alone - 1.36% from gross return.
The contribution of Rui alone - 4.42% from net return.

Treatment 4

The contribution of tilapia alone - 98.91% from gross return.
The contribution of tilapia alone - 156.24% from net return.

&

The contribution of Rui alone - 1.1% from gross return.
The contribution of Rui alone - 1.72% from net return.

About Labor cost:

Among four treatments 3 labors work in T1and there per month income is – BDT 2844.30 and total BDT 14221.51.

3 labors also work in T2 and there per month income is – BDT 2904.012 and total BDT 14520.06.

2 labors work in T3 and there per month income is – BDT 2694.82 and total BDT 13474.09

2 labors also work in T4 and there per month income is – BDT 2724.45 and total BDT 13622.27.

About Labor cost:

As the area of treatment 1 and 2 is greater than treatment 3 and 4 so we had to involved labor in a ratio of (3:3:2:2). Moreover the feed used in treatment 1 and 2 is greater than treatment 3 and 4 and other pond management is frequently done in treatment 1 and 2 so there the labor cost had doubled than T3 and T4.

Sustainable pearl farming in Africa using new spat collection techniques

Narriman. S Jiddawi and Maria C. Haws

Marine pearl culture is an important aquaculture industry in the world. Currently, there is a growing interest in pearl culture production among Tanzanian coastal communities primarily due to the opportunity as an alternative income generation activity and also as a way of using the ocean in a sustainable manner. Attempts to culture pearls have been successful but in Zanzibar and other areas but spat collection is required for long-term sustainability. Spat collection experiments were therefore initiated in two villages (Bweleo and Nyamanzi). Community members 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 report. The targeted species were *P. margaritifera* and *Pteria* spp. Based on the results of this study, it is possible to obtain good number of pearl oyster spat 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 alternate income activity among Tanzanian coastal communities while serving to utilize coastal resources in sustainable way. The women participants were also involved in the experiments and also were provided more training on entrepreneurship skills.

Ensuring sustainable pearl farming using spat collection in Zanzibar TANZANIA

Narriman S. Jiddawi and Maria Haws

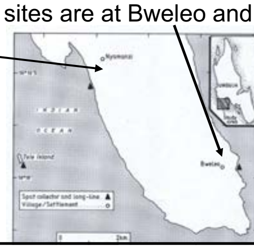
AQUAFISH COLLABORATIVE RESEARCH SUPPORT PROGRAM

UNIVERSITY OF HAWAII HILO

WIOMSA

Introduction

- Zanzibar is part of United Republic of Tanzania
- The current Zanzibar population is 1.3 million
- The population density is very high, with average of 258 people per sq miles for Unguja and 352 for Pemba.
- Fishing, tourism, coconut/spice trade and agriculture are the main economic activities in Zanzibar
- The study sites are at Bweleo and Nyamanzi



Introduction

- Pearl production is a thriving business for coastal communities in many parts of the world. However the farming of half pearls 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.
- 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

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.

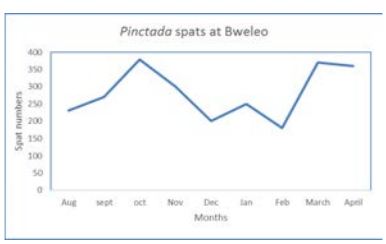
Spat collection

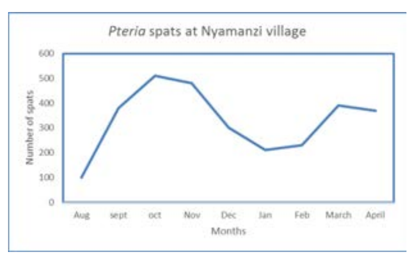
- The spat collection experiment was done from August 2015 to March 2016 and produced a total of 2580 *Pinctada margaritifera* spat and 2970 *Pteria* spats at Bweleo and Nyamanzi respectively

- There was significant variation on the number of spat produced from the three different spat collection materials ($P < 0.01$). Spat were always most abundant on shade cloths and rubber tyres than on coconut shells.

Spat

Monthly numbers of spat settlement at Bweleo and Nyamanzi from August 2015 to March 2016





- The highest number of spats were observed between September and November as well as March coinciding with the rainy season.
- 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)
- Based on the results of this short study, it is possible to obtain good number of pearl oyster spat and grow them

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 to seed.

Funding for this research was provided by the

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AquaFish Technical Session 5
Innovations in Smallholder Aquaculture Technology: AquaFish Research in Capacity Building and Gender

Improving the well-being of Bangladeshi women mud crab culturist using a value chain analysis

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This study had analysed the value chain of mud crab in Southwest Bangladesh and identified areas to improve the livelihood opportunities of women crab culturists in these region. Tracer methodology was employed to map the existing value chain of mudcrab spanning three districts, namely Khulna, Satkhira and Bagerhat. A total of 156 respondents were interviewed composed of 6 crab collectors; 45 mudcrab culturists; 6 assemblers (3 in local/district-based depots and 3 in national or Dhaka-based depots), 3 soft-shelled crab processors and exporters of live crabs in Dhaka; 1 exporter association (with 86 active members) in Dhaka and 10 consumers. Combinations of individual and panel interviews as well as focus group discussions were employed to gather data and information. Secondary data were used extensively to establish a good understanding of the mudcrab industry. These include data on volume and value of production, yield, prices and other market information, among others. Finally, key informants from relevant agencies such as the Bangladesh Ministry of Fisheries and Livestock, Department of Forestry, among others were also interviewed.

The mudcrab industry in Bangladesh had become an important source of income and employment of the fishery sector of the country. Export value of live crabs is now ranked 9th and the 3rd fastest growing fishery product in the country. The major destination of live crabs is the export markets whose demand is growing overtime (include China, Singapore, Malaysia, etc.). But domestic demand is limited to the non-Muslim consumers and foreign tourists. Consumption of crab is not yet accepted by the majority of Bangladeshi albeit not forbidden by their faith.

Marketable live crabs are collected in the wild but “exploitation” made the volume of catch and consistency of crabs’ quality become unsustainable. Hence, crab culture and fattening is recently emerging polyculture fishery product in the country.

The crab’s value chain is composed of crab collectors, crab growers/culturists/fatteners, assembler-agents at local, district and national depots, exporter-processors and end users. The occasional participation of retailers and institutional buyers in the value chain made them insignificant players.

The schedule of volume, prices and product requirements (grade, size, sex, gonad and claw conditions) are provided by the exporters through the assembler-agents. Regular export schedule is done thrice a week. To meet any volume or “quota” requirements, assembler-agents

extend credit (dadon) or advanced payments to crab collectors and crab growers as procurement strategy. Almost all other transactions are settled in cash. In terms of profit shares across players in the value chain, the exporters-processors have the lion share with 57%. The assemblers in district and crab collectors followed next with respective 19% and 16%.profit shares while the local assembler and crab growers have the lowest profit shares of 4.4% and 2.4%, respectively.

Due to poor road, transportation and packaging practices, high incidence (20%) of in-transit mortality and rejects was experienced. To recoup from these losses, exporters began processing crab meats for the export markets. Other major logistical issues and concerns that hamper the overall efficiency and sustainability of the value chain, include: (a) natural sources of crabseeds are becoming unsustainable; (b) poor grow out and feeding technologies in mudcrab culture; (c) poor road conditions, packaging and handling practices; (d) limited working capital; and (e) poor processing technology.

Additionally, the external influences that are harmful to the value chain include (a) frequent floods due to heavy rains; (b) poor water quality, and (c) the lack of government efforts of stimulating domestic demand for crabs.

To address the above issues and concerns, the following measures are recommended: (a) establish crab hatcheries, (b) Improve cultural and value adding technologies via techno transfer and credit programs, (c) Improve product packaging and handling systems, and (d) provide efficient marketing and promotion programs.

Funding for this research was provided by the

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IMPROVING THE WELL-BEING OF MUDCRAB WOMEN CULTURIST IN SOUTHWEST BANGLADESH THROUGH VALUE CHAIN ANALYSIS

ASIAN-PACIFIC AQUACULTURE 2016
Innovations in Smallholder Aquaculture Technology:
AquaFish Research in Asia and Africa
April 28, 2016 (16:00-16:20)
Grand City Convention Center, Surubaya, Indonesia

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Introduction

- Crab farming is still infant in Bangladesh
- Of the 2,428 crab farms 37.8% were owned and operated by women in coastal regions of Bangladesh
- All crab farms rely their seedstocks from the wild (sundarban/dacope) (unsustainable)
- >95% of crabs are exported (growth in demand)
- dearth of info wrt women's participation in the traditional value chain of crabs

Value Chain

- Definition
  - Intra and inter linkages of various firms engaged in production, delivery and sale of a product
  - horizontal and vertical alliances between firms

Weakly connected value chains could have efficiency and equity issues among the players.

OBJECTIVES

- General Objective: To assess the existing value chain of mudcrab in Southwest Bangladesh and identify areas for improvement (esp the participation of women)

OBJECTIVES

- Specific Objectives:

1. To provide an overview of the mudcrab industry;
2. To map out the specific value chain of mudcrab;
3. To analyze the performance of the mudcrab value chain:
    - efficiency, flexibility and overall responsiveness;
4. To identify areas for improvement
    - behavioral, institutional and process
5. To provide specific policy recommendations

Areas for value chain improvement may be classified into three categories:

(1) *Improving economic efficiency*
(production of goods and services were done with least costs, well-being of the sector were raised and transaction costs were reduced)

(2) *Improving business relationships*
(partnerships based on mutual trust and info sharing)

(3) *Improving operational efficiency*
(managing logistics and coordination arrangements to ensure reliability, product quality and delivery schedules)

Research Framework

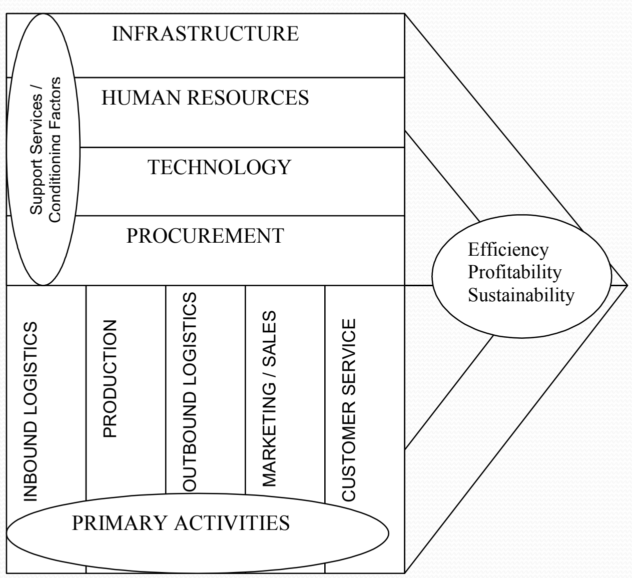
INPUT	PROCESS	OUTPUT
The Bangladesh Mudcrab Industry • Major chain actors • Key processes, activities and services, flows of the product, information and payments • Industry profile • Costs and margins associated with such practices	➢ **Value Chain Analysis:** ➢ **New Institutional Economics** • Transaction Cost • **Agency Theory** ➢ **Relationship Marketing/ Network Theory** ➢ **Operations and Logistics Management** **(Other relevant tools)**	• Value chain maps • Performance of the mudcrab value chain in terms (efficiency, flexibility and overall responsiveness) • Areas for improving the value chain • Specific policy recommendations

Transaction Cost

- Transaction costs are the costs of using the market mechanism, as distinguished from the usual production and marketing costs.

- The cost of using the market may be classified as follows
  - the cost of preparing contracts (search and information costs)
  - the cost of concluding contracts (cost of bargaining and decision-making)
  - the cost of monitoring and enforcing the contractual obligations
  - the cost of establishing and tending social relations (also referred to as social capital)

Conceptual framework for the value chain mapping (Porter, 1985)



Data Requirements

1) Who are the key customers and what are their product requirements?
2) Who are the key players and what are their respective roles?
3) How do product, information and money flow through the value chain?
4) What are the activities and services provided at each step in the value chain?
5) What are the critical logistic issues? and
6) What are the external influences?

Data Sources

- Study areas and coverage
  - Southwest Bangladesh (Khulna, Satkhira, Bagerhat)
- Number of respondents
  - 6 Crab collectors/harvesters
  - 45 Crab farmers
  - 6 Crab traders (agents, depots)
  - 3 Processors
  - 1 Exporters Association (86 active members)
  - Institutional buyers (restaurants, specialty shops, etc)
  - Key informants (Departments of Forest and Fisheries)

Value Chain ~~Performance~~ Indices

Effectiveness - the ability of the chain to meet requirements of key customers such as: quality/standards, delivery volume, schedule and flexibility (i.e. ability of the chain to respond to changes in customer requirements. Other social concerns (environment, equity and fairness)

Brief description for other efficiency measures:

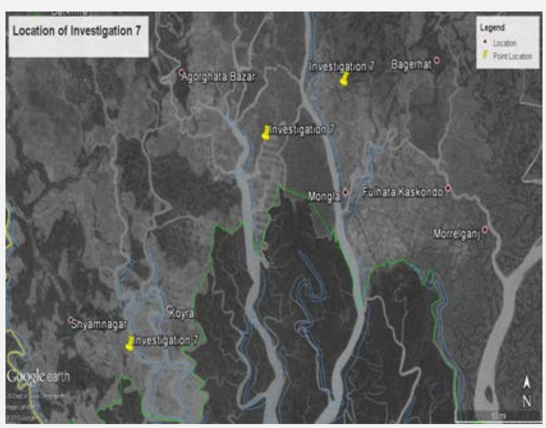
(a) Cost (production cost, distribution cost, transaction cost)

(b)Profit (Return on Investment)

(c)Inventory (housing, capital costs, damages and losses)

Southwest Bangladesh

- Major crab sources
  - Satkhira District
    - ➢ Harinagar
    - ➢ Kalbari
    - ➢ Shyamnagar
  - Bagerhat District
    - ➢ Vagha
    - ➢ Rampal
    - ➢ Mongla
  - Khulna District
  - ➢ Dakope
  - ➢ Nalian
  - ➢ Bajua



RESULTS AND DISCUSSION

Table 1. Volume of Live Crab Imports by Country of Destination

Country or Area	2009	2010	2011	Total	Annual Ave.	Share	Growth	Rank
	Volume Shares ('000 MT)							
Japan	31.82	18.58	12.05	62.45	20.82	19.61%	-38.38%	2
China	16.10	23.91	30.65	70.65	23.55	22.19%	38.38%	1
Korea Rep	13.49	8.62	8.41	30.52	10.17	9.59%	-19.30%	3
Canada	4.25	5.37	6.89	16.51	5.50	5.19%	27.28%	6
Singapore	5.47	5.36	5.58	16.40	5.47	5.15%	1.04%	7
USA	3.29	3.41	1.63	8.33	2.78	2.62%	-24.27%	12
France	7.58	7.12	6.62	21.32	7.11	6.70%	-6.55%	5
China,H.Kong	5.10	6.18	4.15	15.42	5.14	4.84%	-5.85%	8
Spain	8.06	7.88	8.29	24.23	8.08	7.61%	1.46%	4
China,Taiwan	4.21	4.37	4.38	12.96	4.32	4.07%	2.10%	9
Malaysia	3.11	3.02	3.17	9.29	3.10	2.92%	1.03%	10
Portugal	1.90	2.12	1.89	5.90	1.97	1.85%	0.23%	13
Italy	0.85	0.88	1.20	2.94	0.98	0.92%	19.80%	14
Thailand	3.61	2.42	2.40	8.43	2.81	2.65%	-17.01%	11
China, Macao	0.75	0.80	0.59	2.14	0.71	0.67%	-9.76%	15
Others	4.01	3.62	3.28	10.91	3.64	3.43%	-9.52%	
Grand Total	113.59	103.65	101.16	318.40	106.13	100%	-5.58%	

Source FAOSTAT

Table 2. Volume of Live Crab by Country of Origin

Country or Area	2009 Volume Share (MT)	2010 Volume Share (MT)	2011 Volume Share (MT)	Total	Annual Ave.	Share	Growth	Rank
China	3,591	3,580	3,457	10,628	3,543	3.94%	-1.25%	9
Indonesia	7,743	9,347	11,815	28,905	9,635	10.72%	15.71%	3
Canada	6,292	7,859	7,155	21,306	7,102	7.90%	5.32%	5
UK	14,008	13,824	13,096	40,928	13,643	15.18%	-2.19%	1
USA	5,941	7,756	12,136	25,833	8,611	9.58%	29.01%	4
India	5,808	3,213	3,102	12,123	4,041	4.50%	16.04%	8
Myanmar	12,587	11,731	11,442	35,760	11,920	13.27%	-3.09%	2
Philippines	2,984	3,316	4,208	10,508	3,503	3.90%	12.68%	10
Bangladesh	5,147	6,890	7,044	19,081	6,360	7.08%	12.03%	6
Pakistan	3,185	6,361	5,574	15,120	5,040	5.61%	29.12%	7
France	2,252	2,051	1,946	6,249	2,083	2.32%	-4.68%	12
Australia	617	506	502	1,625	542	0.60%	-6.26%	15
Korea Rep	549	495	711	1,755	585	0.65%	11.27%	14
Viet Nam	1,597	720	830	3,147	1,049	1.17%	13.21%	13
Ireland	3,159	3,200	3,128	9,487	3,162	3.52%	-0.32%	11
Total (top 15)	75,460	80,849	86,146	242,455	80,818	89.95%	4.54%	
Others	10,147	9,602	7,349	27,098	9,033	10.05%	4.92%	
Grand Total	85,607	90,451	93,495	269,553	89,851	100.00%	4.21%	

Source: FAOSTAT (2014)

Table 3. Volume of Bangladesh Fish Exports

Products	2010 Volume (MT)	2011 Volume (MT)	2012 Volume (MT)	2013 Volume (MT)	2014 Volume (MT)	Annual Average	Share	Rank	Growth
Prawn	5,714	7,120	7,060	6,679	6,504	6,615	7.78%	3	3.94%
Shrimp	39,236	40,860	35,678	37,274	34,733	37,556	44.16%	1	-2.72%
Carp	4,757	8,270	11,299	7,239	2,848	6,882	8.09%	2	3.47%
Catfish	2,076	2,367	1,698	2,037	2,281	2,092	2.46%	6	4.43%
Hilsha	3,107	8,539	6,174	473	-	3,659	4.30%	5	-11.31%
Dried fish	622	1,200	1,040	1,278	2,895	1,407	1.65%	8	57.22%
Live Eel	1,783	3,296	5,057	6,818	7,158	4,822	5.67%	4	44.53%
Live Crab	692	1,189	710	610	549	750	0.88%	9	1.89%
Shark fin & carapase	954	838	2,758	2,599	2,393	1,909	2.24%	7	50.81%
Others	18,702	22,790	20,555	18,963	15,762	19,354	22.76%		-3.14%
Total	77,643	96,469	92,029	83,972	75,122	85,047	100.00%		0.09%

Source: Ministry of Fisheries and Livestock of Bangladesh

Table 4. Value of Bangladesh Fish Exports

Products	2010	2011	2012	2013	2014	Average	Share	Rank	Growth
	Value ('000 US$)								
Prawn	74,132.30	96,659.53	107,029.60	92,129.18	103,068.81	94,603.88	17.70%	2	9.77%
Shrimp	113,332.67	364,964.99	321,723.19	303,516.00	384,419.33	297,591.23	55.68%	1	57.79%
Carp	9,992.84	24,296.24	30,075.91	19,690.03	7,867.91	18,384.58	3.44%	4	18.09%
Catfish	6,750.73	10,482.13	7,320.21	8,357.00	9,050.91	8,392.20	1.57%	6	11.89%
Hilsha	17,731.34	48,956.55	35,885.15	3,133.66	-	21,141.34	3.96%	3	19.38%
Dried fish	3,579.80	4,287.80	3,519.00	4,634.26	6,611.47	4,526.47	0.85%	7	19.05%
Live Eel	1,888.22	4,477.21	9,698.59	17,966.40	17,631.97	10,332.48	1.93%	5	84.28%
Live Crab	1,486.53	3,037.55	2,479.99	3,833.37	3,590.56	2,885.60	0.54%	8	33.56%
Shark fin & carapase	1,808.07	805.14	1,798.26	1,803.38	2,046.60	1,652.29	0.31%	9	20.41%
Others	63,056.14	80,659.86	77,229.84	78,004.99	76,041.01	74,998.37	14.03%		5.54%
Total	293,758.64	638,626.99	596,759.73	533,068.27	610,328.57	534,508.44	100.00%		28.67%

Source: Ministry of Fisheries and Livestock of Bangladesh

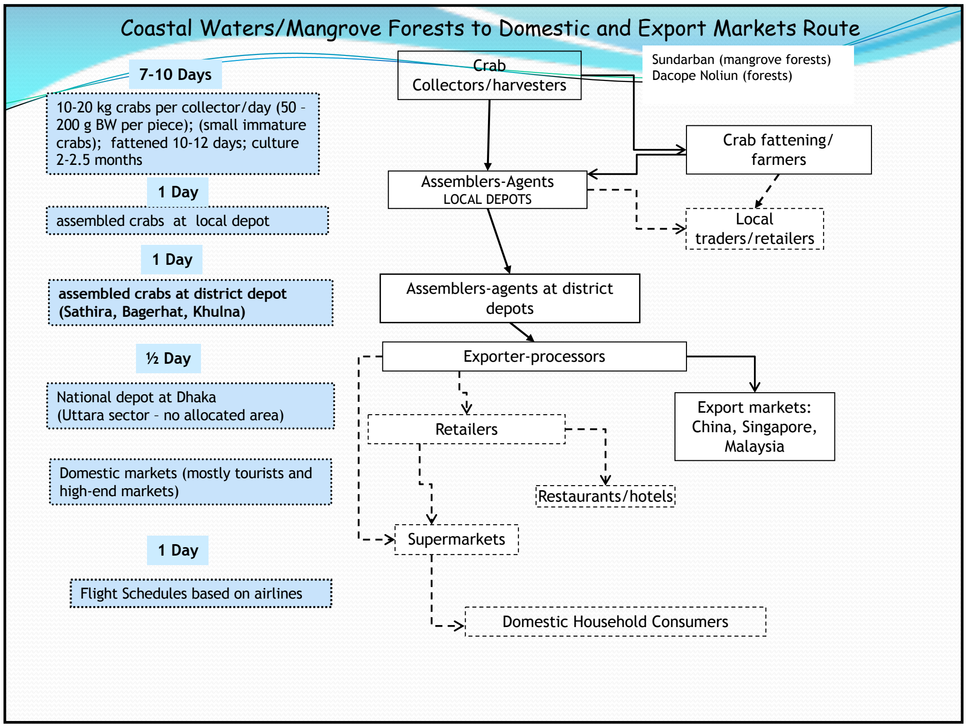
PRODUCT FORMS

Live crab for export markets



Chilled crab for export markets





KEY CUSTOMERS

-Export markets (>95%): China Singapore, Malaysia

-Domestic consumers: Hindu and Buddhists

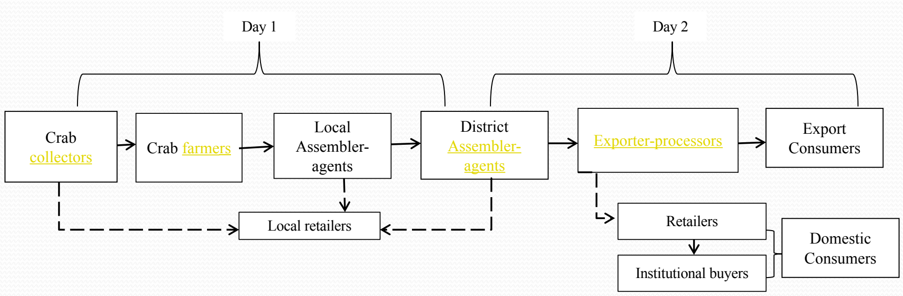
-Institutional buyers:

- -Supermarkets (Lavender, Unimark at Gulshan 2)

- -Restaurants (Baton Rouge Resto)/ Specialty Food Stores

PRODUCT REQUIREMENTS

PRODUCT FLOW



CRAB COLLECTORS






CRAB FARMERS









CRAB EXPORTER-PROCESSORS



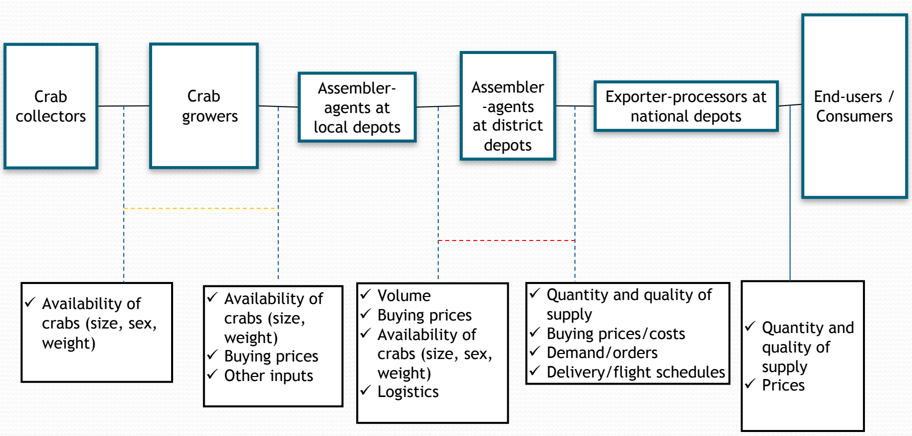




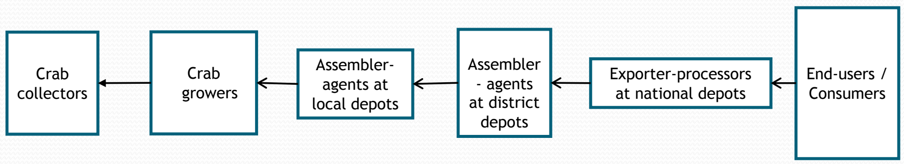
CRAB LOCAL/DISTRICT DEPOTS


CRAB EXPORTER ASSOCIATION


INFORMATION FLOW



PAYMENT FLOW



Payment modes between value chain participants are made on cash on delivery net of interests and commission fees due to cash advances and credit (dadon) terms between processors-exporters, assembler-wholesalers (local and district depots) and crab collectors.

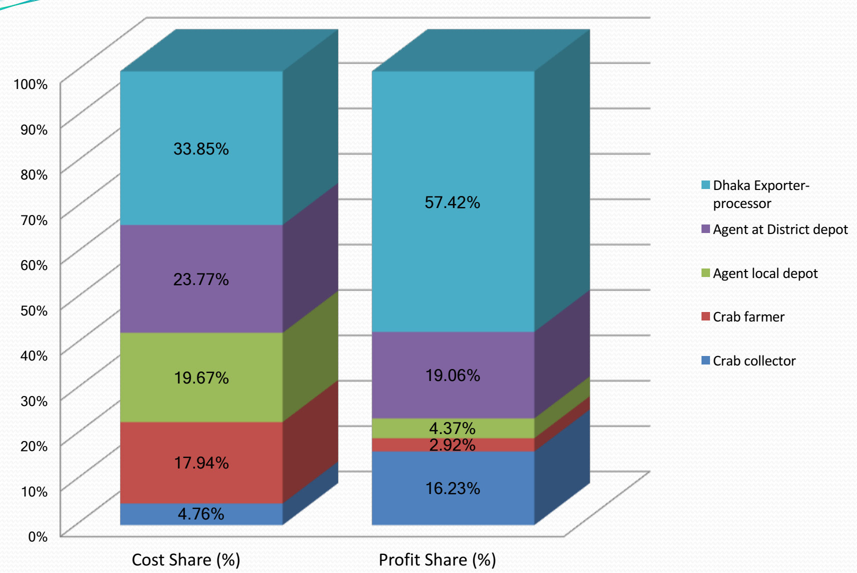
Table 5. Commission Fees by Sex, Grade and Price of Crab at Local Depot

Sex	Grade	Weight (g/crab)	Buying Price (Tk/kg)	Selling Price* (Tk/kg)	Commission (Tk/kg)
Male	XXL (2pcs/kg)	500	470	500	6
	XL (3 pcs/kg)	400	370	400	5
	L (4 pcs/kg)	300	270	300	5
	M (5 pcs/kg)	200	170	180	2
	SM (6 pcs/kg)	150	80	90	nil
Female	F1 (5pcs/kg)	180	400	420	5
	F2 (6 pcs/kg)	145	270	350	5
	F3(10 pcs/kg)	100	170	200	2

Table 6. Price Schedule by Sex, Weight and Shell/Claw Conditions of Crab at Dhaka depot

Sex	Grade	Weight (g/crab)	Shell Condition	Claw Condition	Buying Price (Tk/kg)	Selling Price* (US$/kg)	Tk/kg
Male	XXL (2pcs/kg)	500	Hard	Full meat	600	13.70	1,027.50
	XL (3 pcs/kg)	400	Hard	Full meat	475	11.85	888.75
	L (4 pcs/kg)	300	Hard	Full meat	375	9.70	727.50
	M (5 pcs/kg)	200	Hard	Full meat	300	8.09	606.75
	SM (6 pcs/kg)	150	Hard	Full meat	150	6.72	504.00
Female	F1 (5pcs/kg)	200	Hard	Full gonad	600	14.46	1,084.50
	F2 (6 pcs/kg)	180	Hard	Full gonad	400	13.36	1,002.00
	F3(10 pcs/kg)	150	Hard	Full gonad	300	9.52	714.00
	F4 (12 pcs/kg)	80	Hard	Full gonad	275	8.50	637.50
	KS1	180	Hard	Partial gonad	225	11.12	834.00
	KS2	120	Hard	Partial gonad	150	7.50	562.50

Waterfall Chart



Transaction Costs and Concerns of Crab Value Chain

Key Players	Issues and Concerns	Transaction Costs
Crab collectors	Harvest of marketable crabs are getting fewer and irregular. Cost of renewing permits (NOC) and other related expenses are more exorbitant. No issuances of NOC during demand peaks Limited working capital	High security risks due to the presence of lawless elements at sundarban areas
Crab fatteners	• Irregular availability of crab seeds and feeds • Discounted prices due to dadon practices • Limited working capital • Use of traditional technology	Growth opportunities are limited due to high search cost of market information
	Lack of formulated diet	Culture and fattening period is long (2-2,5 months)
	Product uniformity and consistency is hard to meet	
Assemblers-agents at local depots	Frequent delays in product delivery and marketing	
	High in-transit mortality (20%)	Loss of sales (lower product values)
	Poor product handling and packaging	High in-transit losses (crashed, immature)

Key Players	Concerns	Transaction Cost
Assemblers-agents at district depots	Schedule of product arrival not predictable	High cost of meeting normal load capacity
	Poor handling practices	High handling losses
	• No uniform product grades and standards • Difficulty in meeting desired product volume and quality	Opportunity cost of capital due to advance payments (after 15 days)
Processors of chilled crabs	Poor product quality	Lower product value
	Limited market outlets	Expansion opportunities are limited
Exporters	Unpredictable flight schedules	High cost of delayed deliveries
	No defined location of national depot in Dhaka	
Domestic Consumers	Low effective demand for crab due to socio-cultural barriers Low product awareness	
	Only low quality products are available for the domestic market	High perceived buying prices Limited product availability and choices

Recommendations

Key Players	Concerns	Recommendations
Crab Collectors/ Farmers	• Irregular availability and sustainability of seeds and feeds • Limited working capital • Traditional technology	• Establish hatchery as reliable sources of crab seeds • Formulate nutrition program • Organize or form cooperative or farmers group • Undergo techno transfer activities more regularly
		✓ Women may enter into contract buying scheme. ✓ Women may enter into processing soft-shelled/chilled crab sector.
Traders/Shippers	Poor marketing infrastructures	• Provision of efficient marketing infrastructures and communication facilities
	High in-transit mortality (20%)	Liberalizing trade policies of the government would allow more competition
	Poor product handling	Redesign product packaging and handling system

Recommendations

Key Players	Concerns	Recommendations
Exporter-Processors	• Poor product quality • Limited domestic market outlets	• Comply or adhere to quality assurance program such as Halal, HACCP, ISO, etc. • Design more suitable packaging strategy • Conduct more aggressive marketing program
	Unpredictable flight schedules	• Maintain regular and efficient communication with airlines
	No defined location of national trading center in Dhaka	Establish and allocate area for market operations

Key Players	Concerns	Recommendations
Consumers	Low effective demand for crab due to socio- cultural barriers	• Conduct aggressive marketing and promotional activities
	Only low quality products are available in the domestic market	• Continue establishing niche markets through tourism and other target marketing modes.

Establishing school ponds for educating students to improve health and nutrition of children and women in rural Nepal

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We believe that establishing school ponds and a curriculum for school age children and women's groups should be an effective approach to educate rural communities about the nutritional value of fish and methods of aquaculture. Four ponds of 76-264 m^2 in size were constructed, one each in four public schools of Chitwan and Nawalparasi districts in Nepal. A school curriculum was also established to demonstrate methods of aquaculture and educate school age children on nutritional value of fish. This technology was also disseminated to women's groups to expand understanding of the value of fish production and consumption for their families.

Carps and Nile tilapia seed were provided to each school from nearby government fish hatcheries, and were stocked in each pond at 10,000 fish/ha (7000 carps and 3000 Nile tilapia/ha). The materials necessary to maintain ponds, including feed and fertilizer, were also provided to each school. Fish were cultured for one production cycle with the participation of high-school age students. A course of study was developed for teacher and student education on fish culture. About 30 students of grade 8, 9 and 10 and two teachers were selected from each school to receive training on fish culture. Training of teachers and students included fish pond construction, managing pond depth, pond preparation, species choice, water color, fertilizing, feeding, grow out, harvesting of fish, as well as nutrition education, including fish preparation and eating.

In addition to training of students, 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 training workshop was organized for each women's group. The topic was the role of household aquaculture in family nutrition and income. A linkage was developed so that the women's fish farming groups could ultimately work with the teachers and students in each school to ensure the long term sustainability of the school ponds.

The construction and running of these ponds was a very exciting event for the school communities. Often a number of adults showed up for events like stocking and harvesting, as well as visits during our training exercises. In fact, the ponds were so popular that in Kawasoti area a neighboring farmer constructed some ponds within a few months of our school pond construction, and the local people wanted advice and materials to construct a community pond on school property. We continue the training and testing of knowledge gained by the students involved, and hope to show a dramatic increase of awareness as a result of this project.

A F U

ESTABLISHING SCHOOL PONDS FOR EDUCATING STUDENTS TO IMPROVE HEALTH AND NUTRITION OF CHILDREN AND WOMEN IN RURAL NEPAL

Dilip K. Jha[1], Narayan P. Pandit[1], Ishori S. Mahato[1], Madhav K. Shrestha[1], James S. Diana[2]

[1]Agriculture and Forestry University, Nepal
[2] University of Michigan, USA

A F U

Introduction

Nepal
Land locked country
Area : 147181km^2
Population: 29 million

Eco-zone

Himalaya	: 27% (8848m-4880m)
Middle Hill	: 50% (4880m-305m)
Terai	: 23% (305m-60m)

AFU

- Global concern that nutritious food must be supplied to women as well as their children during the first 1000 days of life.

- Also childhood and adolescence is a critical period need high nutrients. A diet of high nutritional quality is therefore particularly important.

- Fish provides valuable nutrients including high quality proteins

AFU

- Lack of awareness on the nutritional value of fish among the rural communities

- We believe that establishing school ponds and a curriculum for school age children and women's groups should be an effective approach to educate rural communities about nutritional value of fish and methods of aquaculture

A F U

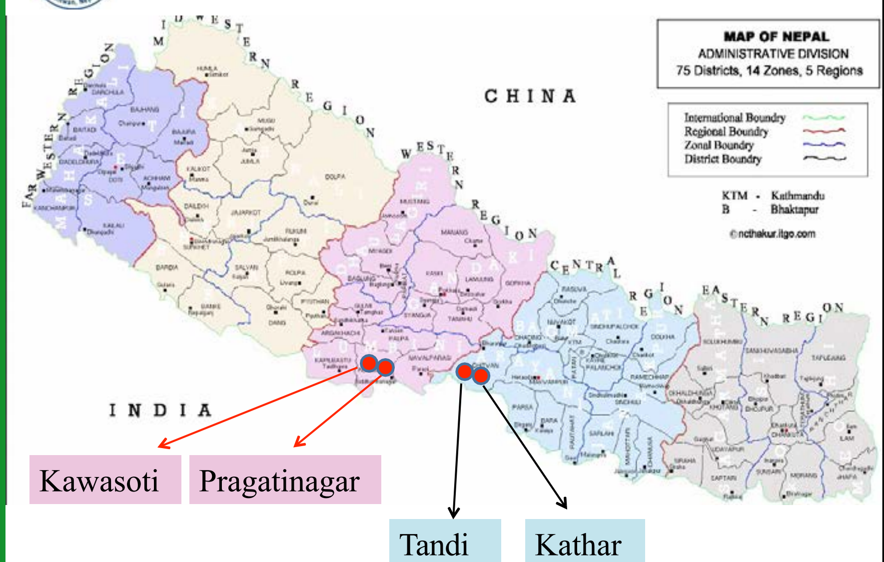
Objectives

- To establish fish ponds in schools and educate students on rearing of fish as well as the nutritional value of fish as a supplement to their regular diet

- To develop one women group in each district to teach them about fish farming and house hold health.

A F U

Location of school ponds



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Methods

- Built one pond in each of four schools
- Target population included the school-going children admitted in those schools and school teachers
- Theoretical and practical hands on training were provided in each school on nutritive value and production techniques of fish
- Structured questionnaire was used to collect data for the pre-training and post training

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Results

Table 1. Name of schools and size of ponds

SN	School name	Address	Pond size	Pond type
1	Nepal Higher Secondary School	Tandi, Chitwan	13 m x 7 m	Earthen pond with plastic lining
2	Kathar Secondary School	Kathar, Chitwan	14.5 m x 8 m	Earthen pond with plastic lining
3	Prithivi Secondary School	Pragatinagar, Nawalparasi	19 m x 4 m	Cemented tank
4	Janta Higher Secondary School	Kawasoti, Nawalparasi	24 m x 11 m	Earthen pond with plastic lining

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Figure. Fish pond constructed at Kathar Higher Secondary School, Kathar, Chitwan, Nepal.

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Figure. Fish pond constructed at Nepal Higher Secondary School, Tandi, Chitwan, Nepal.

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Figure. Fish pond constructed at Prithivi Secondary School, Pragatinagar, Nawalparasi, Nepal.

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Figure. Fish pond constructed at Janta Higher Secondary School, Kawasoti, Nawalparasi, Nepal.

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Training

Total number of students : 117
Female : 63
Male : 54
Total number of teachers : 8

Table 2. Students and teachers participated in the training

School name	Number of students (n)	Male	Female	Teachers
Nepal	35	18	17	2
Kathar	31	12	19	2
Prithivi	28	13	15	2
Janta	23	11	12	2
Total	**117**	**54**	**63**	**8**

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Training

Fig. Students participated in the theoretical training

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Training

Fig. Students participated in the practical training

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Women group formation and training

Figure. Women workshop at Kawasoti, Nawalparasi, Nepal.

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Women group formation and training

Figure. Women workshop at Kathar, Chitwan, Nepal.

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Pre- and post-training test

Table 3.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
Total	**117**	**11.1**	**14.5**	**9.1±18.8**	**13.4±24.3**

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Pre- and post-training test

Table 4.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
Total	**69.2**	**26.5**	**4.3**	**0.0**	**1.0**	**13.7**	**53.0**	**32.3**

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Conclusions

- The development of school ponds increased awareness of the value of nutrition and fish consumption in rural households by teaching school children, teachers and women about aquaculture

- School pond generate income for schools as well as act as teaching material for students

- Trained teachers spread knowledge to parents on the importance of fish nutrition during teacher-parent interactions

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AquaFish Innovation Lab

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Fish and nutrient consumption among women and pre-school children in rainy season in Cambodia

Touch Bunthang, So Nam, Chheng Phen, Pos Chhantana, En Net, and Robert Pomeroy
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Fish is an integral part of women and preschool children's staple food for their daily consumption. Fish is main source of protein and other key micronutrients. The prevalence of malnutrition among women and preschool children continues to be a major problem in Cambodia. However, data and information on the commonly consumed fish species and the current fish and dietary intake of women and preschoolers in Cambodia are lacking. The study aimed to identify the commonly consumed fish species and Other Aquatic Animals (OAAs); evaluate food and fish consumption; and dietary energy and nutrient intakes among women and preschool children. Stung Treng province (Upstream Mekong River); Prey Veng province (Downstream Mekong River); and Kampong Thom province (Tonle Sap Area) were selected for study sites. The data collection was conducted in rainy season from 2 to 26 June, 2014. The target of the study subjects were women and preschool children (aged 6 months to 5 years old). Three hundred (300) eligible women and 343 eligible preschool-age children were selected by using simple randomized sampling. The 24 hour-food recall questionnaire was used. Microsoft Excel 2013 and SPSS Statistics Version 20.0 were used for data entry and analysis. Forty three (43) of fish species and OAAs consumed by women and 38 fish species and OAAs consumed by preschoolers. Fish provides more than three-fourths (80%) to the total animal protein intake of women and pre-school children. Women consumed fish at 145.3 g/p/day and preschoolers at 52.9g/p/day. The total average one day per capita food consumption of women was 861g/p/day, while preschoolers was 489g/p/day. The total average dietary energy intake of women was 1976 kcal/p/day, while preschoolers was 844.9kacl/p/day. Fish, OAAs and its products were the major contributor to energy, fats, carbohydrate, iron, zinc, calcium, and vitamin A of women's energy and nutrients contributed at 69.7%, 54%, 99%, 74.5%, 44.6%, 83% and 87.4%, respectively. Fish, OAAs and products was also the major contributor to energy, fats, carbohydrate, iron, zinc, calcium, and vitamin A of pre-school children's energy and nutrients contributed at 72.1%, 60%, 93%, 57.2%, 44.1%, 92.8% and 56.4%, respectively.

Fish and Nutrient Consumption Among Women and Pre-school Children In Rainy Season in Cambodia

Touch Bunthang, So Nam, Chheng Phen, Pos Channara, In Net, and Robert Pomeroy

Inland Fisheries Research and Development Institute,
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Asian-Pacific Aquaculture Conference , Grand City Convention Center
26-29 April 2016

Outline

Introduction
Objectives
Methodology
Results
Conclusion and Recommendations

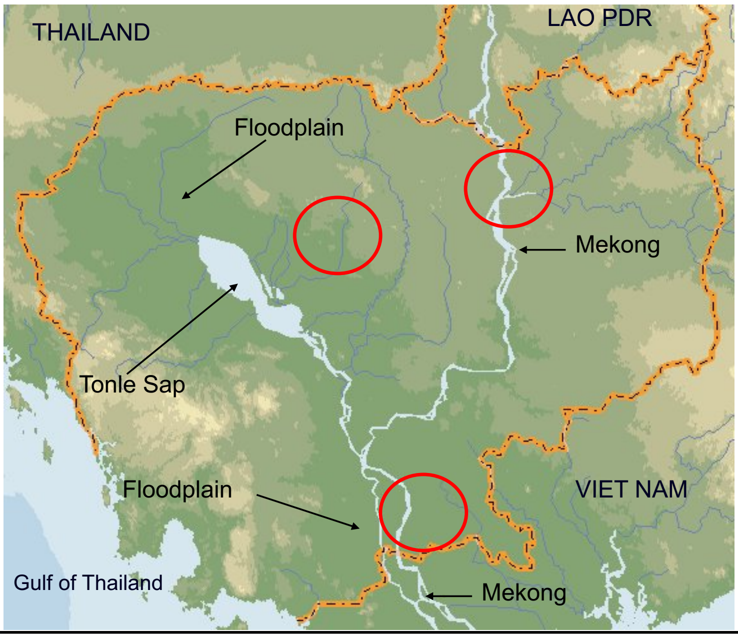
Introduction

- Land Area: 181,035Sq.km
- Population: 15,784,152 millions (2015)
- The prevalence of malnutrition among women and preschool children continues to be a major problem in Cambodia.
- Over 6 million Cambodians = part-time fishing and related fishing activities = 45.5% of the total population
- More than 1.5 million full-time fishers (> 80% is small-scale fishers)
- An estimated Value of fisheries US$ 1.2 – 1.6 billion
- Value of inland fisheries = US$ 0.8 – 1.0 billion
- This estimated value accounts for about 8.0-12% of Cambodia's GDP.
- Max. yield, i.e. approx. 400,000-450,000 tons/y.

Objectives

- To find out the commonly consumed fish species and Other Aquatic Animals (OAAs) of women and pre-school children;
- To evaluate food and fish consumption, and dietary energy and nutrient intakes among women and pre-school children; and
- To evaluate the role of fish in Women and Pre-schooler Nutrition comparing to nutrients derived from other animal sources.

Methodology



Stung Treng province (Upstream Mekong); Prey Veng province (Downstream Mekong); and Kampong Thom province (Tonle Sap Area) were selected for study sites.

Methodology…

- The data collection was conducted in rainy season from 2 to 26 June, 2014.
- 300 eligible women and 343 eligible preschoolers (6mos to 5 ys) were selected by using simple randomized sampling.
- A single 24-hour food recall was used to estimate the amount of food that has been eaten in the past 24 hours.
- Food models were used to identify food items were eaten by the subjects.

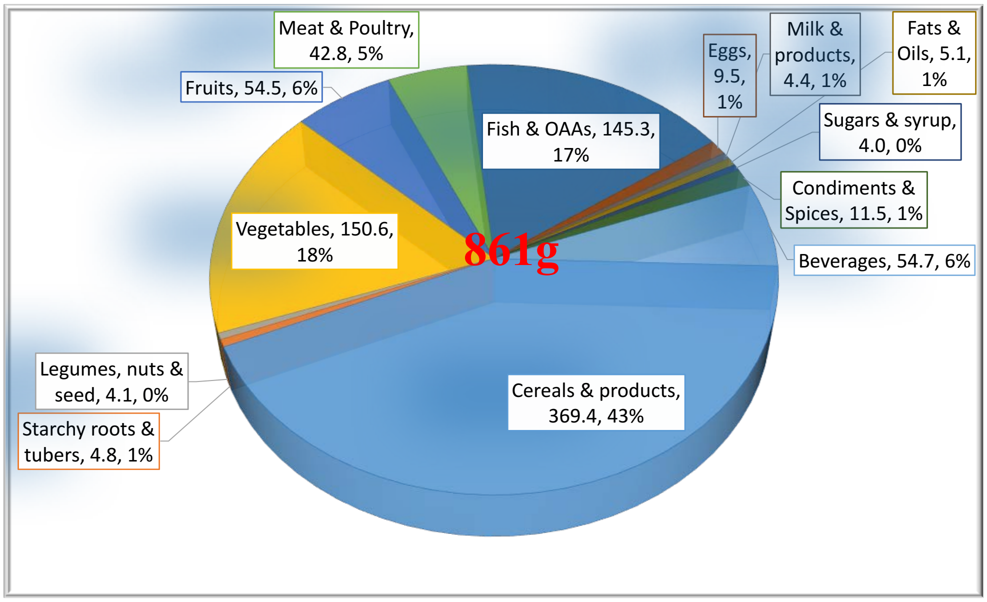
Methodology…

- Electronic Scale (precision to 0.1g) was used.
- The ASEAN Food Composition Table (ASEANFCT, 2000) was used to compute the nutrient content of the foods consumed.
- Included nutrients for evaluation: energy; macronutrients (Protein, Carbohydrate and fats); and key micronutrients (Iron, Zinc, Calcium, and Vitamin A).
- The Recommended Dietary Allowances (RDA)harmonization in Southeast Asia, 2008 (Barba et al., 2008) was used to determine the level of nutritional adequacy of the food intake to estimate the amount of food that has been eaten by women and children

Result

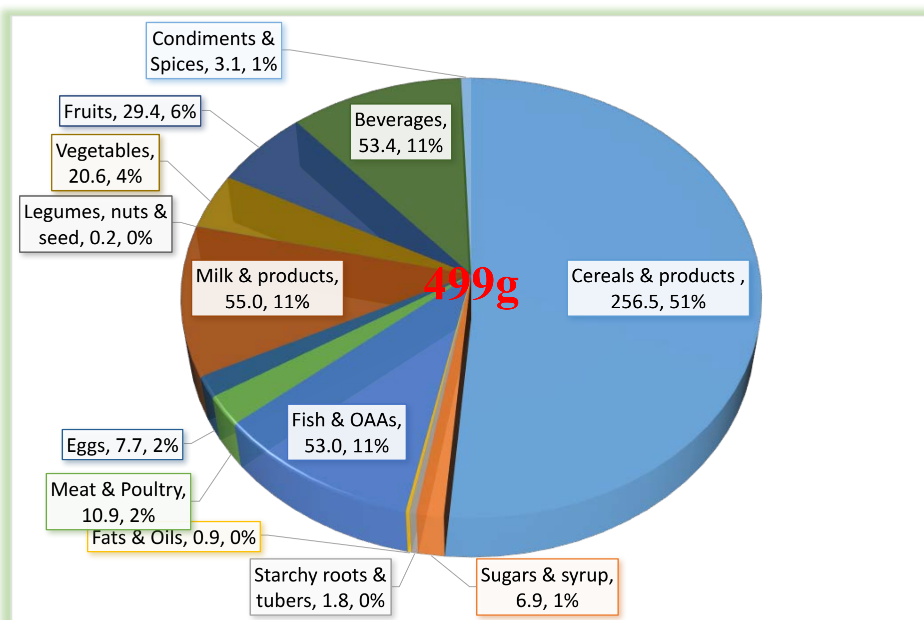
Food Consumption

Percent Distribution of mean one-day per capita food consumption of women by particular food group.



Result…

Percent distribution of mean one-day per capita food consumption of preschool-age children by food group



Result…

First 10 commonly consumed fish and percent distribution of the women's mean one day per capita fish consumption (Women consume 43 of fish and OAAs species)

No.	Khmer Name	Scientific Name	Mean (g)	%
1	Trye Riel	*Cirrhinus sp.*	31.05	21.04
2	Trye Ros	*Channa striata*	19.14	12.97
3	Trye Chhpin	*Barbonymuous gonionotus*	15.04	10.19
4	Trye Kanhchus	*Mystus sp.*	12.64	8.56
5	Trey Chhlang	*Hemibagrus sp.(cf.nemarus)*	9.6	6.5
6	Trey Andeng	*Clarias batrachus*	9.17	6.21
7	Trey Deab	*Channa micropeltes*	7.48	5.07
8	Trey Chab	*Piaractus brachypomus*	5.41	3.66
9	Trey Kranh	*Anabas tastudineus*	4.38	2.96
10	Trey Pou	*Pangasius larnaudii*	4.34	2.94
11	Other species		27.05	19.9

Result…

First 10 commonly consumed fish and percent distribution of the preschool-age children's mean one day per capita fish consumption (Preschooler consumes 38 of fish and OAAs)

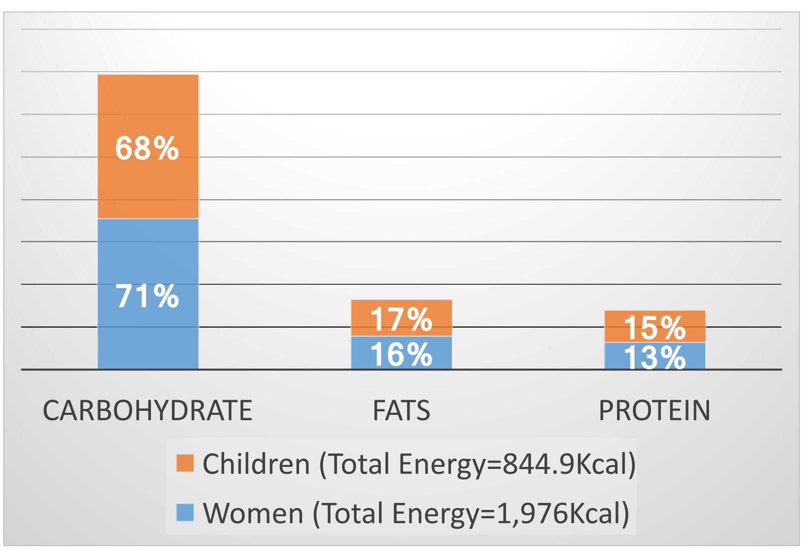
No.	Khmer Name	Scientific Name	Mean (g)	%
1	Trey Riel	*Cirrhinus sp.*	12.9	24.3
2	Trey Ros	*Channa striata*	9.6	17.8
3	Trey Kanhchus	*Mystus sp.*	5.1	9.6
4	Trey Chhpin	*Barbonymuous gonionotus*	4.2	8.0
5	Trey Andeng	*Clarias batrachus*	2.8	5.2
6	Trey Chhlang	*Hemibagrus sp.(cf.nemarus)*	2.6	4.8
7	Trey Chab	*Piaractus brachypomus*	1.4	2.7
8	Trey Chongva	*Rasbora sp.*	1.4	2.6
9	Trey Deab	*Channa micropeltes*	1.3	2.5
10	Trey Tuke	*Cephalophlis sp.*	1.0	2.0
11	Other Species	*Others*	10.8	20.5

Result…

Result

Energy and Nutrient Consumption

Proportion contribution of carbohydrate, fats and protein to total dietary energy: women and children



Result

Mean one-day and percent adequacy of energy and nutrient intake of the women

Energy and Nutrient	All Women	Stung Treng	Kampong Thom	Prey Veng
Energy(Kcal)	1976.0	2032.1	1813.3	2082.6
Meeting 100% of Energy Intake (%)	50.0	52.0	42.0	56.0
Protein(g)	65.7	67.4	61.9	67.8
Meeting 80% of Protein Intake (%)	71.0	75.0	66.0	72.0
Iron(mg)	13.0	11.7	13.9	13.2
Meeting 80% of Iron Intake (%)	10.7	13.0	5.0	14.0
Zinc(mg)	3.8	3.1	4.2	4.1
Meeting 80% of Zinc Intake (%)	36.3	28.0	46.0	35.0
Calcium(mg)	545.2	478.4	537.7	619.3
Meeting 80% of Calcium Intake (%)	24	21.0	26.0	24.0
Vitamin A(mcg RE)	458.4	531.4	438.8	404.9
Meeting 80% of Vitim A Intake (%)	28	24.0	29.0	31.0
Carbohydrate(g)	355.7	346.7	349.0	371.4
Fats(g)	35.5	33.5	28.9	44.0

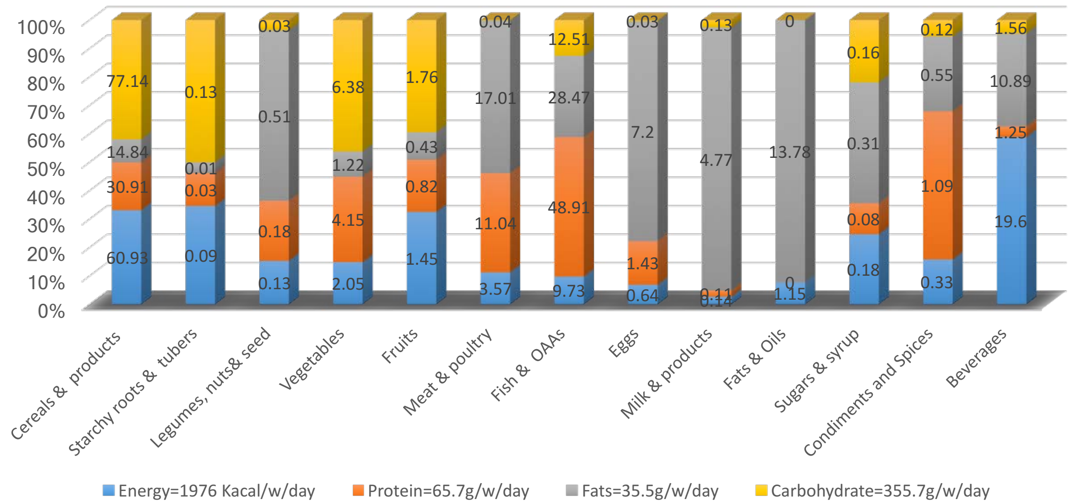
Result…

Mean one-day and percent adequacy of energy and nutrient intake of preschoolers

Energy and Nutrient	All Children	Stung Treng	Kampong Thom	Prey Veng
Energy(Kcal)	844.94	775.94	830.54	922.90
Meeting 100% of Energy Intake (%)	29.58	22.22	28.57	37.38
Protein(g)	28.72	26.72	26.36	32.90
Meeting 80% of Protein Intake (%)	53.37	46.66	48.57	61.68
Iron(mg)	5.09	4.83	4.75	5.67
Meeting 80% of Iron Intake (%)	24.11	15.28	22.85	32.71
Zinc(mg)	1.68	1.26	1.60	2.14
Meeting 80% of Zinc Intake (%)	8.03	2.85	5.71	14.95
Calcium(mg)	277.77	207.56	287.95	332.73
Meeting 80% of Calcium Intake (%)	23.79	15.23	18.09	27.10
Vitamin A(mcg RE)	241.03	233.41	268.03	221.59
Meeting 80% of Vitim A Intake (%)	18.64	13.33	22.85	18.69
Carbohydrate(g)	133.72	119.51	127.52	152.95
Fats(g)	15.10	13.08	13.13	18.90

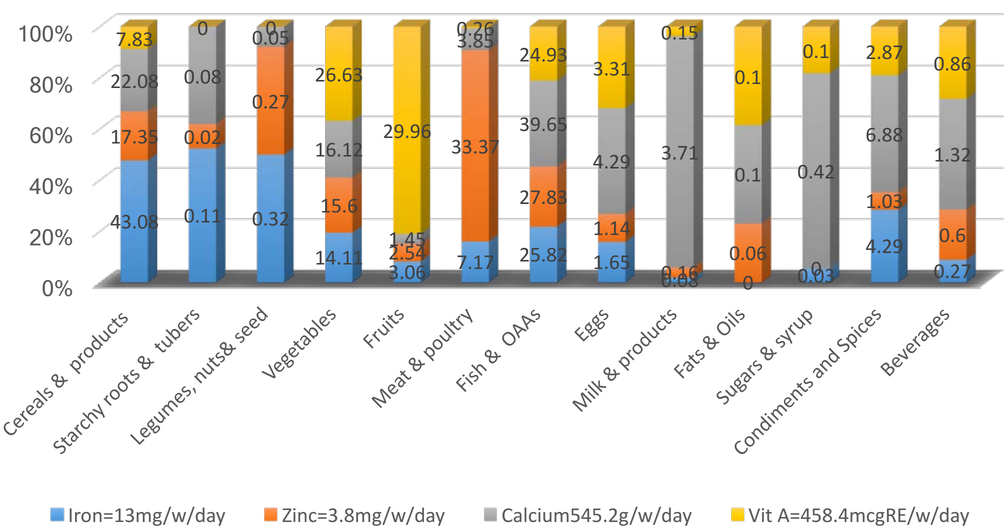
Result…

Percentage contribution of particular food groups to the women total energy and macronutrient intakes



Result…

Percentage contribution of particular food groups to the women total micronutrient intakes



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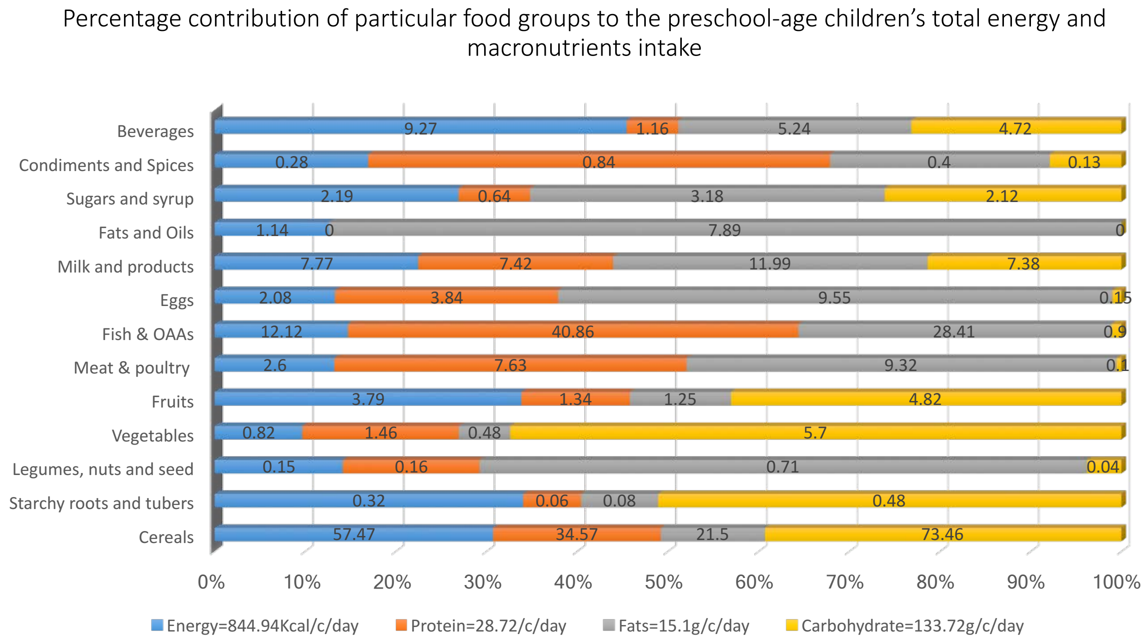

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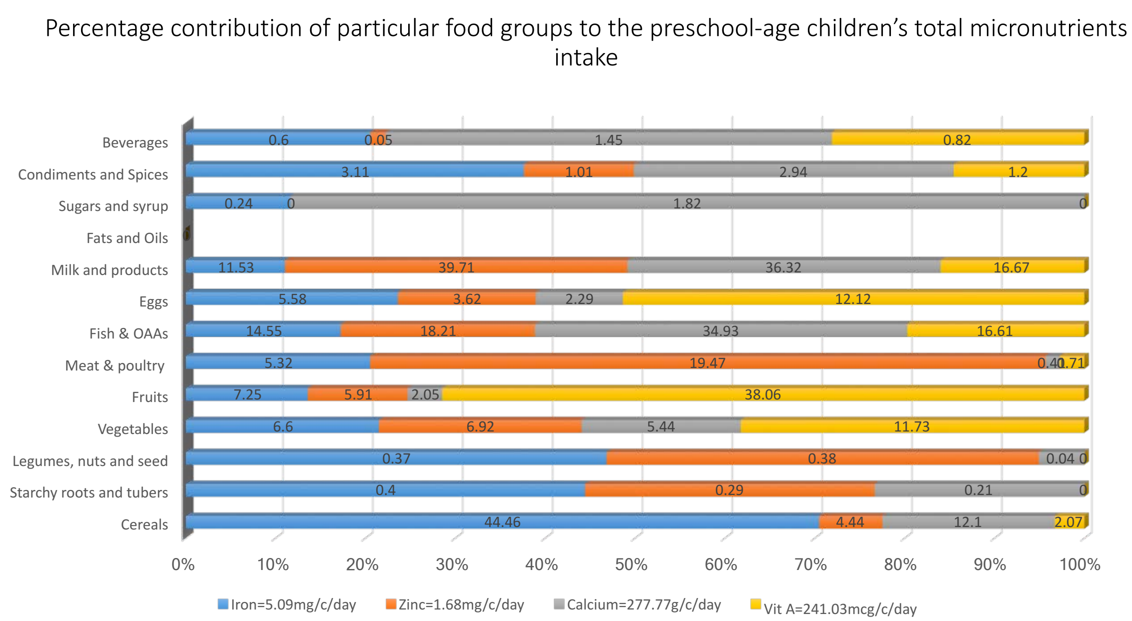
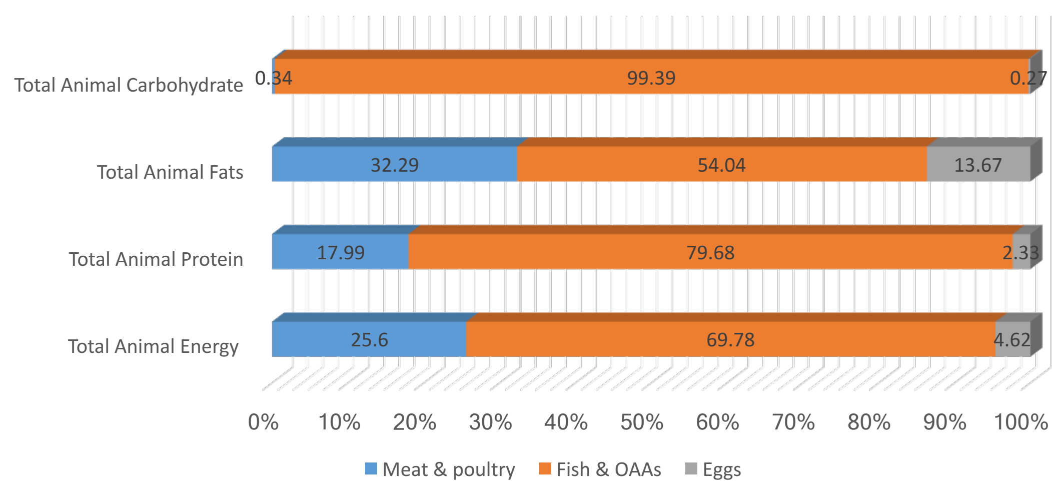


Result…

Result

Role of Fish in Women and Pre-schooler Nutrition comparing to nutrients derived from other animal sources

Percentage contribution of fish to the women's total animal energy and macronutrient intakes



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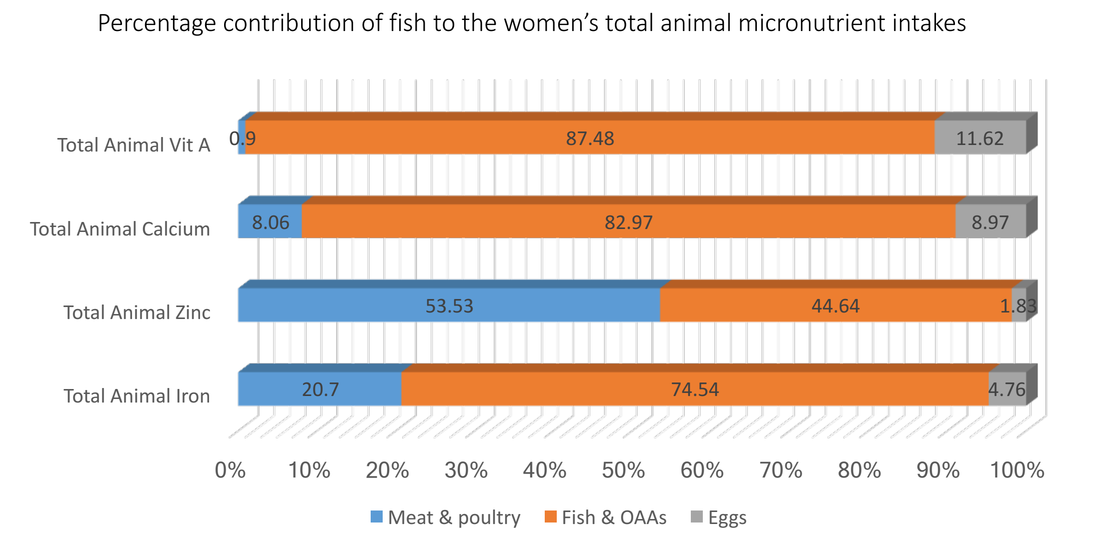

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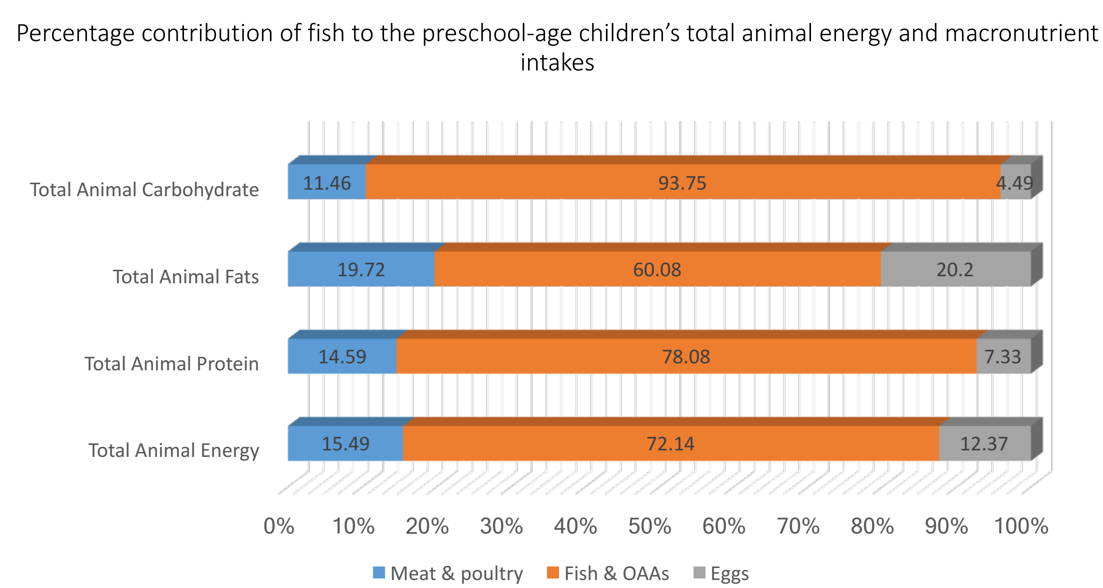
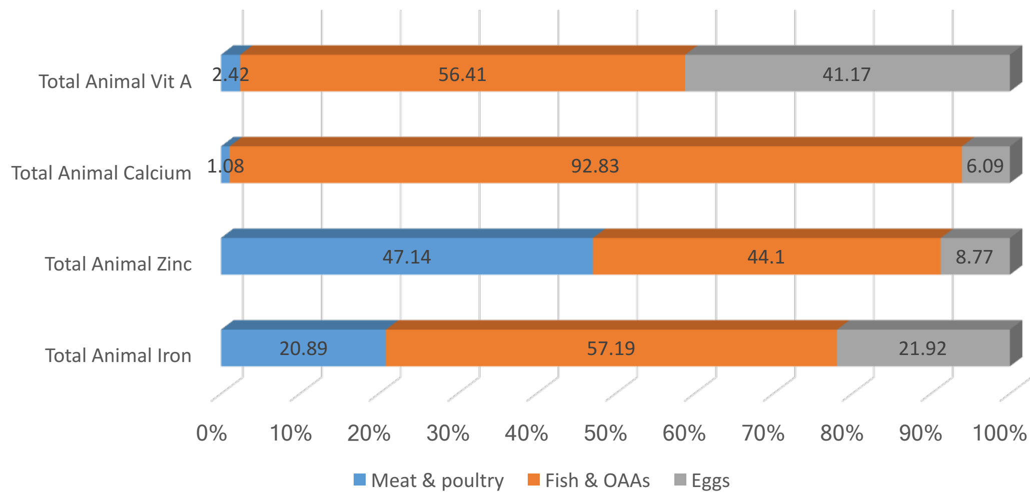


Result…

Percentage contribution of fish to the preschool-age children's total animal micronutrient intakes



Result…

Conclusion

- Rice and fish are the traditional staple foods playing an important role in the diets of women and children in Cambodia.
- Rice is the main source of energy and fish is the main source of animal protein.
- Fish is the major contributor of key micronutrients such as iron, zinc, calcium and vitamin A in women and children.
- Nutritional status of the rural poor women and children was low.
- The low intake of micronutrients in comparison to the recommended daily intake put them in the risk of micronutrient deficiencies.
- Fish is a nutritionally important animal food source contributing to the daily diets of the women and children in poor rural households

Recommendations

The recommendations for adaptation options and strategies to enhance food security and nutrition of women and preschool children in Cambodia are as follows:

- Food-based agricultures (dietary diversification) to promote integrated farming systems at household level with wide diversity of micronutrient-rich vegetables and fruits (commonly dark green vegetables, yellow fruits and vegetables) and food of animal origin (fish, egg, poultry and meat) to extend their season of availability;
- Increase in the accessibility of diverse species of low value small-sized fish species at household level;
- Preparation of recipes using higher proportion of micronutrient-rich foods, i.e. fish;
- Food preparation methods that preserve micronutrients: short cooking times, steaming, adding food to boiling water rather than cold water, and boiling rather than intensive frying;
- Food eating habits and behavior changes (make use of local knowledge and perception on fish, incorporation of fish in the meal, distribution of fish in the family);

Recommendation…

- Eating parts of fish and other aquatic animals such as eyes, head, skin, and meat; and processed fish products that are rich in micronutrients such as iron, zinc calcium, vitamin B complex and Vitamin A with the aim of incorporating these species into cultural practices;
- Avoid or reduce consumption of tea and coffee with meals;
- A nutritional education program in partnership with partners such as the Cambodian Red Cross in consultation with the National Maternal and Child Health Center and the National Nutrition Program on safe water, sanitation and hygiene aspects, cooking methods, food preparation and preservation, food eating habits and behaviors changes, in all Child and Maternal Nutrition programs; and
- A communication strategy can be used to promote dietary behaviors changes that increase consumption of micronutrient-rich fish species and foods of women and children.

Thank you for your attention

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Role of the AquaFish Innovation Lab in university capacity building and aquaculture development in Nepal

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The AquaFish Innovation Lab (formerly CRSP) has supported developing aquaculture for sustained food security and nutrition in Nepal since 2002 by partnering with Agriculture and Forestry University (AFU), formerly the Institute of Agriculture and Animal Science (IAAS) at Tribhuvan University. The AquaFish program has helped in developing research capacity, research facilities, and ultimately in providing quality education for aquaculture and fisheries students in the university. In addition to research projects, AquaFish has supported 22 master's students for their research and assistantship, and also provided assistantships to 30 undergraduate students. It also supported faculty and students participation in international/national seminars and professional conferences. Aquafish has also assisted in organizing and financially helped sponsor aquaculture and fisheries conferences and national fairs in Nepal and the region.

AquaFish supported research projects in Nepal have mainly focused on development of low-cost aquaculture technology and inclusion of indigenous fish species in aquaculture. Funding has been provided to 4 faculty members, 2 government researchers, and also 3 U.S. students to complete research projects in Nepal. At least six technologies have been developed and tested in on-farm trials, which not only serve to determine adoption of technologies but also extend the concepts to practitioners. These trials include Polyculture of grass carp and Nile tilapia, Integrated cage-cum-pond culture systems of sahar (*Tor putitora*) and African catfish (*Clarias gariepinus*) with carps, Polyculture of sahar with mixed-sex Nile tilapia, Polyculture of sahar and Nile tilapia with carps, Inclusion of small indigenous fishes in carp polyculture ponds and Sahar breeding in the tropical and subtropical climates of Nepal. Overall, AquaFish funding and the opportunities generated for faculty members, students, and government officials have produced substantial gains for aquaculture development in Nepal, and helped the University develop a better infrastructure and training program for the future.

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ROLE OF THE AQUAFISH INNOVATION LAB IN UNIVERSITY CAPACITY BUILDING AND AQUACULTURE DEVELOPMENT IN NEPAL

Madhav K. Shrestha
Agriculture and Forestry University, Nepal
James S. Diana
University of Michigan, USA

Asian Pacific aquaculture 2016 (26-29 April) , Surabaya Indonesia

Establishment of University

- Government of Nepal establish Agriculture and Forestry University (AFU) in June 2010
- AFU is the first state owned and technical university of Nepal formed /upgraded by merging Rampur Campus of IAAS and Hetauda Campus of IOF of Tribhuvan University
- This university has got mandate of Teaching, Research and Extension.
- Started its academic program from 2013.

Academic Programs

- Faculty of Agriculture
  - 11 Departments
- Faculty of Forestry
  - 8 Departments
- Faculty of Animal Science, Veterinary Science and Fisheries
  - 10 Departments
  - Aquaculture and Fisheries (A&F) is one of them

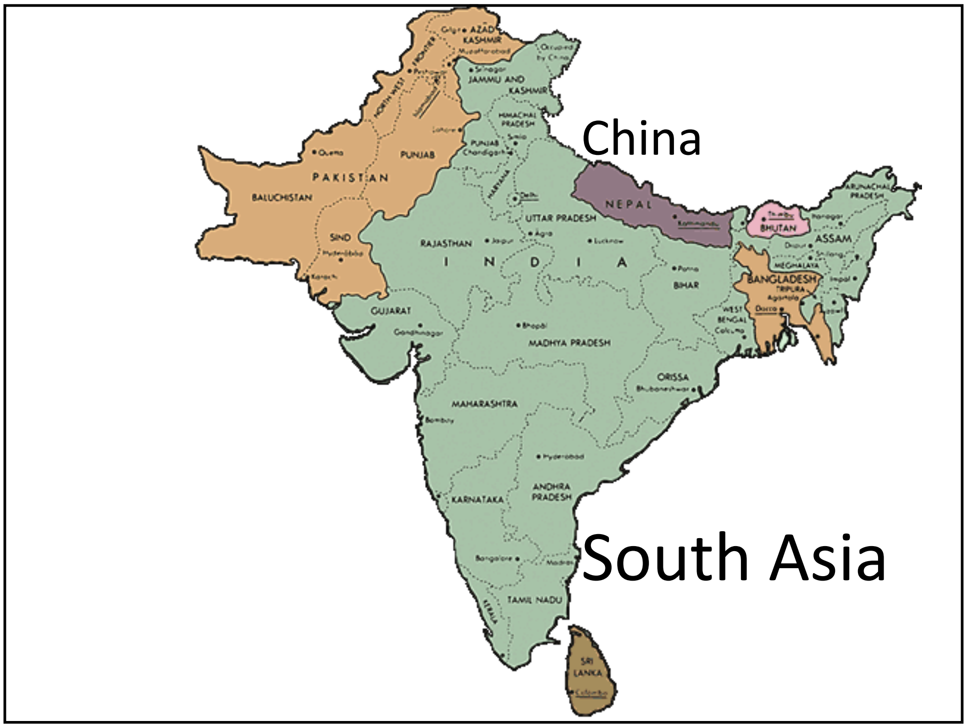
Aquaculture and Fisheries Program

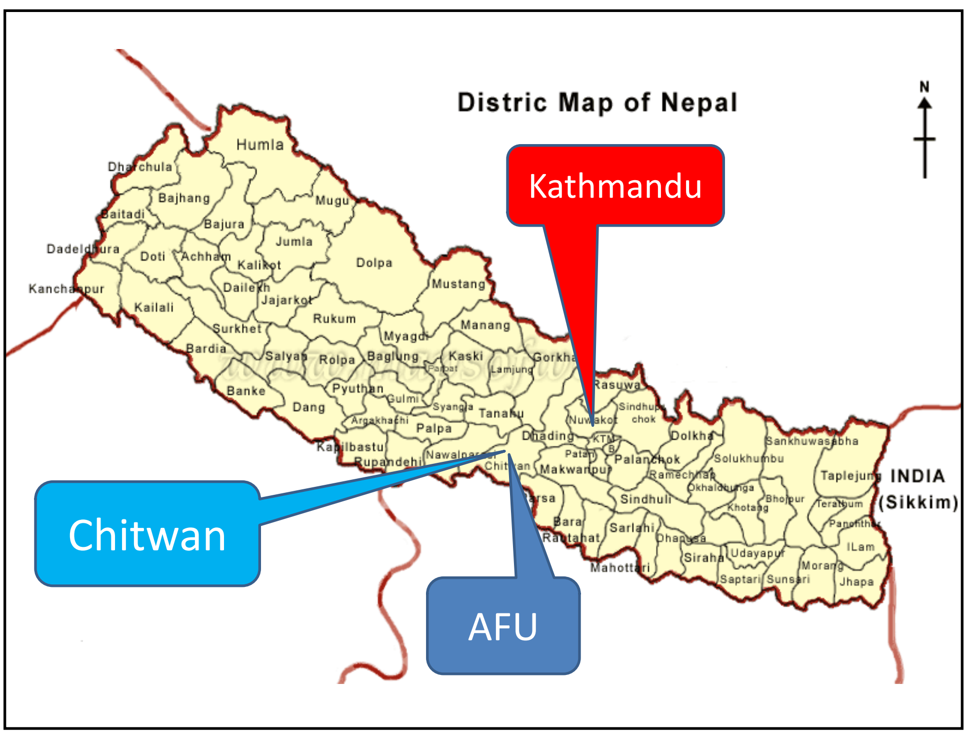
Undergraduate

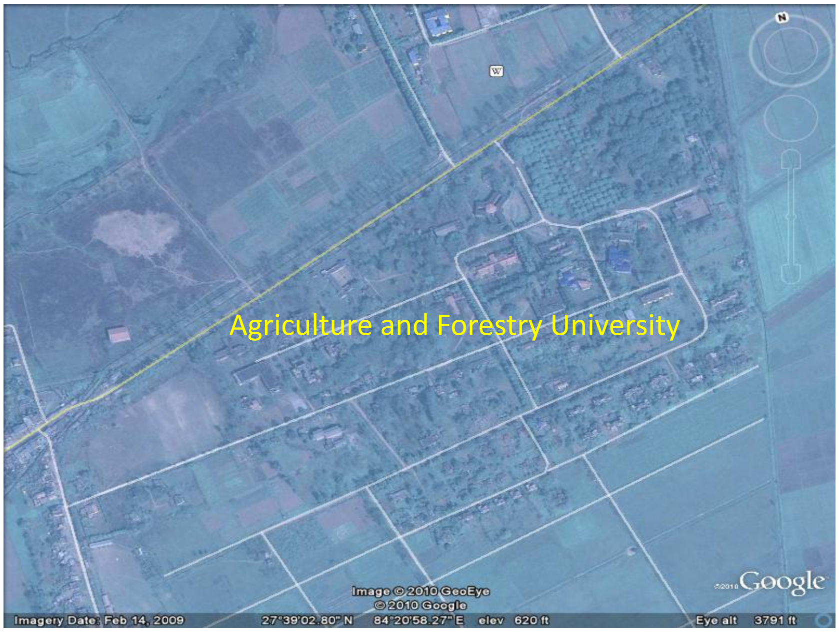
- B Sc Fisheries (4 years)

Graduate

- M Sc Fisheries (2 years)
- PhD (3+ years)


China
South Asia
PAKISTAN
INDIA
NEPAL
BHUTAN
BANGLADESH
SRI LANKA


Distric Map of Nepal
N
Kathmandu
Chitwan
AFU
INDIA
(Sikkim)


Agriculture and Forestry University
Image © 2010 GeoEye
© 2010 Google
Imagery Date: Feb 14, 2009
27°39'02.80" N 84°20'58.27" E elev 620 ft
Eye alt 3791 ft
Google


Animal Science Professor
Image © 2015 CNES / Astrium
© 2015 Google
Google earth
27°39'31.96" N 84°20'59.13" E elev 612 ft eye alt 2391 ft

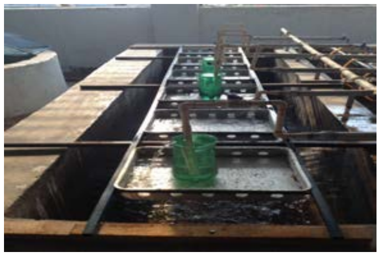
Involvement with AquaFish

- **09/2013 - 12/2015.** AquaFish IL. AFU – UM – OSU
- **09/2011 - 09/2013.** AquaFish CRSP. IAAS - UM - OSU
- **10/2009 - 09/'2011.** AquaFish CRSP. IAAS-SOU-UM-OSU
- **05/2007 - 09/2009.** AquaFish CRSP. IAAS – SFU – UM - OSU
- **09/2004 - 05/2006.** Aquaculture CRSP. IAAS – AIT – UM - OSU
- **08/2001 - 07/2004.** PD/A CRSP. IAAS – AIT – UM - OSU

Teaching and Research Facility Development

- Three cement pond was converted to 18 (2001-2004)

- Construction of Earthen research ponds 28 (2004-2009)



Tilapia Hatchery

Farm house & working shed

Wet lab

Feed Mill

Lab equipments

New Construction

Fisheries Reservoir (Open water lab)

Fisheries Academic Building

New pond construction

Student support

M Sc: (IAAS)

1. Narayan P. Pandit
2. Ravi Lal Sharma
3. Kamala Gharti
4. Ram Bhajan Mandal
5. Ramesh Jaiswal
6. Shailesh Gurung
7. Rim Thapa
8. Prasanta Sapkota
9. Saddam Hussain
10. Nelson Pokhrel
11. Laxmi Karki

PhD:

1. Ram Bhajan Mandal (AFU)

M Sc (AFU)

1. Subhash Kumar Jha
2. Rahul Ranjan
3. Sabita Jha
4. Khop Narayan Shrestha
5. Ishori Singh Mahato
6. Mahendra Prasad Bhandari
7. Rajan Poudel
8. Ruchi Shrivasta
9. Gun Bahadur Gurung
10. Suroj Kumar Singh
11. Charitra Narayan Yadav
12. Raju Khadka

B Sc Ag

1. Hare Ram Devkota

B Sc Fisheries

1st batch: 14

2nd batch: 15

3rd batch: 16

Developing capacity of Faculties

- Madhav Shrestha
  - PhD research, Postdoc reseracher
- Sunila Rai
  - PhD
- Dilip Jha
  - PhD by linkage and travel support
- Narayan Pandit
  - M Sc research
  - PhD by linkage
- Kamala Gharti
  - M Sc research

Publications:

- About 25 publication in Journal and proceedings

Conference/Seminar/Workshop:

- More than 50 presentations in national and International conferences since 2002 in Beijing China to Surabaya Indonesia.

Technology generation

- We (AquaFish – AFU) is proud to claim the success of Research and promotion of tilapia in Nepal which now priority species to promte for culture
- Cage-pond system: intensive feeding in cage and natural food based in pond – tested and demonstrated
- Tilapia-sahar polyculture is a technology developed.
- Carp-SIS technology promotion to small farmers for nutrition and supplemental income.
- Sahar breeding in subtropical (Tarai) in Nepal
- Tilpia-sahar inclusion in carp polyculture system for increased productivity.

Building Linkage

- Build strong linkage and collaboration between national research organization (NARC) and Government development and extension – policy body (DoFD) and University in the field of Aquaculture & Fisheries.

- Building university as one of the main sector in research and development in the country in the field of Aquaculture and Fisheries.

Support to NEFIS Convention and Aquaculture Fair

- Supported/sponsor 1st NEFIS convention held in Kathmandu
- Faculty members; PhD and Master students were supported to attend Convention
- 5 presentations made by AquaFish team member/ faculty.

Support to attend 7th NAST Conference

- Faculty travel; PhD and Master students travel were supported to attend 7th National Academy of Science and Technology Conference.
- 2 presentations were made by faculty.

Summing up

- AquaFish has been the instrumental to establish Aquaculture and Fisheries program in Agriculture and Forestry University and the then Institute of Agriculture and Animal Science (IAAS) of Tribhuvan University.
- All the facilities that was built in IAAS are in use in AFU.
- We expect Faculty of Fisheries in near future under the AFU.
- AquaFish will be remembered and acknowledged by A&F program of AFU for its lifetime.
- Thanks to all who contributed to include Nepal, especially university (IAAS /TU; AFU) for research site in the begoning and host country for AquaFish program.

Funding for these research is provided by the

AQUAFISH INNOVATION LAB

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to participate this APA 2016
at Surabaya, Indonesia