AquaFish Innovation Lab Technical Session at
World Aquaculture Society 2017
Cape Town, South Africa
26 – 30 June 2017
Session Organizer: Dr. Hillary S. Egna

Proceedings

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

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PREAMBLE

2017 AquaFish Technical Sessions at WAS
2017 – Cape Town, South Africa
26-30 July 2017

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Session co-chair: Steve Amisah

On Friday, 30 June 2017, AquaFish Innovation Lab held a day long special session organized by Dr. Hillary Egna and co-chaired by Steve Amisah at the Africa Chapter of World Aquaculture Society's annual conference in Cape Town, South Africa. In total, 20 presentations were given during the session titled "AquaFish." This session covered recent work funded by AquaFish Innovation Lab throughout the globe. The session was a success and well attended by both AquaFish participants and general conference attendees who provided thoughtful questions and feedback.

2017 AquaFish Technical Sessions' Agenda
WAS 2017 – Cape Town, South Africa

26-30 June 2017

Friday, 30 June 2017

AquaFish Technical Session (9:00-17:20)

Session Organizer: Dr. Hillary S. Egna, AquaFish Director
Session Co-chair: Steve Amish, AquaFish Host Country Co-PI

9:00-9:20	**Nutritional control of growth, gut microbiome, and intestinal nutrient transporters in Nile tilapia** Russell J. Borski*, Scott Salger, David Baltzegar, Jimi Reza, and Md. Abdul Wahab
9:20-9:40	**Earthworm meal as protein source in Nile tilapia *Oreochromis niloticus* Diets** Nazael A. Madalla*, Tausi Ally, and Sebastian W. Chenyambuga
9:40-10:00	**Growth, yields and economic benefit of Nile tilapia *Oreochromis niloticus* fed diets formulated from local ingredients in cages** Charles C. Ngugi*, Hillary Egna, Elijah O. Okoth, and Julius O. Manyala
10:00-10:20	**The effect of commercial and experimental diets on growth performance of *Oreochromis niloticus* L. fingerlings reared in hapas in Uasin Gishu County, Kenya** Elizabeth Obado*, Josiah Ani, Julius O. Manyala, Kevin Fitzsimmons, and Charles Ngugi
10:20-10:40	**Growth and survival of Nile tilapia under nursery conditions** Regina Edziyie*, Abigail T. Abachie, Kwasi A. Obirikorang, Daniel Adjei-Boateng, Emmanuel A. Frimpong
10:40-11:00	**Development of low cost aquaponic system in Kenya** Ani J. Sabwa*, Manyala O. Julius, Fitzsimmons Kevin and Ngugi C. Charles
11:10-11:30	**Contribution of small-scale aquaculture to rural livelihoods in Tanzania** Sebastian W. Chenyambuga* and Nazael A. Madalla
11:30-11:50	**Single nucleotide polymorphisms discovery in the transcriptome of marbled lungfish *Protopterus aethiopicus* by next generation sequencing: guiding breeding technology** J. Walakira*, M. Njeri, M. Agaba, J. Njuguna, J. Amimo, R. Bett and S. O. Opiyo
11:50-12:10	**Comparative growth performance of *Oreochromis niloticus, Clarias gariepinus* and *Cyprinus carpio* at a high-altitude environment** James Bundi Mugo* and Charles C. Ngugi
12:10-12:30	**Effects of frequency of grading on the growth, intra−cohort cannibalism and economic benefits of African catfish (*Clarias Gariepinus*, Burchell, 1822) culture** Anthony M. Mwangi*, James Jumbe, and Charles C. Ngugi
14:00-14:20	**Brood mola stocking density in prawn and carp farming to increase household nutrition for rural farmers in southwest Bangladesh** Khandakar Anisul Huq*, Wasim Sabbir, Shikder Saiful Islam, Joyanta Bir, Shahroz Mahean Haque, M. A. Wahab, and Russell Borski
14:20-14:40	**Semi-intensive polyculture of climbing perch with Indian carps** Shahroz Haque*, Moon Dutta, Imrul Kaisar, Mahbub Alam, Hillary Egna, and Russell Borski
14:40-15:00	**Understanding seasonal price variation in the aquaculture sector in Uganda** James O. Bukenya*, Kelvin Lule, Moureen Matuha, Theodora Hyuha, and Joseph Molnar

15:00-15:20	**Consumer preferences and consumption patterns for fish in Uganda** Gidongo Halasi*, Theodora Hyuha, S. K. Chimatro, Hillary Egna, Joseph Molnar, W. Ekere, G. Elepu, and P. Walekwa
15:20-15:40	**Women involvement in coastal activities and community based mariculture in Zanzibar, Tanzania** Jiddawi, NS* and M Haws
15:40-16:00	**Analysis of fish trade in the eastern corridor: The case of central Uganda** Diana Asero*, Theodora Hyuha, Hillary Egna, S.K. Chimatiro, Joseph Molnar, and W. Ekere
16:00-16:20	**Implementing a mobile-based application for marketing and technical support: Developing a sustainable system for fish farmers in Uganda** Joseph Molnar*, Isaac Omiat, Moureen Matuha, Gertrude Atukunda, John Walakira, Theodora Huhya, James Bukenya, Claude Boyd, and Shamim Naigaga
16:20-16:40	**Aquaculture and food security: an assessment of fish farming households in Ghana** Akua Akuffo* and Kwamena Quagrainie
16:40-17:00	**A latent-class analysis of household demand for seafood in Ghana** Akua Akuffo* and Kwamena Quagrainie
17:00-17:20	**Marketing strategy of farmed fish in central** Theodora Hyuha*, Joseph Molnar, Hillary Egna, W Ekere, and Gidongo Halasi

Abstracts and Presentations

AquaFish Technical Session

Nutritional control of growth, gut microbiome, and intestinal nutrient transporters in Nile tilapia

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. Metagenomics 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 different prokaryotic (16S operational taxonomic units) and 288 eukaryotic genus/species (18S taxonomical units). Metagenomics analyses indicated that Tx1 and Tx2 had the greatest diversity of bacteria and eukaryotes in the tilapia fecal material. The predominant bacteria found were *Cetobacterium somerae* (common gut colonizers of Nile tilapia) which are known to produce Vitamin B12. Six unique species were found in Tx2 including members of family Nocardioidacea (shown antimicrobial and antitumor effects), *Bacteroides* sp. (shown to directly modulate the gut function of their hosts), and *Sphingomonas* sp. (produce antioxidant compounds). The predominant eukaryotes in the tilapia fecal material were the diatoms, rotifers, green algae and flowering plants (angiosperms). Gene expression of solute transporters found in the proximal intestine in the Tx2 regime tended to be higher than feeding alone, but lower than the other feeding + fertilization and fertilization alone regimes. 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 tilapia farmers with little impact on fish growth and that this regime increases the diversity of microbiota available to the fish and regulates nutrient uptake, which may contribute to the improved efficiency of tilapia growout. This is the first description of the tilapia microbiome derived from next generation sequencing techniques and should serve as a good reference for future studies aimed at evaluating changes in gut fauna and flora linked to tilapia health and performance under different environmental conditions. To build on these studies, experiments have been initiated to determine if larval nutritional conditioning might modify the gut transcriptome and microbial community in favor of improved efficiency. We have conditioned newly hatched fry on an initial 25% crude protein diet versus a usual 48% crude protein larval diet for different interval to determine whether reducing the amount of crude protein in early fry life will lead to subsequent improvements in protein processing, uptake, and utilization in tilapia during growout. We will discuss how differences in gut gene expression and microbial content may contribute to nutritional imprinting in fish, should the phenomenon be observed.

Nutritional Control of Growth, Gut Microbiome, and Intestinal Nutrient Transporters in Nile Tilapia

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

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

Background

- ➢ Solving global and regional food security problems requires overcoming key obstacles to success.
- ➢ Goal is for reliable and sustainable intensification of seafood production.

Feeds and Growth Technologies: 50-80% of production costs for fish can be attributed to feeds.

- Feed Management – fish are often overfed
- Formulations – nutrient concentrations and sources of ingredients
- Gut microbes – food digestibility and fish health

Objectives of the Studies

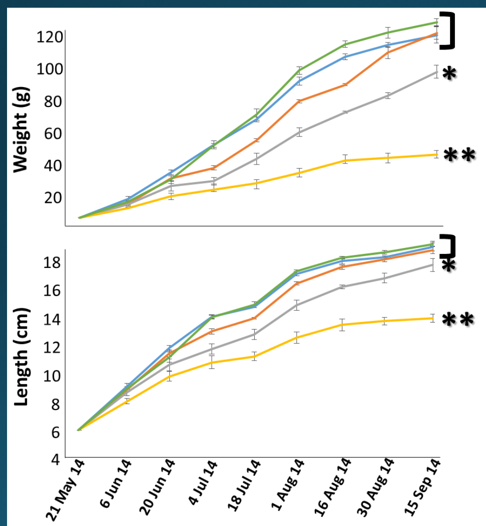
- Evaluate the effectiveness of pulsed-feeding strategies and nutritional programming on Nile tilapia (*Oreochromis niloticus*) production.
- Characterize changes in gut microbial communities in response to pulsed-feeding strategies and nutritional programming.
- Identify key molecular factors associated with nutrient uptake efficiency.

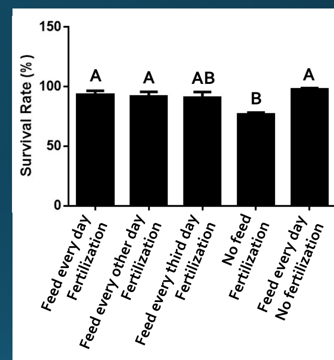
Study 1: Pulsed-Feeding Strategies

Pond Studies – Fisheries Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh

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

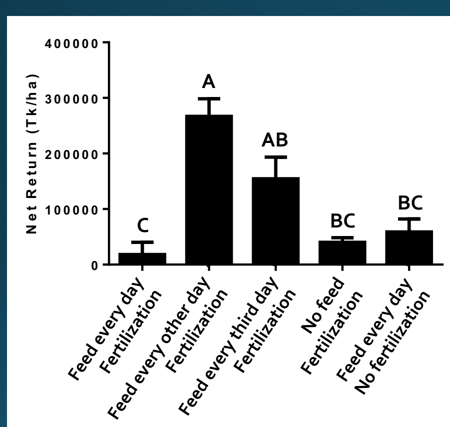
Alternate-day feeding results in tilapia growth similar to every-day feeding with no difference in survival

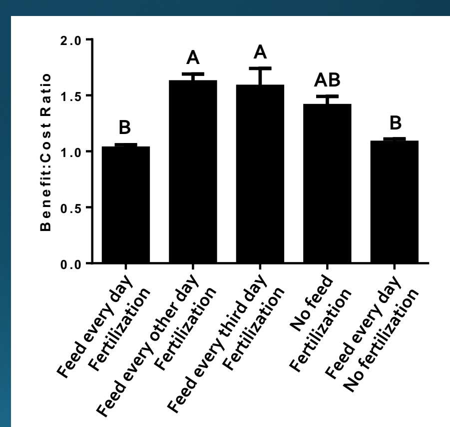




Statistical significance determined by ANOVA. $*p < 0.05$; $**p < 0.01$

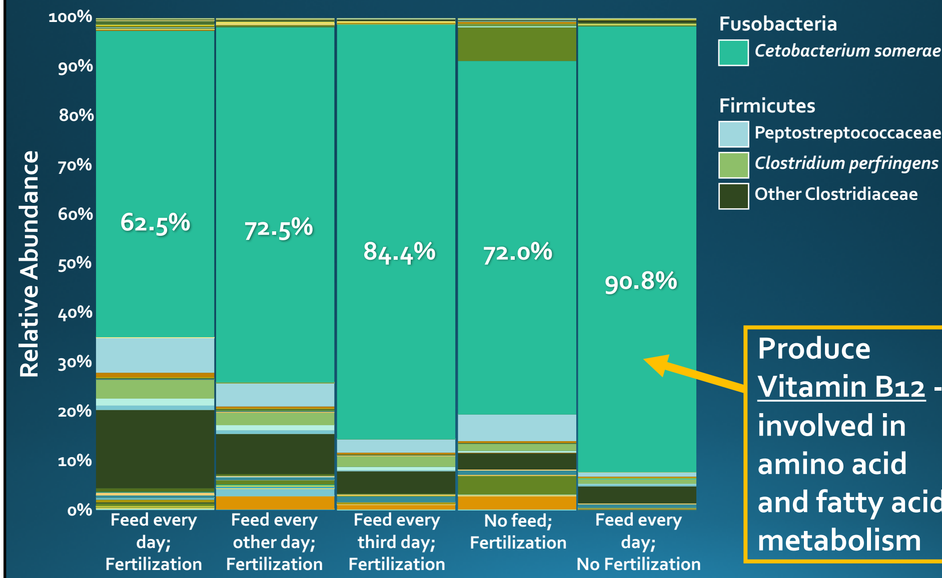
There is also a better economic return to alternate-day feeding that can lead to a 50% reduction in feed and labor costs





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

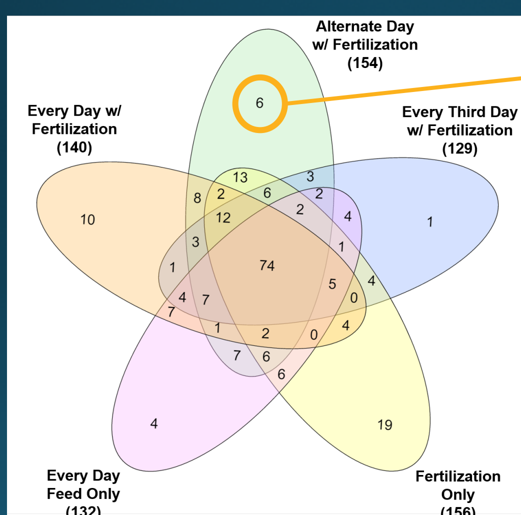
Pulsed-feeding strategies lead to changes in gut bacterial communities



Produce Vitamin B12 - involved in amino acid and fatty acid metabolism

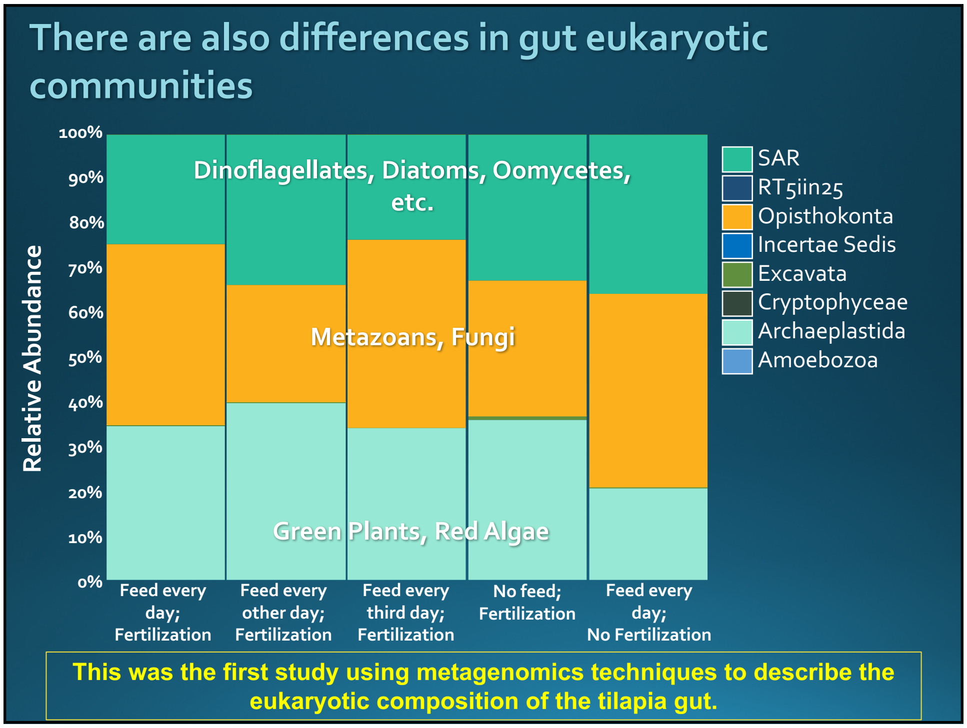
The identified gut microbiome affects the fish's ability to:

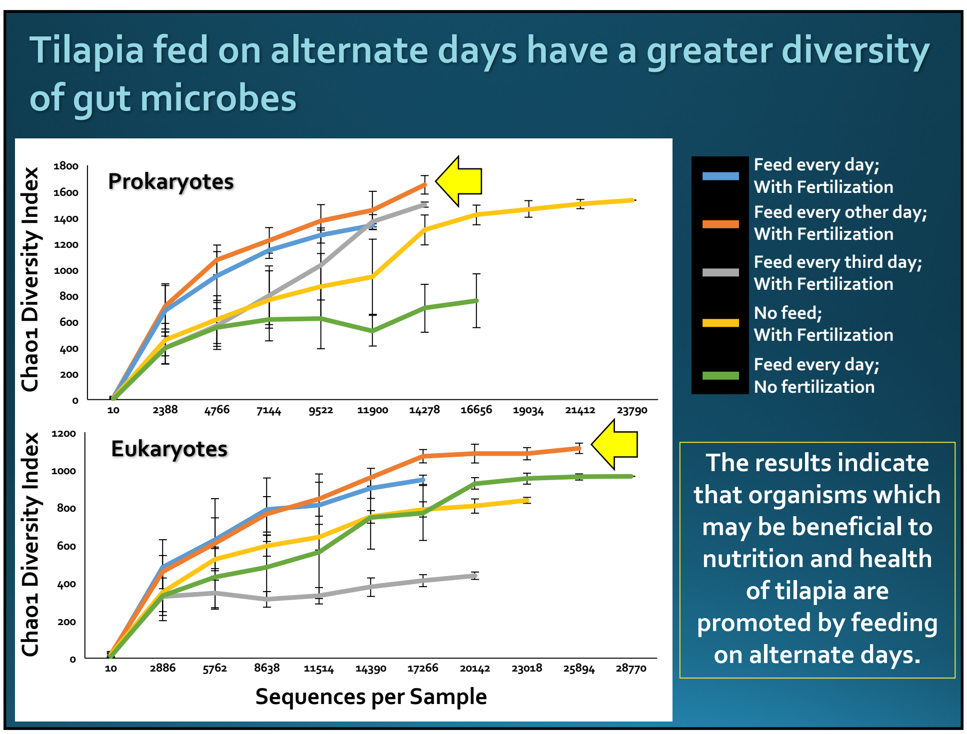
- maintain physiological homeostasis
- process and better utilize nutrients making them available to the fish
- regulate health and wellbeing of the fish



Bacteria that:

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


There are also differences in gut eukaryotic communities
Relative Abundance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Dinoflagellates, Diatoms, Oomycetes, etc.
Metazoans, Fungi
Green Plants, Red Algae
Feed every day; Fertilization
Feed every other day; Fertilization
Feed every third day; Fertilization
No feed; Fertilization
Feed every day; No Fertilization
SAR
RT5iin25
Opisthokonta
Incertae Sedis
Excavata
Cryptophyceae
Archaeplastida
Amoebozoa
This was the first study using metagenomics techniques to describe the eukaryotic composition of the tilapia gut.


Tilapia fed on alternate days have a greater diversity of gut microbes
Prokaryotes
Chao1 Diversity Index
1800
1600
1400
1200
1000
800
600
400
200
0
10
2388
4766
7144
9522
11900
14278
16656
19034
21412
23790
Eukaryotes
Chao1 Diversity Index
1200
1000
800
600
400
200
0
10
2886
5762
8638
11514
14390
17266
20142
23018
25894
28770
Sequences per Sample
Feed every day; With Fertilization
Feed every other day; With Fertilization
Feed every third day; With Fertilization
No feed; With Fertilization
Feed every day; No fertilization
The results indicate that organisms which may be beneficial to nutrition and health of tilapia are promoted by feeding on alternate days.

The next step: Nutritional Programming in Tilapia

- Nutritional programming is the concept that critical events early in life have lifelong effects on growth and health.
- There is strong evidence that this phenomenon is likely to occur across all vertebrates, including fish.

- Rainbow trout (*Oncorhynchus mykiss*) juveniles fed high glucose diets for a short period showed long-term modifications to carbohydrate digestion (Geurden et al., 2007).
- European sea bass (*Dicentrarchus labrax*) juveniles fed a HUFA-deficient diet initially were able to metabolize lipids more efficiently than those fed a high HUFA diet (Vagner et al., 2007).
- Both are carnivorous fishes

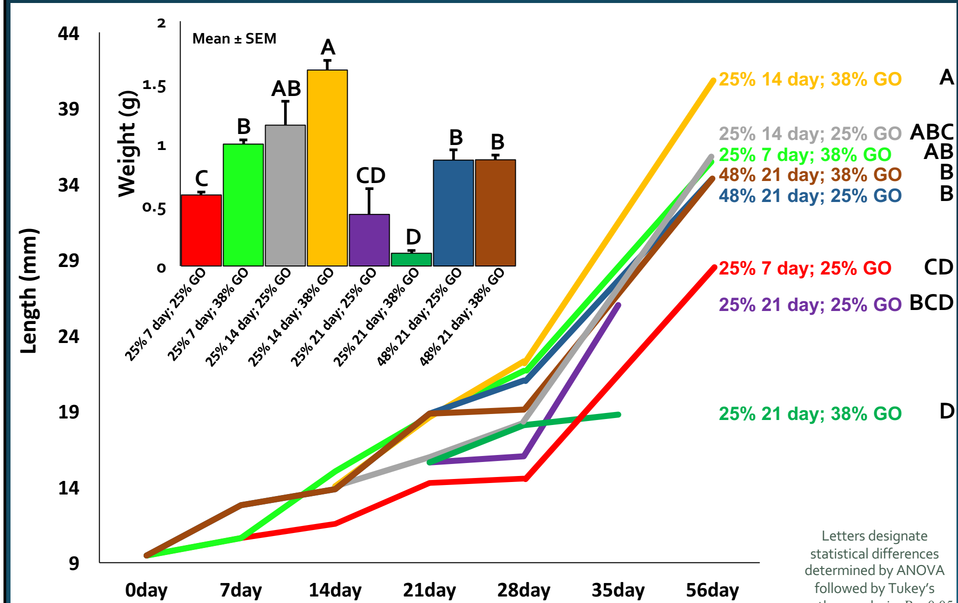
Nothing is known about the effectiveness of applying nutritional conditioning to tilapia culture

Study 2: Nutritional Programming in Tilapia

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

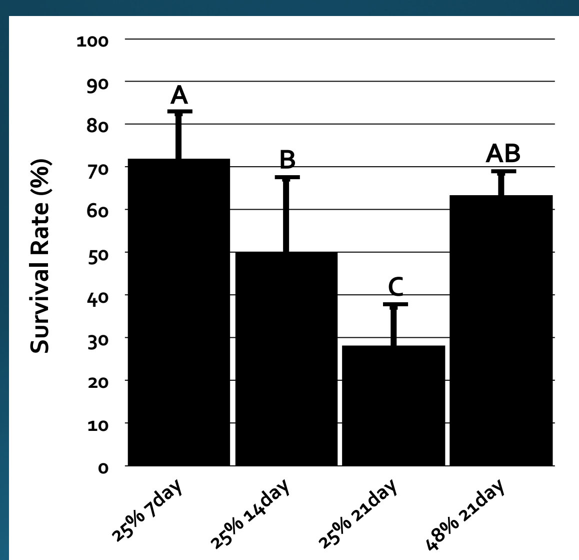
Our goal is to show that restricting protein in the early lives of tilapia will have long-term effects on uptake and utilization of protein.

Tilapia fed lower initial protein diets grew better than those fed higher initial protein diets



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

Protein should be restricted for no more than 7-14 days



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

Summary

- No difference in growth or production parameters of Nile tilapia when employing alternate-day feeding vs. daily feeding strategies.
  - ➢ Feed costs decreased by 50%
- A greater diversity of organisms found in the intestines of tilapia when fed on alternate days.
  - ➢ More diverse nutrients available
  - ➢ Potential probiotic support for more efficient absorption of nutrients and general fish health
- Feeding tilapia an initial low protein diet for 7-14 days post yolk-sac absorption leads to better growth later in the fish's life.

❖ Analysis of key molecular factors and gut microbial communities associated with nutritional programming are currently being conducted.

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NC STATE UNIVERSITY COLLEGE OF SCIENCES DEPARTMENT OF BIOLOGICAL SCIENCES

Earthworm meal as protein source in Nile tilapia diets

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Tanzania has experienced dwindling fish catch due to overfishing and environmental degradation resulting in annual yield of about 350,000 MT which is half of the potential. This has resulted in low per capita fish consumption of 8 kg, far less that the global average of 20 kg. On the other hand, aquaculture has remained subsistence practiced in small semi-intensive freshwater ponds which are mostly stocked with Nile tilapia. Lack of quality affordable aquafeeds is one of the limiting factors as fishmeal and oil seed cakes which are main sources of protein are scarce and costly. Earthworms are locally available and relatively affordable and have high protein content, thus potential alternative protein source. This study was conducted to evaluate earthworm meal (EWM) as alternative protein source in practical aquafeeds. The earthworms were produced using cow manure as substrate. Five isonitrogenous with 30% crude protein were formulated to contain graded levels of EWM (0, 12, 24, 40 & 45%) as shown in Table 1. Each diet was randomly assigned in triplicate to experimental units containing 14 tilapia juveniles each with an average weight of 2.6 g. The diets were fed for eight weeks collecting data on body weights and feed intake. Best growth, feed utilization and cost effectiveness was observed in fish fed diet EWM40 (Table 2). Therefore, EWM can be included at 40% in Nile tilapia diets containing 5% fish meal and 5% cotton seedcake without compromising performance.

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

	Diets				
Ingredients	**EWM0**	**EWM12**	**EWM24**	**EWM40**	**EWM45**
Fish Meal	5.0	5.0	5.00	5.0	5.0
Earthworm meal	0.0	12.0	24.0	39.8	45.0
Cotton seed meal	50.0	38.0	24.5	5.0	0.0
Others*	100.0	100.0	100	100	100.0
Total	100.0	100.0	100.0	100.0	100.0

*Maize meal, wheat meal, sunflower oil and Vitamin/Mineral premix

Table 2: Performance of Nile tilapia fed EWM diets (Mean ± SD, n=3).

	Diets				
Parameter	**EWM0**	**EWM25**	**EWM30**	**EWM35**	**EWM40**
IBW (g)	2.41 ± 0.18^{a}	2.48 ± 0.05^{a}	2.42 ± 0.08^{a}	2.43 ± 0.05^{a}	2.46 ± 0.40^{a}
FBW (g)	7.71 ± 0.071^{c}	8.50 ± 0.28^{b}	8.84 ± 0.48^{a}	8.92 ± 0.06^{a}	7.71 ± 0.02^{c}
BWG	5.30 ± 0.25^{c}	6.02 ± 0.25^{b}	6.42 ± 0.44^{a}	6.49 ± 0.10^{a}	5.25 ± 0.38^{c}
ADWG ($gday^{-1}$)	0.096 ± 0.004^{d}	0.104 ± 0.005^{c}	0.115 ± 0.008^{b}	0.118 ± 0.002^{a}	0.096 ± 0.007^{d}
FI ($gfish^{-1}day^{-1}$)	0.22 ± 0.01^{c}	0.24 ± 0.01^{ab}	0.26 ± 0.01^{a}	0.28 ± 0.01^{a}	0.23 ± 0.01^{c}
FCR	2.47 ± 0.14^{c}	2.22 ± 0.07^{b}	2.10 ± 0.09^{a}	1.85 ± 0.31^{a}	2.43 ± 0.04^{c}
SGR	2.11 ± 0.15^{c}	2.26 ± 0.05^{b}	2.31 ± 0.08^{a}	2.38 ± 0.05^{a}	$2.18\pm.31^{c}$
PER	1.35 ± 0.01^{c}	1.57 ± 0.05^{c}	1.80 ± 0.21^{b}	1.81 ± 0.07^{a}	1.68 ± 0.19^{b}
Surv (%)	88.1 ± 8.6^{a}	97.6 ± 2.4^{a}	97.6 ± 2.4^{a}	97.6 ± 2.4^{a}	92.9 ± 0.0^{a}
CF (TZS/Kg)	1509	1419	1419	1434	1449
CE (TZS/Kg fish)	3727.2 ± 215.9^{d}	3150.2 ± 7.6^{b}	2979.8 ± 348.7^{ba}	2659.8 ± 104.7^{a}	3521.1 ± 280.4^{c}

IBW=Initial body weight, FBW=Final body weight, BWG=Body weight gain, ADWG=Average Daily Weight Gain, FI=Feed Intake, FCR=Feed Conversion Ratio, SGR=Specific Growth Rate, PER=Protein Efficiency Ratio, Surv=Survival, CF=Cost of feed, CE=Cost effectiveness.
Means with different superscript letters within a row are significantly different at P<0.05

Evaluation of Earthworm Meal as Protein Source in Nile Tilapia *Oreochromis niloticus* Diets

Nazael A. Madalla, Tausi Ally, & Sebastian W. Chenyambuga
Department of Animal, Aquaculture & Range Sciences
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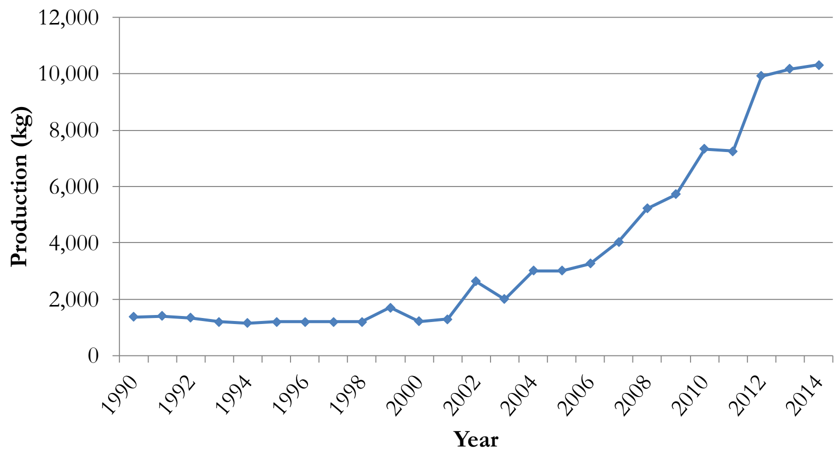
Introduction

- Tanzania – dwindling fish catch due to overfishing and environmental degradation
  - average annual fish catch 350,000 MT
  - low per capita consumption 8 kg (global – 20 kg)
- Tilapia farming is mostly subsistence in small semi-intensive earthen ponds
  - 20,276 farmers who produced 3,240 MT in 2015
- Lack of quality and affordable fish feeds is one of the limiting factors due to high cost and unavailability of fishmeal and soy bean

Aquaculture Production Trend in Tanzania



Source: FAO FishStat

…Introduction

- Earthworms potential alternative protein source
  - reproduce and grow on organic wastes
  - high protein content (37 – 63%)
  - fairly good profile of amino acids, fatty acids and minerals
- The current study evaluated suitability of earthworm meal (EWM) as protein source in practical Nile tilapia diets.

Methodology

- Earthworms were produced using 12 lt plastic containers containing soil mixed with organic manures(cattle, rabbit & chicken) in triplicates at a ratio of 1:2
- Harvested maggots were blanched, oven dried at 65^0C for 48 hours and then ground into a meal
- Proximate composition of earthworms was determined for each type of manure

…Methodology

Earthworm Culture

…Methodology

Earthworm Harvest

…Methodology

- Five diets were formulated to contain 30% protein
- The five diets were randomly allocated in triplicates to 20L tanks
- Each tanks was stocked with 14 tilapia juveniles with an average weight of 2.4±0.05 g
- The juveniles were fed twice a day at 0900 and 1700 hrs according to apparent satiation for eight weeks

…Methodology

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

Ingredients	Diets HFM0	HFM12	HFM25	HFM40	HFM50
Fish meal	5.0	5.0	5.0	5.0	5.0
Earthworm meal	0.0	12.0	24.5	40.0	48.8
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 mg, MAGNESIUM 12, 750 mg, POTASSIUM ACETATE 73, 750 mg, LYSINE 15,000 mg, METHIONINE 12, 000 mg, antioxidant and anticaking qsf 1 kg.

…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
    - FW, BWG, ADG, SGR
  - Feed Utilization
    - FI, FCR & PER
  - Cost Effectiveness
    - Price/kg feed & Cost to produce 1kg of fish
- Data were analysed using one-way ANOVA at significant level of 5%

Results

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

Item (%)	**Substrate**		
	Cattle manure	**Chicken manure**	**Rabbit manure**
Dry matter	95.02±0.96[a]	97.20±0.47[a]	95. 26±0.67[a]
Crude protein	48.61±0.18[a]	40.83±0.43[b]	39.80±0.41[b]
Ether extract	6.80±0.49[a]	5.60±0.22[a]	5.23±0.12[a]
Ash	28.60±0.11[a]	28.77±0.48[a]	29.77±0.10[a]

…Results

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

Item	FM	MM	WM	CSM
Dry matter	98.96	88.01	96.9	97.50
Crude Protein	69.20	10.5	11.74	41.60
Ether Extract	10.28	3.60	1.80	8.5
Crude Fibre	-	2.3	2.31	14.37
Ash	22.76	1.30	1.91	6.70
Nitrogen free extract	2.38	84.30	79.15	23.34
Gross energy(Kcal/g)	19.99	17.93	17.10	18.88

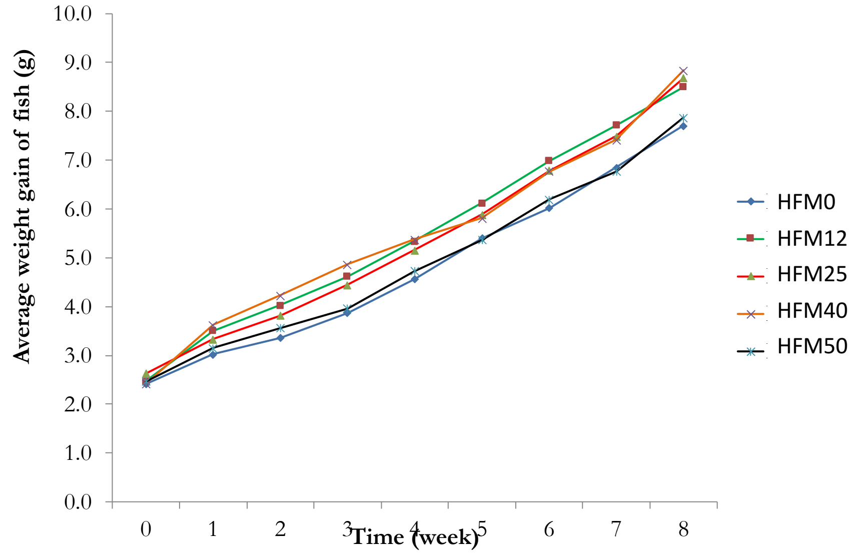
…Results

Proximate Composition (g/100g) and Gross Energy Content of EWM Diets

			Diets		
Item	**EWM0**	**EWM12**	**EWM25**	**EWM40**	**EWM50**
Moisture	6.45	4.21	4.21	7.50	8.10
Crude Protein	29.59	30.31	30.31	29.58	29.80
Ether Extract	8.49	10.34	9.34	9.53	9.84
Crude Fibre	8.17	4.76	3.76	3.00	2.22
Ash	5.03	7.90	7.90	11.80	12.96
Nitrogen Free Extract	46.86	41.61	41.61	40.32	39.10
Gross Energy	18.35	17.21	17.21	16.30	16.07

…Results

Growth - AWG



…Results

Feed Intake & Growth of *O. niloticus* fed EWM Diets (Mean ± SE, n=3)

	Diets				
Parameter	**EWM0**	**EWM12**	**EWM25**	**EWM40**	**EWM50**
Initial body weight (g)	2.41±0.18[a]	2.48±0.05[a]	2.42±0.08[a]	2.43±0.05[a]	2.46±0.40[a]
Final body weight (g)	7.71±0.071[b]	8.50±0.28[ab]	8.84±0.48[a]	8.92±0.06[a]	7.71±0.02[b]
Body weight gain	5.30±0.25[b]	6.02±0.25[a]	6.42±0.44[a]	6.49±0.10[a]	5.25±0.38[b]
Average daily wt gain ($gday^{-1}$)	0.096±0.004[d]	0.104±0.005[c]	0.115±0.008[b]	0.118±0.002[a]	0.096±0.007[d]
Specific growth rate (% day^{-1})	2.11±0.15[b]	2.26±0.05[ab]	2.31±0.08[a]	2.38±0.05[a]	2.18±.31[b]

Means with different superscript letters within a row are significantly (P<0.05) different.

…Results

Feed Utilization & Survival of *O. niloticus* fed EWM Diets (Mean ± SE, n=3)

	Diets				
Parameter	**EWM0**	**EWM12**	**EWM25**	**EWM40**	**EWM50**
Feed intake ($gfish^{-1}day^{-1}$)	$0.22±0.01^{a}$	$0.24±0.01^{a}$	$0.26±0.01^{a}$	$0.28±0.01^{a}$	$0.23±0.01^{a}$
Feed conversion ratio	$2.47±0.14^{a}$	$2.22±0.07^{ab}$	$2.10±0.09^{ab}$	$1.85±0.31^{b}$	$2.43±0.04^{ab}$
Protein efficiency ratio	$1.35±0.01^{c}$	$1.57±0.05^{b}$	$1.80±0.21^{a}$	$1.81±0.07^{a}$	$1.68±0.19^{bc}$
Survival (%)	$88.1±8.6^{a}$	$97.6±2.4^{a}$	$97.6±2.4^{a}$	$97.6±2.4^{a}$	$92.9±0.0^{a}$

Means with different superscript letters within a row are significantly (P<0.05) different.

…Results

Price of Feed & Cost Effectiveness of EWM Diets (Mean ± SE, n=3)

	Diets				
Parameter	**EWM0**	**EWM12**	**EWM25**	**EWM40**	**EWM50**
Cost of feed (TZS/Kg)	1509	1419	1419	1434	1449
Cost effectiveness (TZS/Kg of fish)	$3727.2±215.9^{d}$	$3150.2±7.6^{b}$	$2979.8±348.7^{ba}$	$2659.8±104.7^{a}$	$3521.1±280.4^{c}$

Means with different superscript letters within a row are significantly (P<0.05) different.

Conclusion

- Conclusion
  - Cattle manure produced earthworm with highest protein content (48.6%)
  - EWM inclusion level of 40g/100g in practical Nile tilapia diet results in better growth, feed utilization and cost effectiveness
- Further studies
  - Explore effect of different culture conditions on nutrient content of the EWM
  - On-farm validation trials

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Growth, yields and economic benefit of Nile tilapia (*Oreochromis niloticus*) fed diets formulated from local ingredients in cages

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Small-scale aquaculture in Africa is limited by cost of protein ingredient in fish feeds. We evaluated the suitability of replacing fishmeal with rice bran alone or rice bran in combination with atyid shrimp (*Caridina nilotica*) on growth performance and economic benefits of Nile tilapia (*Oreochromis niloticus*) culture in cages suspended over earthen ponds. The best growth and feed conversion occurred in fish fed fishmeal followed by a combination of rice bran and *C. nilotica*, while rice bran alone resulted in poorest fish growth. The best economic benefit was from fish fed a combination of rice bran and *C. nilotica*. By formulating diets using rice brain and *C. nilotica*, the cost of fish production reduced by 80%. It is thus possible to replace expensive fishmeal in the diet of *O. niloticus* using combination of cheaper rice bran and *C. nilotica* without compromising economic benefits for the small-scale fish farmer.

Keywords: Low cost formulation, fish feed, Caridina nilotica, rice bran, small scale aquaculture, cages

Growth, Yields and Economic Benefit of Nile tilapia (*Oreochromis niloticus*) in Cages and fed Diets Formulated from Local Ingredients

Charles C. Ngugi, Hillary Egna, Elijah O. Okoth and Julius O. Manyala

WAS Conference
June 26 – 30, 2017, Cape Town, South Africa

Introduction

- **Small-scale Aquaculture in Africa is limited by cost of protein ingredients in fish feeds.**
- **For sustainable aquaculture in the region, suitable replacement of low cost feeds that does not compromise fish growth is required**
- **Farmers at the semi-intensive levels rely on expensive, imported fish feed**
- **Appropriate to evaluate alternative cheaper protein sources.**
- **Use of on-farm resources such as agricultural by products for increased tilapia production is a low-cost means of developing rural aquaculture in Africa**

Low cost feed alternatives

- **Fishmeal and other animal protein ingredients are expensive.**
- **Protein ingredients make up 60-70% of feed costs.**
- **Finding cheaper alternatives will help formulate less expensive feeds.**
- **Fish farmers can learn and adopt the required technology to formulate such feeds and operate at lower costs."**

Previous work done

- Various agricultural products have been utilized to replace fishmeal based protein (Fontaínhas-Fernandes *et al*., 1999; Hossain *et al*., 1992; Gomes *et al*., 1995; Burel *et al*., 2000; Allan and Booth, 2004)
- Liti *et al*., 2006, and Mugo-Bundi et al 2015 used atyid shrimp (*Caridina nilotica)* as feed for Nile tilapia (*Oreochromis niloticus*) with success
- Rasowo *et al*., 2008 and Chepkirui-Boit *et al*., 2011 used it on Larval stages of the African catfish (*Clarias gariepinus*).

Why RB and *Caridina nilotica*

- **Rice bran is being used in livestock although little is known about the role of rice bran as fishmeal replacement in the diets of fish**

- *Caridina nilotica* **(Roux) also known as atyid shrimp is a by-catch, is underutilized and can be profitably exploited as a source of protein in the aquaculture industry**

- **Since 1986, the abundance of** *C. nilotica* **in the waters of Lake Victoria has increased tremendously, (Cowx *et al*., 2003).**

Our objectives were to:

- **Investigated the suitability of replacing fish meal with low-cost feeds either rice bran alone or rice bran in combination with atyid shrimp (***Caridina nilotica***)**

- **Test its on growth performance, nutrient utilization and economic benefits in Nile tilapia (***Oreochromis niloticus***).**

Aimed at getting farmers to grow fish at low cost

Stocking fingerlings in cages

- **Tilapia fry hatched in round plastic tanks (12M^3) and and received feeds laced with MT so as to sex reverse them**
- **All male fingerlings (mean weight 24.0 ± 2.0 g) stocked randomly in cages (Feb to Aug 2016)**
- **Floating cages (3 m$^{3)}$ stocked with 300 Tilapia fingerlings**
- **Water quality stayed within acceptable range.**

Feeds - Experimental Diets Offered

- **Experimental diets had Rice Bran (D1), Rice Bran and** *Caridina nilotica* **(D2) and Fishmeal as control diet (D0) at 45% CP.**
- **Fish were fed on Aller Aqua Starter feeds (0.2mm to 0.5mm) complete diet for the first 2 months before transfer to cages.**
- **Later hand fed at 2.5% of their body weight twice a day (0900 h and 1700 h) and weighed, every month.**

- Male and Females brooders were seined from Mwea Fish farm Ponds
- Kept separately in tanks for 10 days
- Released in liner ponds to provide fry
- Fry collected were kept in round tanks and offered MT laced feed

Table 1: Ingredients, formulation and proximate composition ($g\ kg^{-1}$) of experimental diets

Ingredients	Ingredients composition		
	DO	D1	D2
Sardines Fish Meal	**640.0**	**0.0**	**0.0**
Caridina Nilotica	**0.00**	**0.0**	**475.0**
Rice Bran	**120.0**	**760.0**	**285.0**
Wheat Bran	**0.0**	**0.0**	**0.0**
Perch Oil	**40.0**	**40.0**	**40.0**
Binder (Cassava)	**40.0**	**40.0**	**40.0**
Vitamin Premix	**30.0**	**30.0**	**30.0**
Mineral Premix	**30.0**	**30.0**	**30.0**
Cellulose	**80.0**	**80.0**	**80.0**
Salt (NaCl)	**20.0**	**20.0**	**20.0**

Table 2: Analyzed Chemical Composition and Essential Amino Acids

Chemical Analyses Ingredients	Ingredients Composition		
	D0 (FM Diet)	D1 (Rice Bran)	D2 (Formulated Diet)
Dry Matter	92.3	92.5	92.1
Crude Protein	45.0	9.1	27.0
Crude lipid	9.4	2.8	2.8
Ash	6.2	6.2	6.1
Crude fibre	5.8	5.7	5.9
NFE	28.4	71.0	58.6
Gross Energy	1857.0	1478.6	1548.7
Amino Acids um/mg			
Arginine	2.30	1.74	1.44
Isoleucine	3.35	1.30	1.51
Lysine	3.51	1.19	2.49
Leucine	2.15	1.25	1.74
Methionine	3.45	1.31	1.96
Phenylalanine	4.03	1.91	3.32

Growth Performance

- Growth trend curves in the present study differentiated at different sizes in O. niloticus during the growth trial periods suggesting that the different test diets had differential critical standing crops (the point at which growth declines)

- Diets containing rice bran become less efficient in sustaining growth of *O. niloticus* compared to fish meal and diets containing both *C. nilotica* and rice brain.

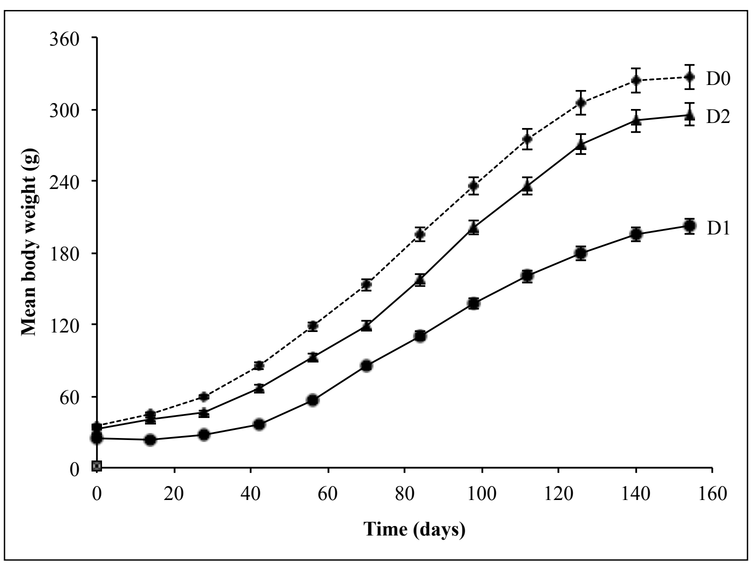

Fig. 1: Mean body weight of *O. niloticus* fed on the three test diets for160 days

Growth Performance

- **There was a significant difference in the final body weight between the experimental groups ($F = 6.734$, $df = 2$, $P = 0.0007$).**
- **Rice bran and *C. nilotica* (D1) in the diet of *O. niloticus* had better growth performance but lower than those fed fish meal diet (D0) and higher than those fed rice bran (D2), However D1 had best economic returns.**
- **The possible reason for the poor performance associated with the use of rice bran than the fishmeal-based control diet is the imbalance of nutrients, particularly protein composition.**

Table 3: Growth Performance of *O. niloticus* on the different test diets during the study

Parameters	D0 (FM)	D1 (RB)	D2 (FM)
Stocking Weight (g)	24.4± 0.3	24.7± 0.2	23.8± 0.5
Harvest weight (g)	327.4 ±31.3	210 ±14.5	291 ±23.5
Mean Weight gain (g)	303.4± 21.4	185.3 ±11.3	267.2 ±16.9
Weight gain (%)	1241.80	750.20	1122.69
SGR (%/day)	1.73± 0.43	1.43 ±0.22	1.67 ±0.31
Survival (%)	86.2	46.0	76.5
Daily feed intake (g/day)	9.38	6.34	8.64
FCR	1.06± 0.21	2.99 ±0.44	1.27 ±0.23

Low cost Diet and Profitability

- In this study, the total investment, operational costs as well as profitability were affected by dietary treatments.
- Highest total fish yield and gross revenue was achieved in control diet accounted for by higher growth performance and better fish weight consuming the fish meal formulated diet.

Table 4: Partial Enterprise Budget (US $)

Parameters	D0 (FM)	D1 (RB)	D2 (FD)
Final Fish Weight	327	210	291
Survival (%)	86.2	46.0	76.5
Yield (kg)	8,950	3,478	7,250
Unit Cost/kg	3.00	3.00	3.00
Gross Receipts	26,850	10,433	21,750
Total Variable Cost (TVC)	19,007	8,762	9,555
Total Cost (TC)	21,127	10,882	11,675
Net Returns Above TVC	7,843	1,670	12,195
Net Returns Above TC	5723	450	10075
Break Even Price	0.81	3.81	0.52

Conclusion

- The best economic benefits occurred when feeding fish with diets formulated using rice brain and *C. nilotica* (D2).
- It is economically feasible to culture *O. niloticus* based on diets formulated using rice bran and *C. nilotica*

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What next ?

- We are evaluating more protein components from the amaranth leaf, its concentrates and hydrolysates, as well as other animal-based ingredients.
- More alternative feed ingredients will enable farmers formulate their own feed at a lower cost.

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Thank you !

The effect of commercial and experiment diets on growth performance of *Oreochromis niloticus* L. fingerlings reared in hapas in Uasin Gishu County, Kenya

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Commercial diets are produced in bulk with significant amounts of anti-nutritional factors and toxic components increasing aquaculture production cost. Information about proximate composition of local feed ingredient is usually limited and unreliable. Unbalanced dietary amino acid contents increases de-amination and ammonia levels in water. This study intended to formulate on farm diets using locally available ingredients and balancing the Essential Amino Acids (EAAs) to enhance the physical quality and nutritive value for culture of *Oreochromis niloticus*. Four diets comprising methionine+lysine and lysine supplemented at 5.1 g kg^{-1}, 2.7 g kg^{-1} to non-EEAs supplemented and commercial tilapia diets at the University of Eldoret Fish Farm were tested. The diets consisted of 48% wheat bran, 30% freshwater shrimp, 18% cotton seed meal, 2% fish oil and 1% vitamin/mineral premix formulated at 30% crude protein before EAAs supplementation. The growth performance was conducted in hapas suspended in three earthen ponds (150 m^2) each in a randomized design for 105 days. There were significant variations in temperature and pH, but still within suitable range for tilapia at 18-20°C and pH of 7.2 to 7.0. Dissolved oxygen over the period were at (4.8 to 6.2 mg L^{-1}). The diets were estimated to provide about 17.17 MJ kg^{-1} with about 22.9% digestible CP level, 8.03% ash and 90.7% dry matter. Diet 2 with lysine supplement exhibited better growth than other diets with a Phi prime (∅') of 3.441, Body Weight Gain of 289.8, Specific Growth Rate of 2.4, Food Conversion Ratio of 1.24 and Protein Efficiency Ratio of 2.68. These results show a high potential for on-farm fish feed formulation benefiting over 1000 fish farmers in formulating nutritionally balanced diets to improve growth and production of tilapia in Western Kenya. The protocol will be adopted to provide quality fingerlings at the at the University of Eldoret hatchery for fish farmers in Uasin Gishu County.

THE EFFECT OF COMMERCIAL AND EXPERIMENTAL DIETS ON GROWTH PERFOMANCE OF *Oreochromis niloticus* L. FINGERLINGS REARED IN HAPAS SUSPENDED IN EARTHEN POND

By:

Elizabeth Obado, Julius O. Manyala and Phillip O. Raburu*

WAS Conference
June 26 - 30, 2017, Cape Town, South Africa

INTRODUCTION - 1

- **Aquaculture is challenged in improving economic and environmental sustainability.**
- **High cost of feeds over 50% with expensive animal protein sources**
- **Commercial feeds; anti-nutritional factors and toxic components with lower protein levels (17–25 %)**
- **Commercial manufacturers produce bulk feeds leaving small fish farmers with the option of buying large quantities of expensive feeds(Pandey, 2013)**

INTRODUCTION - 2

- **Improvement in feed formulation and expansion of nutrient requirement data (NRC, 2011)**
- **proximate composition of locally available fish feed ingredient is limited and not reliable.**
- **Amino acid deficiency in fish feeds may cause poor growth and feed conversion.**
- **Lysine and methionine are the first limiting nutrients in several plant protein sources.**

OBJECTIVES

Overall Objective:

To study the effect of experimental and commercial diets on growth performance of monosex male *Oreochromis niloticus* L. Fingerlings

Specific Objectives:

I. **To compare commercial and experimental diets on growth performance of monosex male *O. niloticus***
II. **To study proximate composition of experimental and commercial diets fed to *O. niloticus***
III. **To study the Amino acid composition of *O. niloticus* fed on experimental and commercial diets**

JUSTIFICATION

- **Modern and environmentally-sound formulation techniques are based on nutrient value, on supplementation with crystalline EAAs and on animal nutrient requirements.**
- **Cost-effective feeds requires access to cheap and locally available ingredients, and palatability of the feed.**
- **Lysine and methionine are essential amino acids that cannot be synthesized in the body but obtained from the diet; improving fish appetite and weight gain (Barrows and Hardy, 2001).**

MATERIAL AND METHODS

Study area:

- **The study was conducted at University of Eldoret fish farm (Longitude 35^{o} 18E Latitude O^{0}30 N) for 105 days from in twelve hapas of capacity 1m^3 suspended in an earthen pond of 150 m^2.**
- **Monosex male *O. niloticus* fingerlings were obtained from Sagana Aquaculture Research and Development Centre.**
- **The fingerlings were acclimatized for two weeks prior the experimental stocking**

Study design:

- A randomized design
- Stocking density of twenty fingerlings per hapa.
- Four diets were tested for the experiment in triplicate for each treatment.
- Diet4: commercial diet 32%CP
- Pond fertilization; DAP at $2 g/m^2$/week, urea at $3 g/m^2$/week.

Plate1: Hapa nets suspended in the experimental pond

Table 1: Feed Ingredients of experimental diets of *O. niloticus* fingerlings.

Ingredient	Diet 1	Diet 2	Diet 3
Wheat bran	48.0	48.0	48.0
C. nilotica	30.0	30.0	30.0
Cotton seed meal	18.0	18.0	18.0
Fish oil	2.0	2.0	2.0
Trace mineral	1.0	1.0	1.0
Lysine supplement (%)	1.96% + 5.1 g kg^{-1}	1.96% + 5.1 g kg^{-1}	None
Methionine supplement (%)	0.95% + 2.7 g kg^{-1}	None	None

PREPARATION OF EXPERIMENTAL DIET

PROXIMATE ANALYSIS OF DIET AND CARCASS OF *Oreochromis niloticus*

- AOAC (1990) procedures followed;
- Dry matter, by drying in an oven at 105 °C for 8 hours;
- Crude fat, by Soxhlet extraction with petroleum ether;
- Crude ash, by incineration in a muffle furnace at 580 °C for 8 hour;
- Crude protein (N× 6 .25), by the Kjeldahl method after acid digestion.
- Feeds were offered daily in hapas at 10:00 am and 4:00 pm. with initial feeding offered at 10% , to 5% and to 3% adjusted body weight, respectively.

DATA ANALYSIS

$$Body \quad Weight \quad Gain \quad (BWG) = \frac{[(Final\ weight\ (g) - Initial\ weight\ (g)]}{Initial\ weight\ (g)}$$

$$Daily \quad Weight \quad Gain \quad (DWG) = \frac{Final\ weight\ (g) - Initial\ weight\ (g)}{Time\ interval\ in\ days\ (t)}$$

$$Specific \quad Growth \quad Rate \quad (SGR) = \frac{[Ln(Final\ weight\ (g)) - Ln(Initial\ weight\ (g))] \times 100}{Time\ interval\ in\ days\ (t)}$$

$$Food \quad Conversion \quad Ratio \quad (FCR) = \frac{Weight\ of\ dry\ feed\ (g)}{[Final\ weight\ (g)] - [Initial\ weight\ (g)]}$$

$$Protein \quad Efficiency \quad Ratio \quad (PER) = \frac{Final\ weight\ (g) - Initial\ weight\ (g)}{Protein\ consumed\ (g)}$$

ECONOMIC ANALYSIS

- A simple economic analysis was used to assess the cost effectiveness of diets used in the feed trial. (Winfeed Ver. 2.8 software)
- The cost of feed were calculated using market prices as follows;
- Incidence cost= $\frac{Cost\ of\ feed (Ksh)}{Weight\ of\ fish\ produced (g)}$
- Profit Index= $\frac{Weight\ of\ fish\ produced}{Cost\ of\ feeds}$

COMPARISON OF GROWTH PERFORMANCE

- **The growth performance index (∅') was computed according to the relationship:**

  $\varnothing' = Log_{10}(K) + 2 \bullet Log_{10}(L)$ (Pauly, 1984)

- **L and K are parameters of Von Bertallanfy growth equation**
- **Statistical analysis**
- **The water quality and growth parameters were compared using one way Analysis of Variance (ANOVA).**
- **Duncan's multiple-range test was applied to quantify the differences between treatments**
- **Simple and Multilinear regression will be used.**

Table 1: Proximate composition of the Experimental and commercial Diet

Composition(g/kg)	Diets			
	Diet1	Diet 2	Diet 3	Diet 4
Dry Matter	90.6	90.6	90.5	90.3
Moisture content	0.38	0.48	0.415	0.47
Crude Protein	**32. 5**	**32.3**	**30.3**	**28.9**
Crude Lipid	0.054	0.052	0.05	0.036
Ash Content	7.13	6.7	7.07	8.02

Table 4: Performance indicators of test diets on monosex *O. niloticus* in hapas for 105 days

	Diet 1	Diet 2	Diet 3	Diet 4
Initial average weight (g)	1.22±0.1	1.24±0.1	1.27±0.1	1.25±0.1
Final average weight (g)	196.00±0.04[a]	201.81±0.01[b]	182.19±0.03[c]	174.66±0.02[d]
Weight of dry feed (g)	250.00	250.00	250.00	250.00
BWG	271.22±0.02[a]	289.79±0.01[b]	245.53±0.01[c]	253.60±0.01[d]
DWG	0.265±0.05[a]	0.274±0.03[b]	0.247±0.05[c]	0.237±0.04[d]
SGR	2.34±0.01[a]	2.40±0.02[b]	2.25±0.01[c]	2.28±0.01[c]
FCR	1.28	1.24	1.38	1.44
PER	2.60	2.68	2.42	2.32
Condition factor (K)	3.25	3.13	3.63	4.26

Table 2. Carcass Composition of *O. niloticus* Fed On Different Diets

Composition (g/kg)	Diets			
	Diet1	Diet 2	Diet 3	Diet4
Moisture content	7.77±0.12[a]	7.64±0.19[b]	7.67±0.14[b]	7.536±0.16[c]
Crude Protein	64.1±0.20[a]	64.4±0.18[a]	63.0±0.23[b]	58.9±0.19[c]
Crude Lipid	0.076±0.01[a]	0.074±0.03[a]	0.08±0.05[b]	0.082±0.07[b]
Ash Content	7.55±0.02[a]	7.52±0.03[a]	7.51±0.01[a]	8.058±0.02[b]

Table 3: Economic Analysis of Commercial and Experimental Diets

Diets	Cost/Kg feed (Ksh)	Harvested Biomass	Incidence Cost	Profit Index
Diet1	52.75	196.00±0.04[a]	0.261	3.715
Diet2	52.75	201.8±0.01[b]	0.269	3.825
Diet3	52.75	182.19±0.03[c]	0.289	3.453
Diet4	90	174.66±0.02[d]	0.515	1.9406

CONCLUSION AND RECOMMENDATION

- **Formulation of cheap and locally available feed ingredients supplemented with (EAAs) promotes efficient growth and health of cultured fish at low costs.**
- **Amino acids profile is key guide in selection and use of feedstuffs in the production of processed tilapia feeds.**
- **Balancing dietary amino acids in plant protein sources in fish feeds can improve feed utilization while maintaining rapid growth.**
- **The supply of amino acids from natural food may be an economically attractive strategy of supplementing limiting amino acids in tilapia diets.**
- **To study the amino acid profile in the fish muscle using High performance liquid Chromatography (HPLC)**

Funding for this research was provided by the

AQUAFISH INNOVATION LAB

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Growth and survival of Nile tilapia under nursery conditions

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One of the major challenges facing the rapidly developing aquaculture industry in Ghana is the lack of well-established nurseries that serve as intermediaries between the hatcheries and the grow-out fish farmers. Nurseries are a vital link in the aquaculture value chain that needs to be well developed in order to strengthen the industry and are also needed for expanded production. This study was done to evaluate the survival, feed conversion, and growth of Nile tilapia raised in ponds on high-protein commercial feeds from fry to fingerling sizes. Nile tilapia were stocked at 1.9g and raised in 1m X 1m hapas in a 900m^2 pond. Two factors each with three replicates were considered using a completely randomized design: 1) stocking density at 25, 50, 75, and 100/m^3, and 2) Time (time-to-harvest) at 10, 20, 30, and 40 d. Fish were fed twice daily to satiation on a 45% protein commercial feed. Harvesting was done at the predetermined times and the following measures were determined: survival, growth, and FCR. Survival was relatively high between 67-92%, and neither the time-to-harvest nor stocking density had a significant effect on fingerling survival. FCR was good and growth was good; with average final weights on day 40 being 20.6g, 19.47g, 20.5g and 21.6g in the treatments with 25/m^2, 50/m^2, 75/m^2 and 100/m^2 respectively. The maximum stocking density does not appear to have been reached as the highest stocking density had the highest final average weight. There is a real potential to develop nurseries in Ghana.

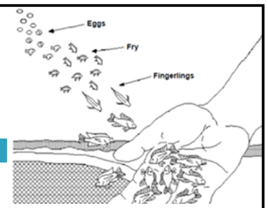
GROWTH AND SURVIVAL OF NILE TILAPIA UNDER NURSERY CONDITIONS

Regina Edziyie, Abigail Tarchie, Kwasi Obirikorang, Daniel Adjei-Boateng, Emmanuel Frimpong

Aquaculture in Ghana

- Aquaculture in Ghana- some growth but nowhere near our production potential
- Attributed to several factors
  - Production systems – have not been optimised
  - Disjointed efforts by researchers, academics etc.
  - Several missing links in the value chain
- Expanded growth = Well developed value chain

Nurseries



- In Ghana, heavy pressure on hatcheries have led to **progressively smaller sized fingerlings/fry** being sold to grow-out farmers
- Currently, there are **no true nurseries in Ghana**
  - Longer grow-out periods for farmers
  - Hinders rapid development of the industry
- There are **no established protocols**
- Nurseries - vital in boosting aquaculture production

What is important?

- **Main determinants:**
  - Quality fish
  - Quality feed
  - Quality water
- **Fish**
  - **Stocking density and size** of tilapia fingerlings - key to good growth performance and high survival rates.
    - ✓ **Bigger** fingerlings = **higher** survival rates = reach market size faster (Arce and Lopez, 1981).

Objective/ hypothesis

- **Objective:** to evaluate the survival, feed conversion, and growth of Nile tilapia fingerlings raised in ponds on high protein commercial feeds.
  - **Hypothesis 1:** Growth rate of fry/fingerling will increase with decreasing stocking density.
  - **Hypothesis 2:** Survival rate of fry/fingerling will increase with decreasing stocking density.
  - **Hypothesis 3:** FCR will decrease with decreasing stocking density.

Methodology

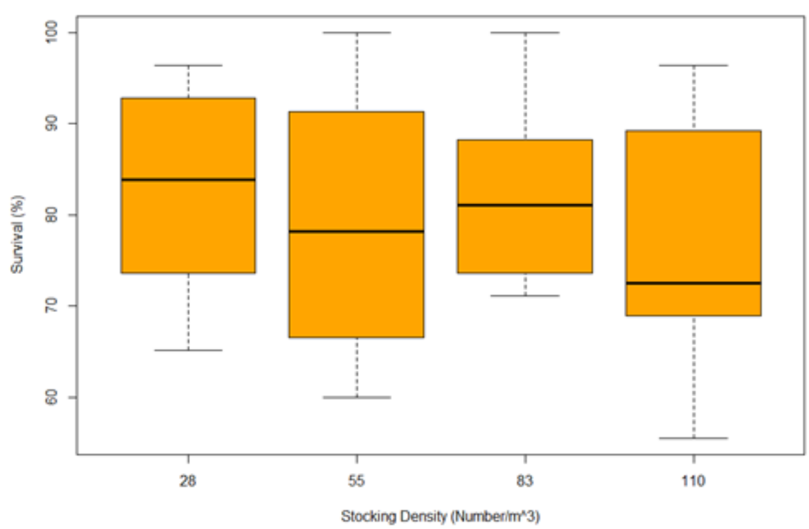
- **Experimental units** - 1m^3 hapas in 900m^2 pond.
- **Treatments:** triplicates; two factors:
  - 1) **Stocking density** at 28, 55, 83, and 110/m^3,
  - 2) **Time** (time-to-harvest) at 10, 20, 30, and 40 d.
- **T. Assignment:** Completely randomised design
- **Variables monitored:** Survival, Growth, FCR

Husbandry

- **Fingerlings:** All male tilapia (Pilot Aquaculture Centre)
- Initial stocking size - 1.9g
- Fish were fed twice daily to satiation on a commercial starter feed (48% protein).
- Harvesting was done at predetermined times

Density	28 fry/m³			
Days till Observed	10 d	20 d	30 d	40 d
	10 d	20 d	30 d	40 d
	10 d	20 d	30 d	40 d

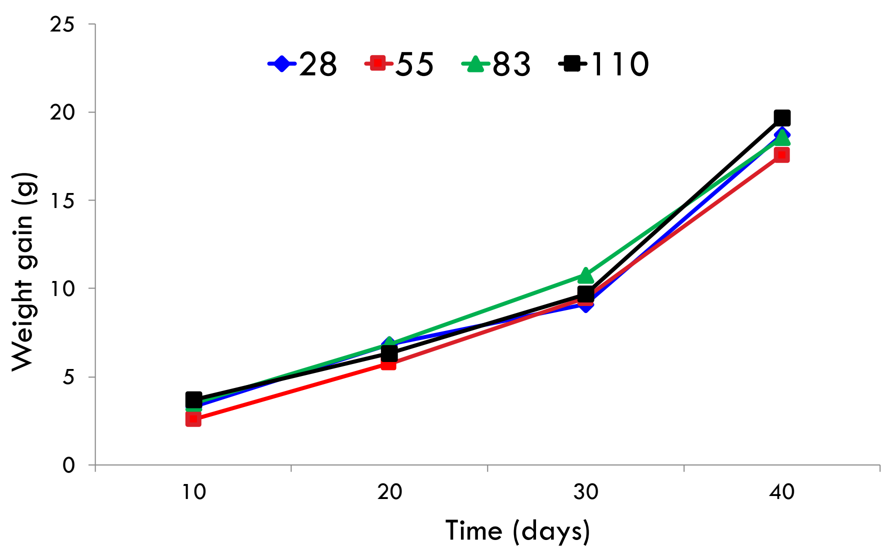
Results/Discussion – Survival



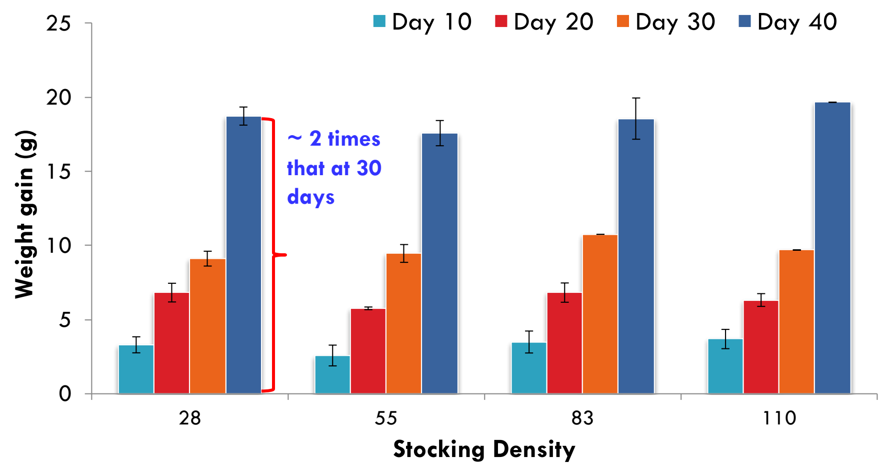
Survival

- Rates were -
  - Dependent on stocking density ($p < 0.001$)
  - Lowest at the highest stocking den. (110/m^3), however, the 83/m^3 >55/m^3; variable
- Other studies have shown a much higher rates
  - Higher rates associated with feeding with live foods (Hassan 2011)

Weight Gain



A relook at the weight gain



Growth

- Stocking den. - **no significant effect** on weight gain*
  - Similar results from Brown and Bolivar (2005)
  - Possibility of increasing stocking density above $110m^{-3}$
- Period - **significant effect** on weight gain (r-0.94)
  - ✓ By day 40 all treatments were ~20g (19.54 – 21.56g)
  - ✓ Perhaps it is possible to achieve even higher daily weight gain after 40 days.......

FCR

Stocking den./ Days	10	20	30	40	Overall
28	0.60	0.60	0.58	0.64	0.61
55	**0.94**	**0.71**	**0.64**	**0.74**	0.76
83	0.63	0.56	0.52	0.69	0.60
110	0.58	0.57	0.52	0.70	0.59

FCR were good! – 0.6 -0.8

FCR

- FCR- consistently low (0.6- 0.8) through the 40 days
  - **Good** -Even though nursery feeds cost 2X that of adults
  - **Suggests**: Good use of feeds and possible increase in stocking density
- Low FCR
  - Good feed (good feeder)
  - The way FCR is calculated
  - Plankton
    - ✓ In Hassan (2011); zooplankton in stomach > 73%
- Others - Phytoplankton > zooplankton

  (Gupta et al 2012, Abdel-Tawwab and El-Marakby, 2004)

- Low FCR - better water quality - good growth

Water Quality

PARAMETERS	MEAN ± SD	RANGE
Temperature (°C)	33.69 ± 0.93	32.38 – 34.63
pH	-	5.12 – 6.95
DO (mg/L)	6.62 ± 1.48	4.43 – 8.34
Conductivity (mg/L)	104.3 ± 23.27	65 – 125
TDS (mg/l)	45 ± 10.22	28 – 55

- Putting the different stocking densities into separate ponds – measure impacts

Conclusions

- Survival:
  - Rates of 62-92%
  - Higher stocking rates had lower survival rates
- Growth:
  - Possible to achieve 20g in 6 weeks at a stocking wt of 2g
  - No difference in the ave. final weights of fish at different stocking densities
- FCR:
  - Was not significantly lower at higher stocking densities

Farmer Engagement - Workshop

❖ What is a fair price for 20g fingerling?

Way forward

- Inclusion of a nursery phase in the tilapia value chain is critical if we want to increase production
  - Need to develop a protocol for nursery producers
  - Provide training for interested farmers (niche)
  - Could be an area more suited for resource poor women- Land, labour, good feeders`
  - Optimize systems and probably use live feeds (cultured)
  - Need to find out the preferred size of fingerlings farmers want

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Development of low cost aquaponics systems in Kenya

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The University of Eldoret activities involved the design and testing of a low-cost aquaponic system that can be used for training, extension and by small-scale fish hobbyists in water deficient situations and urban/semi urban areas where land is scarce. An aquaponics prototype was developed and its efficiency assessed using different fish stocking densities. The system consists of a rectangular fish culture tank raising to 460 mm from the bottom and a plant bed raising to 270 mm from a raised platform, both units being arranged in a vertical tier. Water overflow from the fish unit is passed through a bio-filter made of cut plastic material to increase the surface area. This unit acts as a nitrification chamber before the water is pumped back to the plant unit using a submersible lift pump as shown in the appendices. Water discharge from the plant unit flows back to the fish unit by gravity thereby elimination the need for double pumping. The prototype unit was tested using all male tilapia (*Oreochromis niloticus*) fry for 35 days to the fingerling stage. Results from the trial show that fish stocking density has an effect on the nutrient budget of the system. High nitrate content in the fish unit was associated with high stocking density of 80 Fish/T as compared to 60 Fish/T. The nitrification unit exhibited high efficiency since ammonia was not detected in the plant bed. Quantities of ammonia detected in the fish tanks after 35 days was close to the target values of zero. All-important water quality parameters for aquaponics system such as DO, pH, alkalinity and Temperature were within optimum values, it is concluded that the system is viable and self-regulating in terms of nitrogen cycle. The only limiting factor is the provision of other nutrients required for plant growth by supplemental fertilization. This report provides both design specifications and technical drawings of the aquaponics system developed during this activity. The unit offers good opportunities for rapid commercialization by the private entrepreneurs but there is need to improve on energy requirement through solar technology.

DEVELOPMENT OF LOW COST AQUAPONICS IN KENYA

By:

Ani J. Sabwa, Manyala O. Julius, Fitzsimmons Kevin and Ngugi C. Charles*

WAS Conference

June 26 - 30 2017, Cape Town, South Africa

INTRODUCTION

- **Fisheries and aquaculture: food and income**
- **Systems:**
  - **Stand-alone (less efficient)**
  - **Integrated Systems (crop, agriculture and livestock-efficient)**
- **Innovative production methods (intensive aquaculture)**
- **Aquaponics (fish/plants)**
- **Limited application and few trials**
- **Great potential in water deficient areas**
- **Efficient in water utilization, waste management and climate smart**

PROBLEM STATEMENT

- **Traditional aquaculture systems are often designed to discharge 5-10% of their water daily**
- **Promotion of re-circulating systems reduces the volume of waste discharge to the environment.**
- **This volume is certainly reduced but the pollution load (organic matter and dissolved nutrients) per unit of discharge is correspondingly higher**
- **The hydroponic component helps reducing the need to discharge water to the environment and thereby extending water use.**

OBJECTIVES:

Overall objective:

- **To investigate the growth performance of monosex Nile tilapia (*O. niloticus*) and lettuce (*Lactuca sativa*) in a recirculating aquaponic system.**

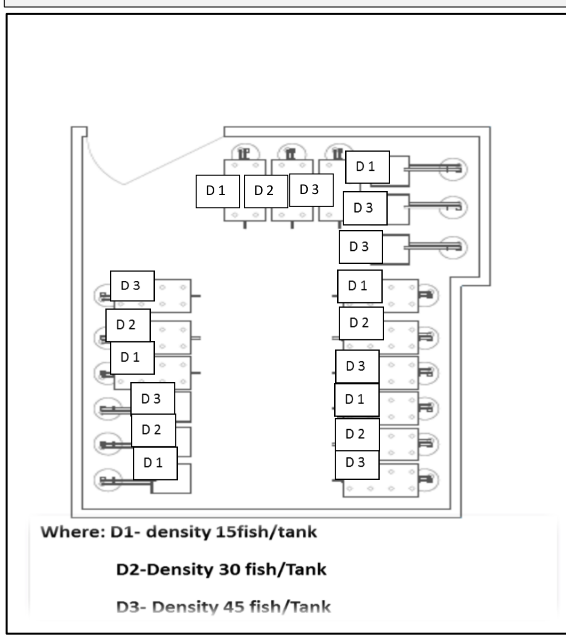
Specific Objectives:

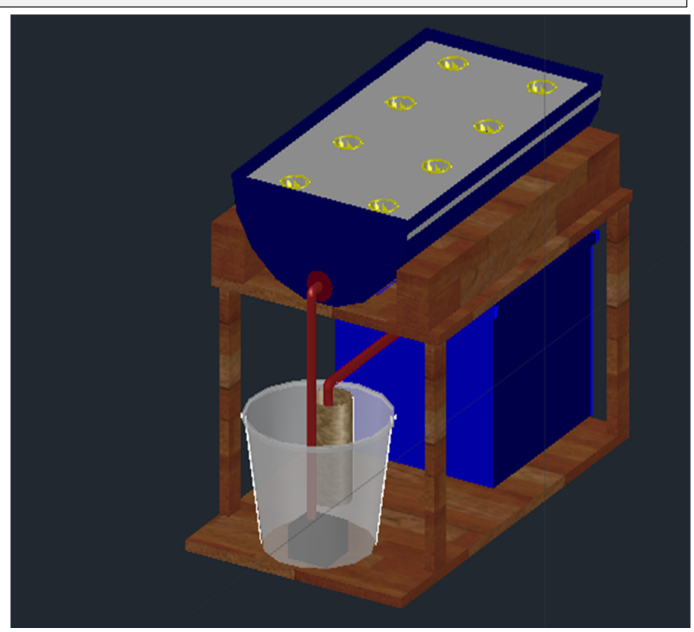
- **Determine optimum production levels of the aquaponics system at different stocking density of *O. niloticus* and lettuce**
- **Determine the efficiency in nutrient and water utilization**
- **Determine nutrient budget**
- **Economic evaluation/performance**

MATERIALS AND METHODS

- **Conducted at the University of Eldoret hatchery**
  - **Used 18 plastic rectangular tanks of 100L each**
  - **Three aquaponic treatments stocked with Monosex Nile tilapia fingerlings at densities of 15 fingerlings tank^{-1}, 30 fish tank^{-1} and 45 fish tank^{-1} for treatments 1, 2 and 3 respectively.**
- **These treatments were replicated six times and each was subjected to a 16 lettuce density m^{-2}.**
- **Water quality -YSI 9500 photometer, YSI 550 DO and temperature Meter and YSI Pro multi-parameter.**
- **Graphs compared growth and tables compared change in water quality parameters**

EXPERIMENTAL SETUP





PICTORIAL PRESENTATION

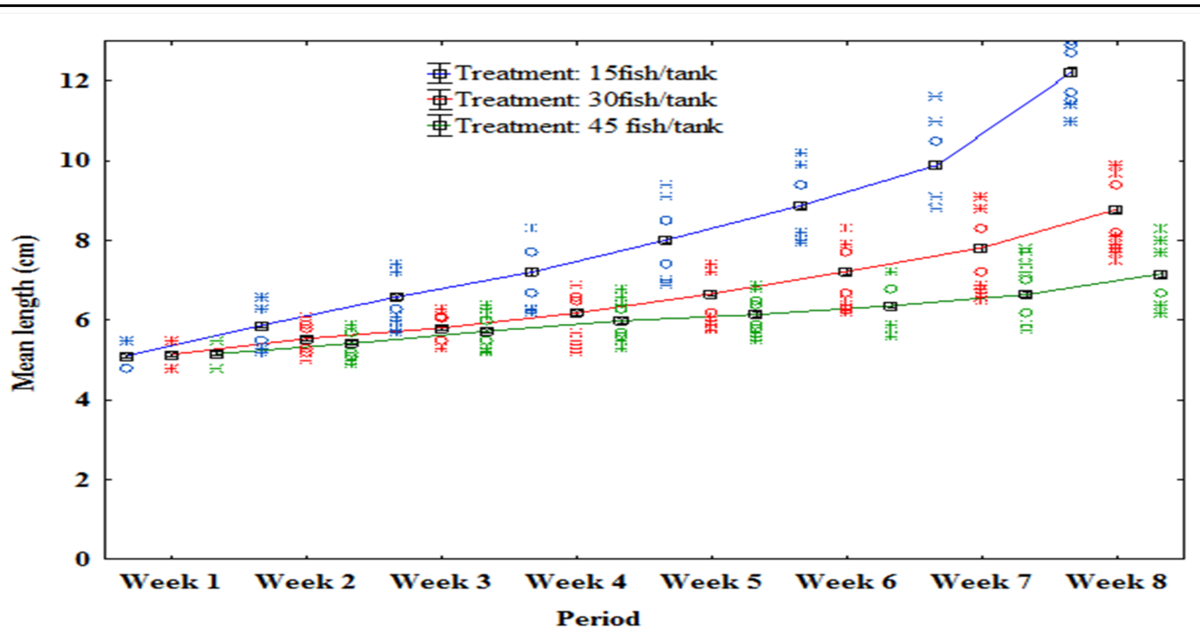


Fig. 1: Weekly mean length (cm) of fish at different stocking densities

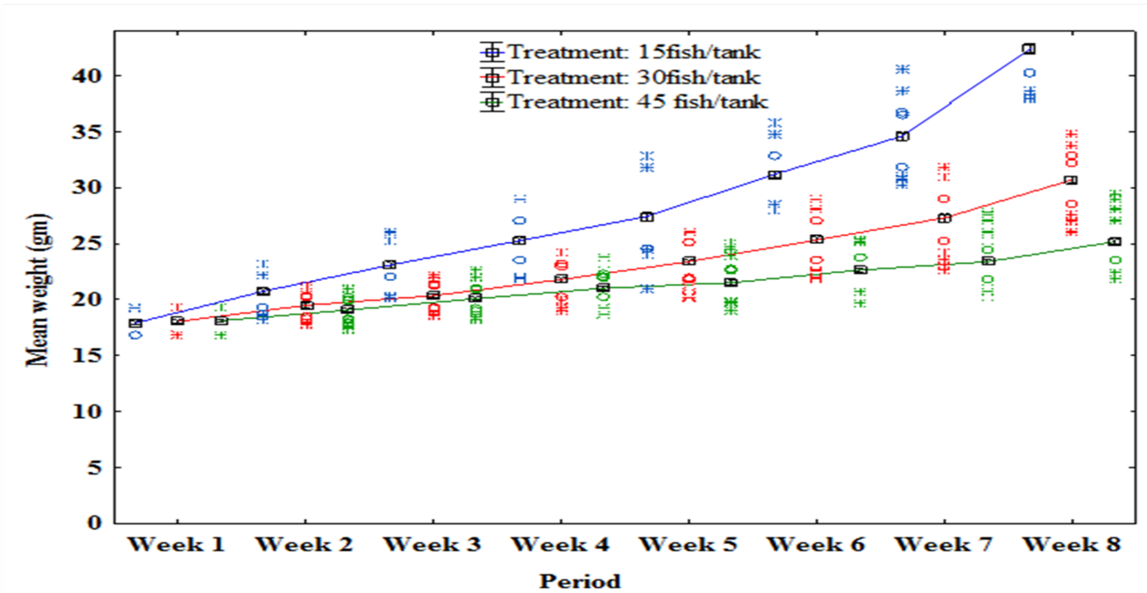


Fig. 2: Weekly mean weight (g) of fish at different stocking densities

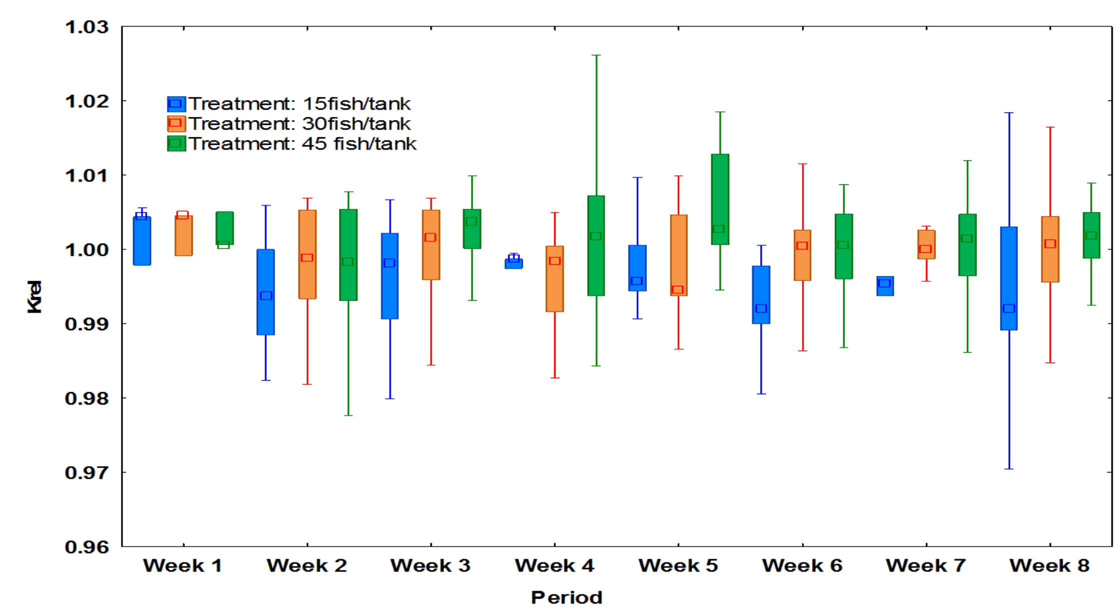


Fig. 3: Condition factor for fish under different stocking density

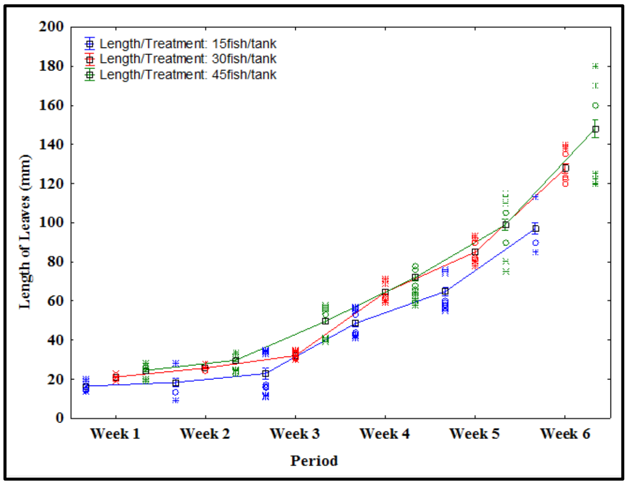


Fig. 4: Weekly change in length of plant leaves (mm)

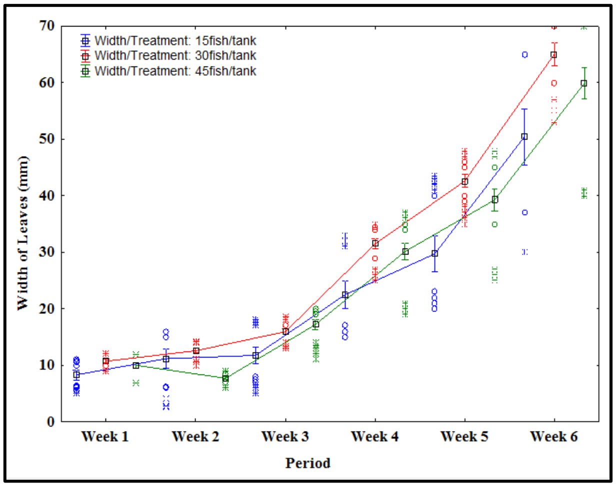


Fig. 5: Weekly change in width of plant leaves (mm)

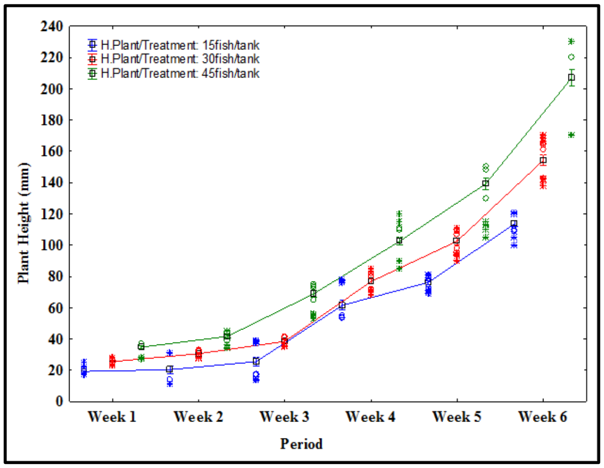


Fig. 6: Weekly change in plant height (mm)

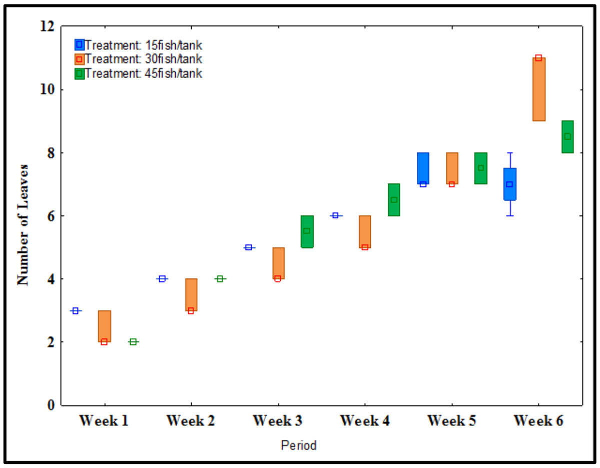


Fig. 7: Weekly increase in the number of leaves

Table 1: Growth performance of *Lactuca sativa* in the three treatments

Growth indicator	T1	T2	T3
Number of plants/m^2	16	16	16
Initial biomass (g)	0.5±0.1	0.5±0.1	0.5±0.1
Mean final biomass (g)	161±9	228±50.3	242±82.9
Growth rate (% g/day)	3.8	5.4	5.76
Mean number of leaves	19±0.52	21±0.88	23±1.25

Table 2: Average water quality parameters during the study-1

		15 fish/tank	30 fish/tank	45 fish/tank
Parameter	Source	Mean ±SE Mean	Mean ±SE Mean	Mean ±SE Mean
Ammonia	FishTank-Out	0.01 ± 0.01^{a}	0.02 ± 0.01^{ab}	0.03 ± 0.01^{b}
	Hydro-In	0.02 ± 0.01^{b}	0.00 ± 0.00^{a}	0.01 ± 0.00^{b}
	Hydro-Out	0.02 ± 0.01^{b}	0.00 ± 0.00^{a}	0.01 ± 0.00^{b}
	FishTank-In	0.02 ± 0.01^{b}	0.00 ± 0.00^{a}	0.03 ± 0.01^{b}
Ammonium mg/NH_4	FishTank-Out	0.01 ± 0.00^{a}	0.02 ± 0.01^{ab}	0.03 ± 0.02^{b}
	Hydro-In	0.01 ± 0.00^{b}	0.00 ± 0.00^{a}	0.02 ± 0.01^{b}
	Hydro-Out	0.01 ± 0.00^{a}	0.00 ± 0.00^{a}	0.02 ± 0.01^{b}
	FishTank-In	0.01 ± 0.00^{b}	0.00 ± 0.00^{a}	0.03 ± 0.02^{b}
Nitrate (mg/l -N)	FishTank-Out	1.26 ± 0.48^{b}	0.80 ± 0.35^{ab}	0.77 ± 0.04^{a}
	Hydro-In	0.89 ± 0.34^{b}	0.00 ± 0.00^{a}	1.12 ± 0.45^{b}
	Hydro-Out	0.89 ± 0.34^{b}	0.00 ± 0.00^{a}	1.56 ± 0.49^{b}
	FishTank-In	1.26 ± 0.48^{b}	0.24 ± 0.15^{a}	0.96 ± 0.23^{b}
Nitrate (mg/l -NO_3)	FishTank-Out	5.55 ± 2.10^{b}	1.11 ± 0.40^{a}	3.38 ± 0.22^{b}
	Hydro-In	3.90 ± 1.47^{b}	0.00 ± 0.00^{a}	2.06 ± 0.73^{b}
	Hydro-Out	3.90 ± 1.47^{b}	0.13 ± 0.09^{a}	2.40 ± 0.76^{b}
	FishTank-In	5.55 ± 2.10^{b}	1.08 ± 0.66^{a}	3.32 ± 0.25^{b}
Nitrite (mg/l -N)	FishTank-Out	0.01 ± 0.00^{a}	0.69 ± 0.52^{c}	0.03 ± 0.01^{b}
	Hydro-In	0.00 ± 0.00^{a}	0.14 ± 0.03^{c}	0.05 ± 0.02^{b}
	Hydro-Out	0.00 ± 0.00^{a}	0.61 ± 0.46^{c}	0.02 ± 0.01^{b}
	FishTank-In	0.01 ± 0.00^{a}	0.16 ± 0.03^{c}	0.05 ± 0.02^{b}
Nitrite (mg/l -NO_2)	FishTank-Out	0.00 ± 0.00^{a}	0.54 ± 0.06^{c}	0.10 ± 0.02^{b}
	Hydro-In	0.00 ± 0.00^{a}	0.47 ± 0.09^{c}	0.16 ± 0.06^{b}
	Hydro-Out	0.00 ± 0.00^{a}	0.49 ± 0.05^{c}	0.09 ± 0.02^{b}
	FishTank-In	0.03 ± 0.01^{a}	0.52 ± 0.10^{c}	0.17 ± 0.07^{b}

Table 2: Average water quality parameters during the study-2

		15 fish/tank	30 fish/tank	45 fish/tank
Parameter	Source	Mean ±SE Mean	Mean ±SE Mean	Mean ±SE Mean
pH	FishTank-Out	7.90±0.07^{b}	7.60±0.00^{a}	7.60±0.00^{a}
	Hydro-In	7.74±0.08^{b}	7.40±0.00^{a}	7.40±0.00^{a}
	Hydro-Out	7.84±0.08^{b}	7.48±0.01^{a}	7.50±0.00^{a}
	FishTank-In	7.90±0.07^{b}	7.60±0.00^{a}	7.60±0.00^{a}
PO_4(mg/l P)	FishTank-Out	0.73±0.04^{b}	1.59±0.27^{c}	0.55±0.03^{a}
	Hydro-In	0.74±0.03^{b}	0.84±0.05^{c}	0.53±0.06^{a}
	Hydro-Out	0.74±0.03^{b}	1.32±0.30^{c}	0.54±0.06^{a}
	FishTank-In	0.73±0.04^{b}	1.23±0.05^{c}	0.56±0.04^{a}
PO_4(mg/l -PO_4)	FishTank-Out	2.25±0.13^{b}	2.84±0.49^{b}	1.18±0.09^{a}
	Hydro-In	2.25±0.09^{b}	2.63±0.15^{c}	1.52±0.20^{a}
	Hydro-Out	2.25±0.09^{b}	2.20±0.38^{a}	1.68±0.20^{a}
	FishTank-In	2.25±0.13^{b}	3.67±0.15^{c}	1.33±0.15^{a}
Potassium (mg/l k)	FishTank-Out	5.23±0.14 ^{b}	5.01±0.44^{b}	2.20±0.16^{a}
	Hydro-In	5.30±0.04 ^{b}	5.17±0.15^{b}	2.30±0.59^{a}
	Hydro-Out	5.33±0.03^{c}	4.61±0.42^{b}	1.70±0.42^{a}
	FishTank-In	5.25±0.13^{b}	5.47±0.02^{c}	2.81±0.68^{a}
Temp (^{0}C)	FishTank-Out	23.68±0.22^{b}	23.14±0.07^{a}	23.95±0.25^{b}
	Hydro-In	24.58±0.55^{b}	23.07±0.08^{a}	24.13±0.26^{b}
	Hydro-Out	24.35±0.49^{b}	23.20±0.07^{a}	24.13±0.26^{b}
	FishTank-In	23.68±0.22^{b}	22.97±0.04^{a}	23.95±0.25^{b}
DO (mg/l)	FishTank-Out	4.35±0.52^{c}	3.36±0.24^{b}	2.21±0.02^{a}
	Hydro-In	4.85±0.40^{b}	3.52±0.27^{a}	3.35±0.03^{a}
	Hydro-Out	4.77±0.44^{b}	3.42±0.16^{a}	3.33±0.03^{a}
	FishTank-In	4.40±0.51^{c}	3.60±0.38^{b}	2.20±0.02^{a}
Hardness	FishTank-Out	163.30±27.40^{b}	133.00±13.0^{b}	120.00±0.00^{a}
	Hydro-In	120.00±0.00^{a}	120.00±0.00^{a}	185.00±24.60^{b}
	Hydro-Out	120.00±0.00^{a}	120.00±0.00^{a}	185.00±24.60^{b}
	FishTank-In	185.00±0.00^{b}	120.00±0.00^{a}	120.00±0.00^{a}

DISCUSSIONS & CONCLUSION

- **Fish grown at density 15 had the highest ($P<0.05$) growth compared to 30 and 45 in terms of both mean weight and length.**
- **This agrees with several works on stocking density which concluded that at lower densities the growth of fish is higher.**
- **Lower fish density aquaponic system had the lowest lettuce growth as compared to 30 and 45 densities.**
- **It was noted that lettuce grown in aquaponic systems that had fish densities of 30 and 45 fish per tank performed very well as compared to 15fish/tank treatment**

CHALLENGES AND SOLUTIONS

- Pests:
  - Cutworms
  - Aphids
  - Whiteflies
  - Rodents
- Power failure
- Possible solutions:
  - Use of nets
  - Use of organic pesticides that are non toxic to fish
  - Use of solar power system
  - Inclusion of deficient nutrients when formulating feeds

Funding for this research was provided by the

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Thanks for listening

Contribution of small-scale aquaculture to rural livelihoods in Tanzania

Sebastian W. Chenyambuga* and Nazael A. Madalla
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Aquaculture is one of the world's fastest growing animal producing sector with an average growth rate of 8.8% outpacing capture fisheries (1.2%) and terrestrial farmed meat production (2.8%). Globally, aquaculture is considered as an important sector for poverty alleviation and rural development. In Tanzania aquaculture is primarily based on subsistence farming of pond cultured Nile tilapia (*Oreochromis niloticus*). In recent years, there has been increased interest on promoting aquaculture as a tool for poverty reduction and combating malnutrition in rural areas. Many non-governmental organizations, church based organizations and research institutes/Universities have been distributing Nile tilapia fingerlings to small-scale farmers in rural areas as an effort to contribute effectively to poverty alleviation and improve food security among the rural poor people. Currently it is estimated that there are 20,235 fish ponds owned by 17,725 small-scale farmers. Most fish farmers in the country prefer to produce Nile tilapia (*Oreochromis niloticus*) and few culture African catfish (*Clarias gariepinus*). The main objective of this study was to determine the contribution of aquaculture enterprise to income and wellbeing of rural households in Tanzania. A household survey was carried out in four districts (Morogoro Rural, Kilosa, Mpwapwa and Mufindi districts) in Tanzania. A total of 60 small-scale fish farmers (15 per district) were randomly selected and individually interviewed. The study found that, on average farmers owned 2.8 ± 0.6 ponds which had a mean (± se) size of 258.5 ± 74.0 m^2. All farmers cultured Nile tilapia and the main reasons for engaging in fish farming were production of fish for home consumption and generation of household income. On average, 23.6% of the fish harvested were consumed by the family while the remaining 76.4% were sold. Most households consumed fish either two to three times in a month (36.7%) or once per month (31.7%). All farmers reported that they consume fish which are harvested from their own ponds and rarely they buy from the village markets. All fish farmers sold fresh fish directly to consumers (75%), fish vendors (35%) and retailers (20%). The mean (± se) annual income from fish farming was TZS 826,357.1 ± 179,764.5, and this contributed 19.3% of the total household income. The income from aquaculture enterprise was used for house construction (45%), to pay school fees (40%), buy consumer goods (25%), buy livestock to increase herd size (15%), pay medical bills (5%), pay costs for crop farming (5%) and buy food during period of food shortage (5%). The study revealed that small-scale aquaculture enterprise contributes significantly to household income and wellbeing of rural farmers.

CONTRIBUTION OF SMALL-SCALE AQUACULTURE TO RURAL LIVELIHOODS IN TANZANIA

Sebastian W. Chenyambuga and
Nazael A. Madalla
Sokoine University of Agriculture, Tanzania


Introduction

- Tanzania is one of the poorest country in the world, in terms of per capita income.
- There has been a general decline in poverty in Tanzania from 38.6% in 1991/92 to 28.2% in 2011/2012, but poverty remains widespread, particularly in rural areas.
- Agriculture provides direct livelihoods to approximately 80% of the total population.

- Thus, improving agricultural production would create the most immediate impact on poverty reduction and livelihood improvement in Tanzania.
- Globally, aquaculture is considered as an important sector for poverty alleviation and rural development.
- Aquaculture is one of the world's fastest growing animal producing sector with an average growth rate of 8.8%, outpacing capture fisheries (1.2%) and terrestrial farmed meat production (2.8%).

- In Tanzania, aquaculture is being promoted as an option for rural development because it provides an important opportunity for reducing poverty and protein malnutrition of the rural poor people.
- Furthermore, aquaculture is emphasized as an alternative to capture fisheries due to decline of wild fish from natural water bodies.
- Most fish farmers in the country prefer to produce Nile tilapia (*Oreochromis niloticus*) and few culture African catfish (*Clarias gariepinus*).

Fig. 1: Number of ponds over the years

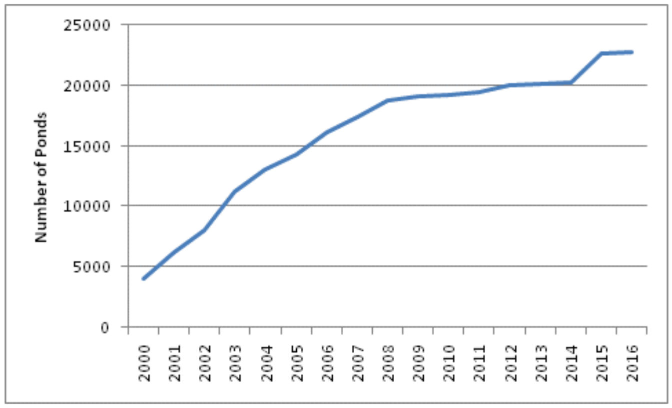


Fig. 2: Number of fish farmers over the years

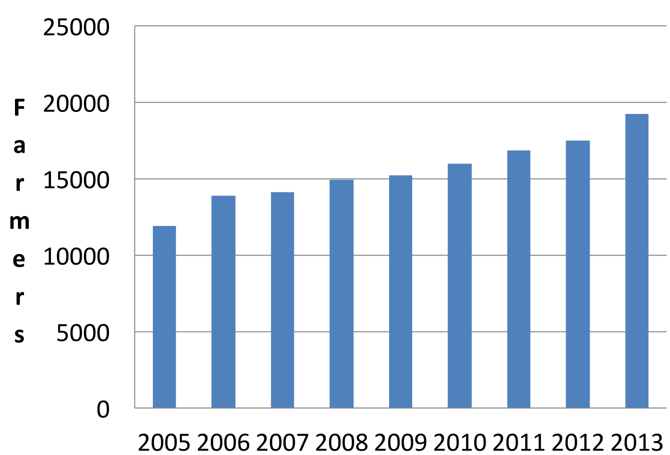


Fig.3: Number of ponds by regions in Tanzania in 2013

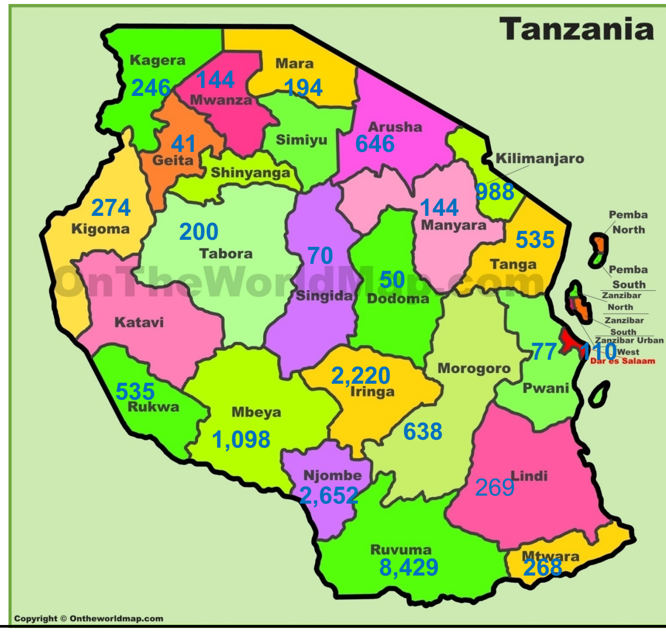


Fig.4: Fish production from aquaculture for 2000 - 2012

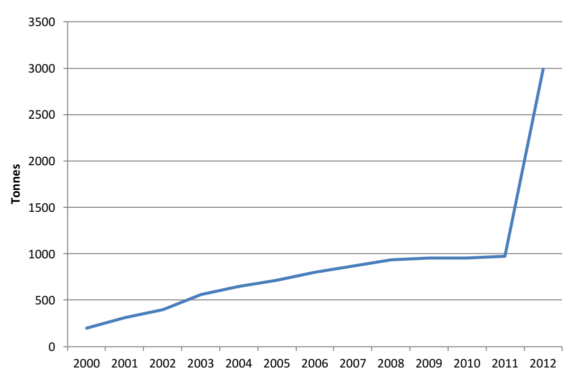


Fig. 5: Contribution of fisheries to GDP between 2005 and 2016

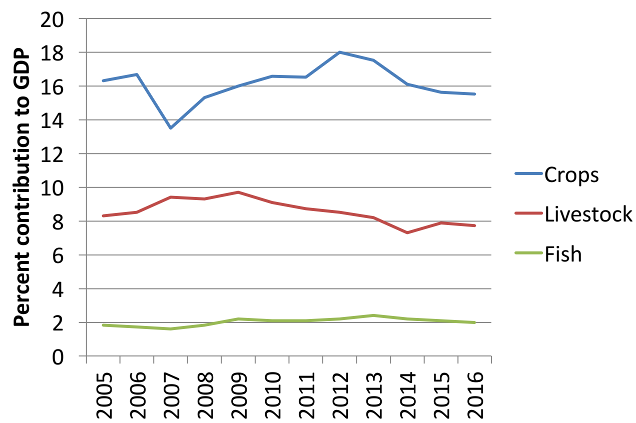
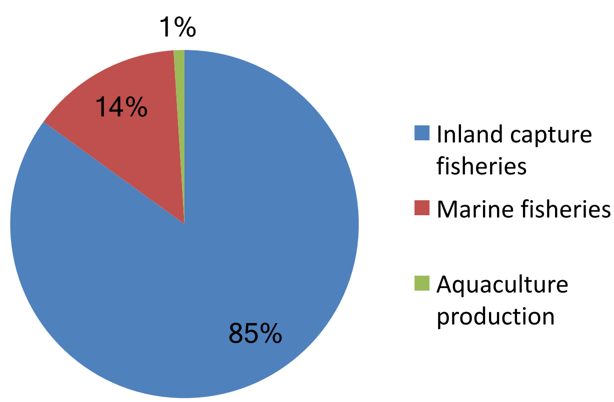


Fig. 6: Contribution of aquaculture to fish production in 2013



- The interest in aquaculture has increased tremendously in recent years.
- We carried out a study to determine the contribution of aquaculture enterprise to income and wellbeing of rural households in Tanzania.

Table 1: Socio-economic characteristics of the farmers

Variable		District				
		Mpwapwa (15)	Kilosa (15)	Mufindi (15)	Mvomero (15)	Overall (60)
Gender	Male	86.7	53.3	100	66.7	75.0
	Female	13.3	46.7	0	33.3	25.0
Age	≤ 30 yrs	0	13.3	0	0	3.3
	> 30 yrs	100	86.7	100	100	96.7
Occupation	Farmer	100	100	53.3	86.7	85
	Business	0	0	46.7	13.3	15
Species cultured	Tilapia	100	86.7	100	100	96.7
	Catfish	0	13.3	0	0	3.3
Experience in fish farming	1 – 10 yrs	80.0	33.3	100	86.7	75.0
	> 10 yrs	20.0	66.7	0	13.3	25.0

Importance of aquaculture

- Produce fish for income generation and home consumption

Table 2: Frequency of fish consumption by households of small-scale farmers

Parameter	Mpwapwa	Kilosa	Mvomero	Mufindi	Overall
Proportion of fish eaten at home (%)	14.14	17.5	26.44	50.0	27.0
Frequency of fish consumption					
3 – 4 times /week (%)	13.3	53.3	0	0	16.7
2 – 3 times/month	40.0	0	26.7	20.0	21.7
Once/month (%)	26.7	0	26.7	20.0	18.3
Source of fish					
Own pond (%)	93.3	100	100	100	98.3
Market (%)	20.0	0	73.3	46.7	35.0
Vendor (%)	6.7	0	26.7	0	8.3

Table 3: Marketing of fish produced from ponds of small-scale farmers

Parameter	Mpwapwa	Kilosa	Mvomero	Mufindi	Overall
Proportion of fish sold	85.9	83.0	73.6	50.0	73.1
Type of fish sold					
Fresh	100	100	100	100	100
Sun dried/smoked/fried	0	0	0	0	0
Selling point					
Pond site (%)	86.7	100	80.0	53.3	80.0
Village market (%)	26.7	0	66.7	46.7	35.0
Market in town (%)	6.7	0	0	0	1.7
Customers					
Neighbours	86.7	100	86.7	53.3	81.0
Vendors	40.0	100	20.0	0	40.0
Retailers	13.3	100	100	26.7	60.0

Fig. 6: Comparison of income obtained from fish farming and other economic activities

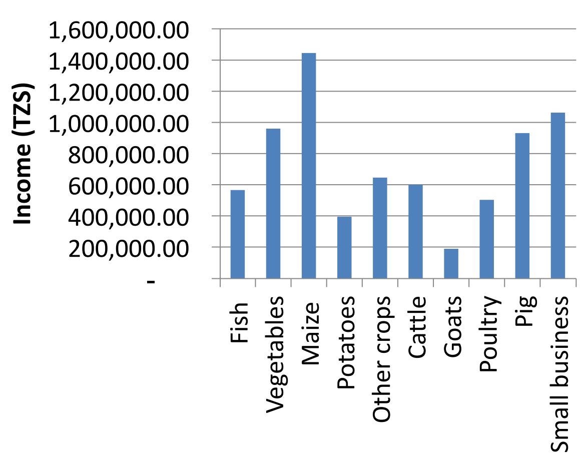
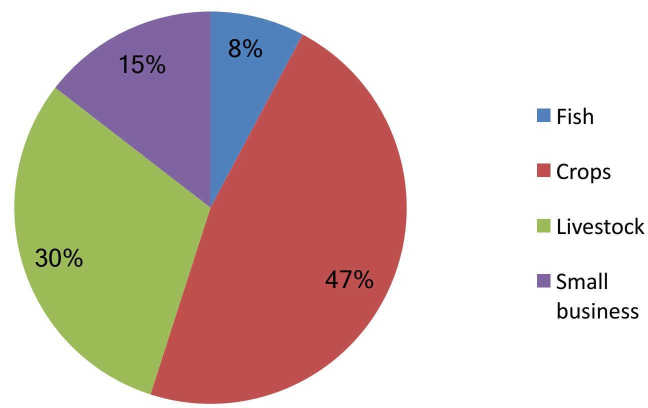


Fig. 7: Proportionate contribution of aquaculture to income of small-scale farmers



Problems faced by small-scale fish farmers

- Unreliable supply of water
- Lack of capital
- Predators
- Unreliable supply of good quality fingerlings
- Lack of good quality feeds
- Theft

Conclusions

- In Tanzania fish production from aquaculture is very low, and its contribution to household income, animal protein consumption and national GDP is low.
- Given the existing potential for expansion, there is a need to increase the efforts for promoting aquaculture in the country.
- There is a need to improve the productivity of the commonly cultured fish species in order to meet the growing demand for animal protein and contribute significantly to poverty reduction and improvement of well-being of the rural poor.

- There is a need to improve the extension services in rural areas and train fish farmers on appropriate management practices so that they can sustainably manage their fish ponds.

Funding for this research was provided by the

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Single nucleotide polymorphisms discover in the transcriptome of marbled lungfish (*Protopterus aethiopicus)* by next generation sequencing: Guiding breeding technology

J. Walakira[*], M. Njeri, M. Agaba, J. Njuguna, J. Amimo, R. Bett and S. O. Opiyo.
National Fisheries Resources Research Institute, Uganda.
Email: johnwalakira2003@gmail.com

The marbled lungfish *(Protopterus aethiopicus)* is a potential aquaculture candidate in the East African region supporting livelihoods of many communities. There is limited genetic information on *P. aethiopicus* to guide its domestication. Therefore, Single Nucleotide Polymorphism (SNPs) molecular markers were developed for future use in selective breeding and genetic diversity programs. Genomic selection based on informative SNP markers would play a major role in the shift to appropriate breeding strategies. Total RNA was extracted from 18 marbled lungfish (3 fish per lake) specimens collected from Lakes Bisina, Edward, George, Kyoga, Nawampasa and Wamala. Through *de novo* assembly a total 6693 SNPs were identified. A total of 198 SNPs with a maximum heterozygosity value of 0.5 and flanking sequences of 140 base pairs of 40-60% Guanine-Cytosine content were selected. These were considered suitable to further guide in the aquaculture and conservation program of *P. aethiopicus*.

SINGLE NUCLEOTIDE POLYMORPHISMS DISCOVERY IN THE TRANSCRIPTOME OF MARBLED LUNGFISH (*Protopterus aethiopicus*) BY NEXT GENERATION SEQUENCING: GUIDING BREEDING TECHNOLOGY

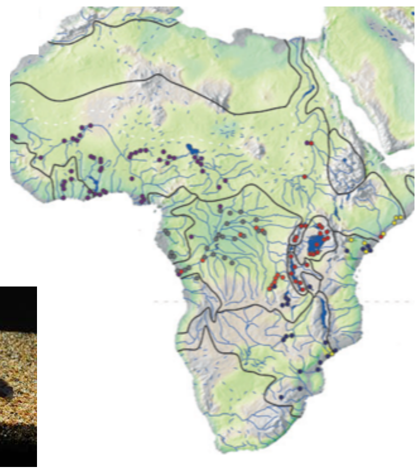
M. Njeri, J. Walakira*, M. Agaba, J. Njuguna, J. Amimo, R. Bett and S. O. Opiyo

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} (Thomson, 1972),

Generating sustainable aquaculture technologies: improve livelihoods & Nutrition security

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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

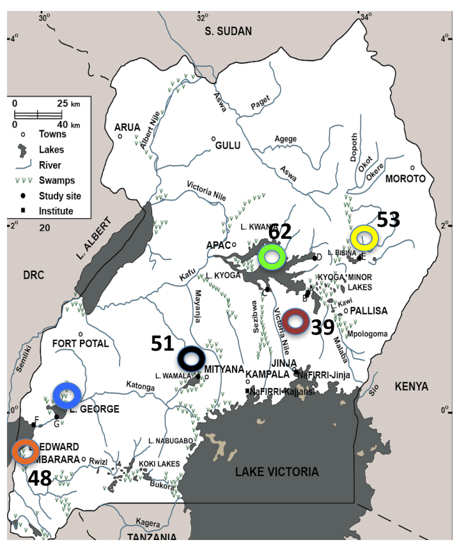
Objectives

Overall objective: Genetic diversity of African lungfish for use in aquaculture in Uganda-East Africa.

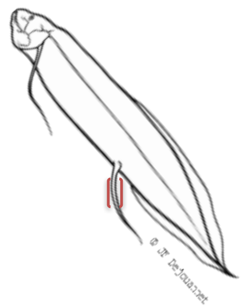
Specific objectives:

Objective 1: Understand the diversity of African lungfish from six lakes in Uganda

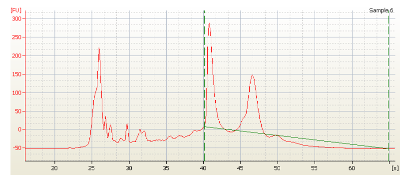
Objective 2: Develop a panel of SNP to guide the domestication of African lungfish

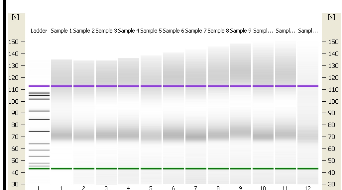


Nucleotide diversity: SNP panel using RNA Seq



Total RNA from 30/60 : Trizol protocol





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

cDNA, MiSeq platform

71,191,331 reads; Paired end 2X 300;
26 – 301 bp

- FastQC to check quality
- Adapter trimming Fastx-toolkit
- Removal of rRNA and PhiX Bowtie
- Trimming of low quality reads solexaQA
- FastQC to check final quality
- Trimmed reads
- Reference Mapping BWA(aln)
- GATK pipeline for SNP calling
- SNP filtration and analysis

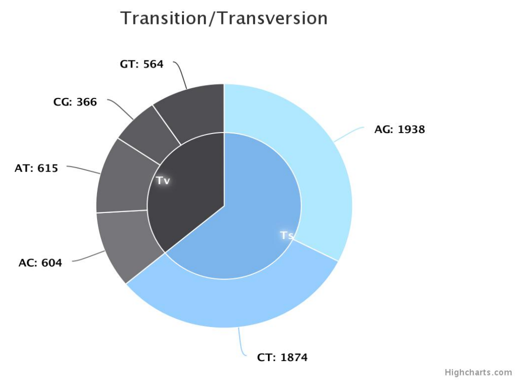
Results

Table I The total number of the quality reads and the *de novo* assembled contigs from the six selected lake sites

Lake	**Quality reads**	**Number of contigs from the *de novo* assembly**
Bisina	14928708	172903
Edward	9594690	127255
George	10693363	124536
Kyoga	10150714	99747
Nawampasa	12390914	106054
Wamala	13432942	123307
Total	71191331	753802

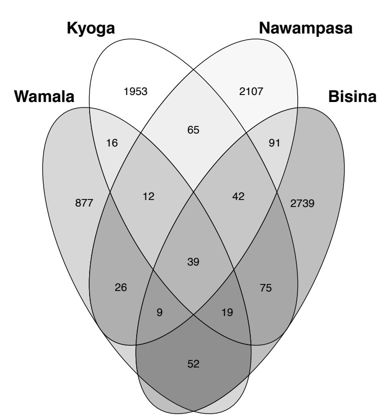
Summary

	Reads
Total number of reads: Raw	80,540,951
Total number of reads: clean	71,191,331
Mapped to Reference	41,075,265
Mapped read Ratio	57.70%
Average GC content after Trimming	43.4%
SNPs genetic markers derived	**5,961**



The SNPs transition: transversion ratio (1.73) indicated a low genetically varied population (n=18), with moderately polymorphic heterozygosity values.

Unique SNPs



An informative panel of **198 SNPs** with maximum heterozygosity and a GC content of 40-60%. = moderately polymorphic

Conclusion

- A total of 198 SNPs with a maximum heterozygosity values is considered highly informative
- Basic information for breeding, conservation, management and genetic diversity

On-going Breeding program

Funding for this research was provided by the

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Comparative growth performance of *Oreochromis niloticus, Clarias gariepinus* and *Cyprinus carpio* at a high-altitude environment

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jbmugo@gmail.com
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ccngugi@gmail.com

The introduction of Economic Stimulus Program (ESP) in Kenya led to increased culture of warm water fish species in high altitude areas. There was an unprecedented increased culture of Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and common carp (*Cyprinus carpio*) in extremely high altitudes areas (> 3000 m asl). However, performance of these species in such altitudes has rarely been elucidated. This study evaluated the growth of the three species in the high-altitude areas near Mt. Kenya region. Fingerlings were stocked at 3.3 fish m^{-2} with an average body weight of 4.9-5.6 g. Feeding were done at the recommended body weight twice a day. Sampling for fish performance and water quality was performed every two months and daily respectively. After 420 days of culture, the final mean weight of *C. gariepinus* was 785.4±8.6g representing a mean weight gain of 780.4±5.4g and SGR of 2.9%. Meanwhile *O. niloticus* final mean weight was 148.1±3.2g, which translated to 143.1±2.8g in terms of weight gain and SGR of 2.2% while *Cyprinus carpio* final mean weight was 328.2±6.8g which translated to 323.2±4.6g in terms of weight gain and SGR of 2.5%. Survival was 68%, 96%, and 95% for *C. gariepinus*, *O. niloticus* and *C. carpio* respectively. Parameters of water quality did not deviate significantly during the culture period and were in ranges for culture of fish. The low temperature in this study (13−18°C) was found still suitable for culturing warm water species at the high altitude. We demonstrate that warm water species can still be cultured in high altitude areas.

Keywords:
Nile tilapia, African catfish, Common carp, fish growth, high altitude areas

COMPARATIVE GROWTH PERFORMANCE OF *Oreochromis niloticus*, *Clarias gariepinus* AND *Cyprinus carpio* AT HIGH ALTITUDE ENVIRONMENT

By

James Bundi Mugo* and Charles Ngugi

WAS Conference

June 27- 30 2017, Cape Town, South Africa

INTRODUCTION - 1

- **Efforts are being put by all stakeholders (Government of Kenya, NGOs, private fish commercial & small scale fish famers, private & public institutions etc.) to enhance aquaculture practice in Kenya.**
- **In 2009, Government of Kenya introduced a government-funded Economic Stimulus Program (ESP).**
- **ESP was aimed at injecting commercial thinking into fish farming to build up a vibrant aquaculture industry (Munguti *et al*., 2014)**
- **Major focus was on *Oreochromis niloticus* and *Clarias gariepinus* (Warm fresh water fish species)**

INTRODUCTION - 2

- This led to increased culture of warm water fish species in all parts of the country irrespective of environmental/climatic condition.
- Meaning that culture of both Nile tilapia and African catfish was done in extremely high altitudes areas (> 3,000 m a.s.l).
- Performance of these species in such altitudes has rarely been assessed.
- Fish ponds dominates the cultures systems but there is no species suitability maps for pond culture of these species

OBJECTIVES

Overall Objective

- This study was carried out to assess the growth of the three species (*Oreochromis niloticus, Clarias gariepinus* and *Cyprinus carpio*) in the high altitude areas in the Mt. Kenya region.

Specific Objectives

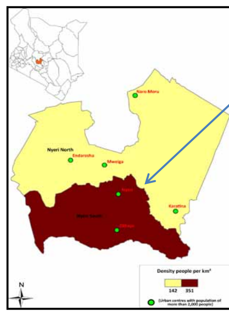
- To determine the growth performance of Nile tilapia (*Oreochromis niloticus*)
- To determine the growth performance of African catfish (*Clarias gariepinus*)
- To determine the growth performance of Common carp (*Cyprinus carpio*)

STUDY AREA – KARATINA UNIVERSITY

Nyeri County

Tea Plantation

Mathira Sub-county



Location:
- Nyeri County,
- Mathira Sub-county
- A tea zone/middle of tea
- Elevation of 3500m
- High altitude areas
- 1° 0' 0" S, 36° 46' 0" E

METHODOLOGY - 1

- **Fingerlings of Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and Common carp (*Cyprinus carpio*) were stocked at 3.3 fish m^{-2} with an average body weight of 4.9 - 5.6 g.**

- **Feeding was done twice a day (10.00 am and 4.00 pm)**

METHODOLOGY - 2

Stocked – an average body weight of 4.9-5.6 g

Fish stocking

7

METHODOLOGY - 3

Fish Sampling for growth performance was performed every two months

The culture was for 420 days (14 months)

8

RESULTS/DISCUSSION

Table 1: Growth performance parameters of Nile tilapia, African catfish and common carp

	Nile Tilapia	African catfish	Common Carp
Initial Mean Weight_g	4.8±0.4	5.4±3.2	5.3±2.2
Final Mean Weight_g	148.1±3.2	785.4±8.6	328.2±6.8
Mean Weight_g	54.1±1.2	248.4±1.4	167.7±1.2
Mean Weight gain_g	143.1±2.8	780.4±5.4	323.2±4.6
Daily weight gain_g	0.3	1.9	0.8
Specific Growth Weight_g	2.2	2.9	2.5
Percent Survival (%)	96.0	68.0	95.0

- **African catfish – Highest final mean (SD) wt (785.4 ± 8.6 g), mean (SD) wt (248.4 ± 1.4 g), mean (SD) wt gain (780.4 ± 5.5 g) and SGR (2.9%) but lowest % survival (68%)**
- **African catfish is more adaptable to low water temperatures than the other two fish species**

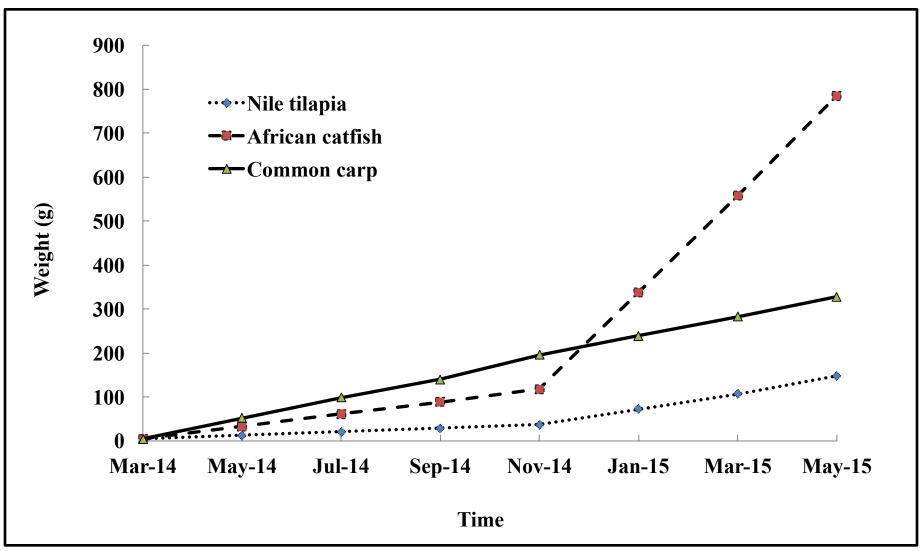


Fig. 1: Growth in weight (g) of Nile tilapia, African catfish and common carp reared at high altitude areas

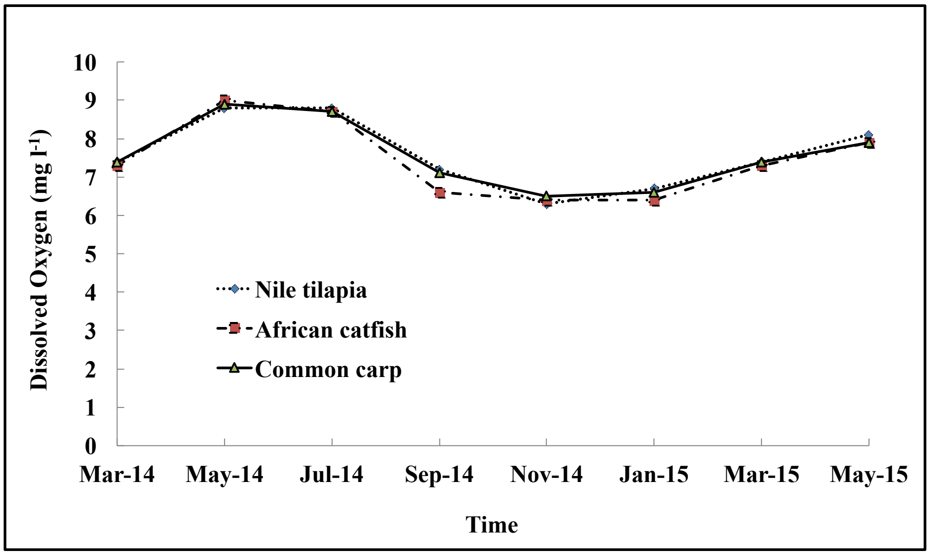


Fig. 2: **Dissolved oxygen (mg l^{-1}) in fish ponds stocked with Nile tilapia, African catfish and common carp at high altitude areas**

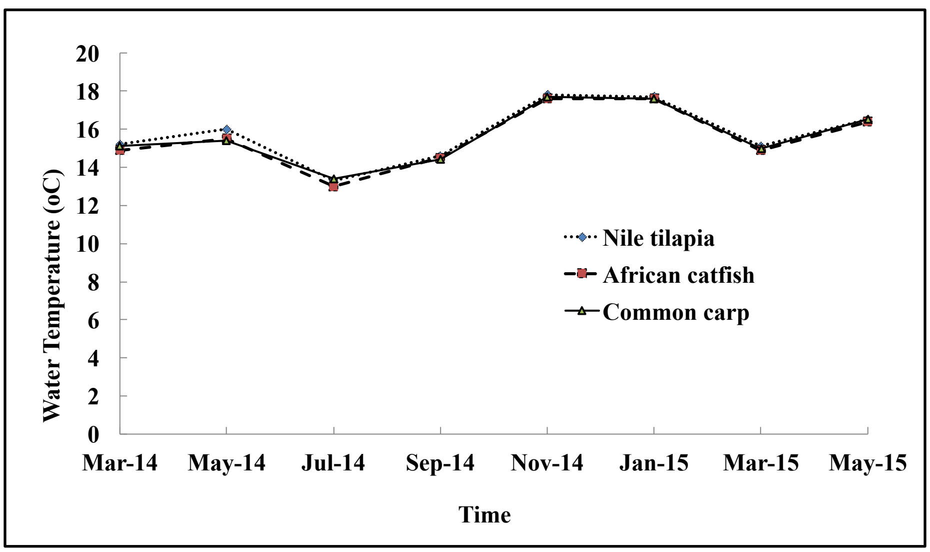


Fig. 3: **Water temperature in fish ponds stocked with Nile tilapia, African catfish and common carp at high altitude areas. Temperature in this study ranged from 13°C to 18°C**

CONCLUSION

- The low temperature in this study (13−17°C) was found to be still suitable for culturing warm water species at the high altitude areas.
- The findings demonstrate that warm water species can still be cultured in high altitude areas
- Out of the three fish species cultured in this high altitude area, African catfish performed more better than all the other fish species

RECOMMENDATION

- On farm trials to be carried out to test the growth performance based on fish farmers environmental natural conditions
- There is need to conduct extensive field trials in different agro-ecological zones in the country
- Develop a national aquaculture fish zonation based on growth performance

ACKNOLEDGMENTS

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Prof. Mucai Muchiri – Karatina University, Kenya

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THANK YOU

Effects of frequency of grading on the growth, intra−cohort cannibalism and economic benefits of African catfish (*Clarias Gariepinus*, Burchell, 1822) culture

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The profitability of *C. gariepinus* still suffers from poor growth performance, low survival and high cases of cannibalism. Attempt that aims at increasing economic benefits must therefore target strategies that decouple link between catfish culture with poor growth survival and cannibalism. This study determined the effects of in−pond grading frequency on the growth performance, cannibalism and economic benefits of *C. gariepinus* in tank culture system. Three treatments designated as G0 (no grading), G2 (grading every 2 weeks) and G4 (grading every four weeks) in a completely randomized design (CRD) was applied in triplicate. The tanks were stocked with 200 fingerlings each. Sampling was conducted weekly to measure length and weight of fish. Mortalities were recorded and dead fish observed under dissecting microscope to ascertain that it is due to cannibalism. An enterprise budget was conducted to determine the economic benefits of grading frequency. Data were analyzed using One−way ANOVA. Growth performance in terms of final mean weight, weight gain, Specific Growth Rate (SGR) and Food Conversion Ration (FCR) were affected by frequency of fish grading. The *C. gariepinus* graded every two weeks grew better than those graded every four weeks and were all above the no grading treatment. Changes in fish heterogeneity was observed after day 42 and continued until day 60. The size variation was significantly affected by grading frequency. The mean TL of fish graded every 2 weeks was the highest, followed by grading every four weeks and finally the no grading treatment was the lowest. Fish size heterogeneity (CV% and skewness) was consistently the highest in *C. gariepinus* in no grading treatment followed by fish where grading was done every four weeks while it was lowest in treatment where grading was done every two weeks. Mortality owing to cannibalism was affected by grading frequency where highest cannibalism mortality occurred in *C. gariepinus* where there was no grading followed by grading every four weeks and intermediate at grading frequency every four weeks. Meanwhile other mortality by other causes such as such as wounds and suffocation in fish did not differ with grading frequency. Highest total fish yield, net returns above TVC and TC was obtained in treatment where grading was done every 2 weeks. The enterprise budget analysis of grading frequency in the present study indicated that it is economically feasible to culture *C. gariepinus* when grading was done every four weeks but the best economic returns occur when the grading frequency is done every two weeks.

EFFECTS OF FREQUENCY OF GRADING ON THE GROWTH, INTRA–COHORT CANNIBALISM AND ECONOMIC BENEFITS OF AFRICAN CATFISH (*Clarias gariepinus*, Burchell, 1822) CULTURE

By
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WAS Conference

June 26 - 30 2017, Cape Town, South Africa

INTRODUCTION - 1

- Aquaculture: fastest growing food production sector in the world.
- Supplied 42 percent (67 million tonnes) of fish consumed globally(FAO 2012)
- Economic Stimulus Programme (ESP) revived the Aquaculture industry in Kenya-ponds stocked with Nile tilapia *Oreochromis niloticus*.
- The country's aquaculture production has increased by over 500% in the last five years.
- Production stood at 4,220 metric tonnes in 2008 and increased to 22,000 metric tonnes in 2014.

INTRODUCTION - 2

- **Nile tilapia *Oreochromis niloticus* is the most popular species for culture**
- **However, the prolific breeding trait of tilapia results to several challenges:**
  - **overpopulation,**
  - **stunted growth,**
  - **low production**

INTRODUCTION - 3

- **Some farmers are shifting from culture of tilapia to culture of African catfish *Clarias gariepinus***
- **Favorable traits of African catfish include:**
  - **Does not reproduce in captivity**
  - **Hardy species**
  - **Fast growth**
  - **Gives 2.5 times higher yields than tilapia**
  - **Has a high flesh to intramuscular bone ratio**

CHALLENGES IN CATFISH CULTURE

- African catfish is an important species for the sustainability of the aquaculture industry in the country.
- One major challenge facing catfish farmers is the high rate of intra-cohort cannibalism (Image 1)
- Results to a small harvest comprising of a few large fish.
- Size variation is both a cause and effect of cannibalism.
- Fast growing fish, commonly known as jumpers or shooters, predate on the rest of the stock.

Image 1: Shooter/jumper as a result of intra-cohort cannibalism

CATFISH CANNIBALISM CHALLENGE

Image 2: Giant Catfish harvest due to cannibalism

OBJECTIVE OF STUDY

Specific objectives

The specific objectives of the study were:

- **To establish the effect of frequency of grading on growth performance of *C. gariepinus***
- **To evaluate the effect of frequency of grading on cannibalism rates of *C. gariepinus***
- **To determine the effect of frequency of grading on economic benefits of *C. gariepinus***

EXPERIMENTAL DESIGN - 1

- The study was conducted at Mwea Aquafish Farm
- The study consisted of three treatments in a completely randomized design (CRD).
- The three treatments were designated as G0 (no grading), G2 (grading every 2 weeks) and G4 (grading every four weeks).
- The entire experiment was executed in triplicate.
- 9 tanks of surface area 1.5 m^2 were stocked with 200 fingerlings each sourced from MAFF hatchery; mean weight of 0.83 ± 0.12 g.

EXPERIMENTAL DESIGN - 2

- Fingerlings were fed with a diet containing 40% crude protein, 9% crude lipids, 3.5% crude fibre and 5.5% ash.
- The fish were manually hand fed at 8% body weight for the first month and then reduced to 6% body weight for the second month.
- Feed was administered four times per day i.e. at 0900 h, 1200 h, 1400 h and 1600 h

Fig 2: Map of study area (inset) and site

Fig. 3: Photo of Mwea Aquafish Farm (MAFF)

Fig. 4: Plastic circular tanks culture system at MAFF

CALCULATION OF GROWTH, MORTALITY AND CANNIBALISM

Thirty (30) fish in each tank sampled fortnightly

- **Weight gain = Initial weight–Final weight**
- **Percent weight gain = (Initial weight–Final weight)/Initial weight×100**
- **Specific growth rate (SGR, % day^{-1}) = $(e^g - 1)100$**
  - **where $g = (\ln(W_2) - (\ln(W_1))(t_2 - t_1)^{-1}$ and W_2 and W_1 are weights on day t_2 and t_1 respectively.**
- **Survival = Final remaining fish/Initial number stocked×100.**
- ***Cannibalism* = (Number of fish missing or consumed/Initial number of fish) × 100.**
- **FCR =Feed intake/weight gain**

RESULTS AND DISCUSSION

Effects of grading on growth performance & survival

- ***Clarias gariepinus*** **graded every two weeks grew better than those graded every four weeks and were all above the no grading treatment (Table 1)**
- **The final mean weight and weight gain in *C. gariepinus* among treatments were significantly ($F = 7.4519$, $df = 2$, $p = 0.0001$) the highest in treatment involving grading every two weeks.**
- **Specific growth rate (SGR) was significantly ($F = 6.1513$, $df = 2$, $p = 0.0005$) highest in fish that were graded every two weeks**
- **The lowest FCR also occurred in treatment that were graded every two week**

Table 2: Growth performance (means ± SD) of *C. gariepinus* in different grading treatments

Growth performance parameters	Frequency of grading		
	G0 (No grading)	G2 (Every 2 weeks)	G4 (Every 4 weeks)
Initial mean fish weight (g)	0.69 ± 0.31	0.92 ± 0.39	0.89 ± 0.21
Final mean weight (g)	36.32 ± 10.3^{a}	51.72 ± 11.15^{c}	42.48 ± 8.2^{b}
Weight gain (g)	35.63 ± 10.02^{a}	50.8 ± 12.42^{c}	41.59 ± 10.27^{b}
Specific growth rate (SGR; % day^{-1})	8.81 ± 0.27^{b}	8.95 ± 0.08^{c}	8.59 ± 0.06^{b}
FCR	1.81 ± 0.23^{c}	1.21 ± 0.13^{a}	1.42 ± 0.24^{b}

RESULTS-II

- Differences in the weight due to grading occurred at day 42 ($F = 7.8226$, $df = 2$, $p = 0.0251$), day 56 ($F = 11.8413$, $df = 2$, $p = 0.0002$) and day 70 ($F = 23.8554$, $df = 2$, $p = 0.0000$) where grading every two weeks produced the best weight followed by grading every four weeks and low weight in no grading treatments (Figure 5)

EFFECTS OF GRADING ON SIZE HETEROGENEITY MORTALITY AND CANNIBALISM

- The size variation was significantly affected by grading frequency ($F = 10.8511$, $df = 2$, $p = 0.0002$)
- The mean TL of fish graded every 2 weeks was the highest (19.1 ± 2.9 cm), followed by grading every four weeks (17.4 ± 2.3 cm) and finally the no grading treatment was the lowest (15.8 ± 1.9 cm).(Fig 7)
- Mortality owing to cannibalism was significantly affected by grading frequency ($P < 0.001$, Table 3).
- Highest cannibalism mortality was highest in *C. gariepinus* where there was no grading
- Grading every two weeks resulted in the lowest total mortality.

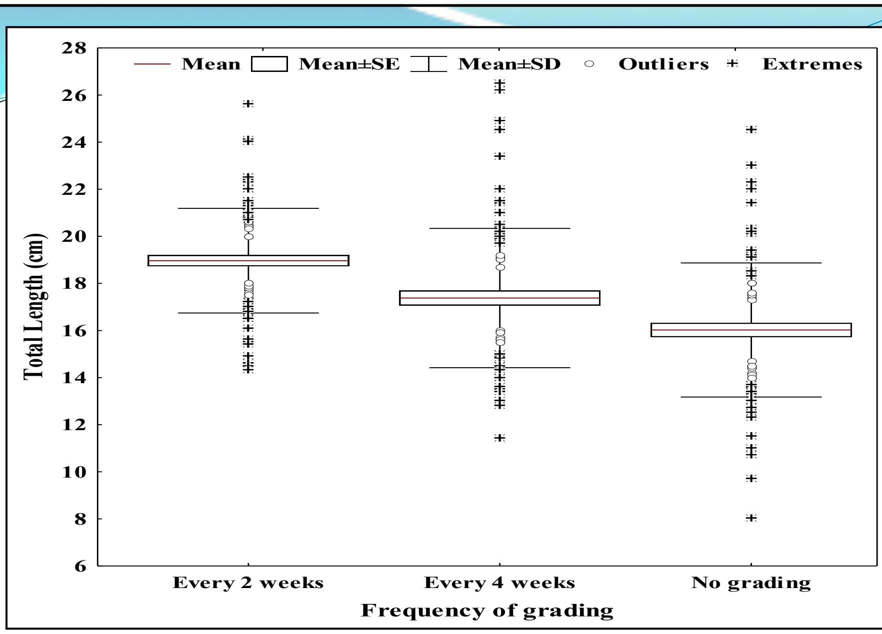


Figure 7: Fish Total Length (TL) at different grading treatments in *Clarias gariepinus*

Table 3: Mortality due to cannibalism and other causes in fish under different frequency of grading

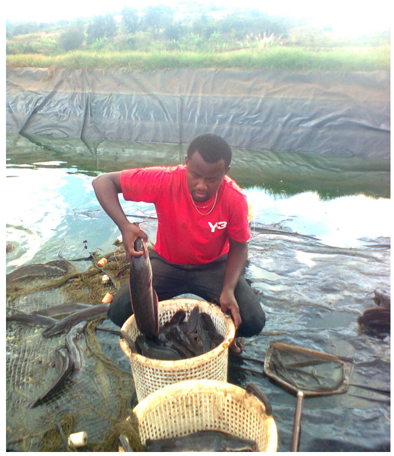
Grading frequency	Cannibalism mortality (%)	Mortality by other causes (%)	Total mortality (%)
G0 (No grading)	42.4 ± 10.2^{c}	11.5 ± 12.3	56.8 ± 15.3^{c}
G2 (Every 2 weeks)	7.5 ± 2.0^{a}	10.8 ± 3.1	18.4 ± 4.4^{a}
G4 (Every 4 weeks)	18.9 ± 4.9^{b}	13.7 ± 3.2	35.6 ± 14.5^{b}
One-Way ANOVA			
F	23.4522	3.3212	21.3342
P value	0.0000	0.09222	0.0000

CONCLUSIONS AND RECOMMENDATIONS

- **The growth performance in terms of final mean weight, weight gain, SGR and FCR in *C. gariepinus* was affected by frequency of fish grading.**
- **The *C. gariepinus* graded every two weeks grew better than those graded every four weeks and were all above the no grading treatment.**
- **Changes in fish heterogeneity was observed after day 42 and continued until day 60.**
- **The size variation was significantly affected by grading frequency..**

RECOMMENDATIONS

- **The results of the present experiment indicate that the sorting of *C. gariepinus* fingerlings according to size based on different grading frequencies has a positive impact on the effectiveness of their rearing in tanks.**
- **Future research should focus on determining the optimal procedure of sorting, because sorting helps to reach high survival rates and minimizes stress that accompanies this treatment**
- **To save on cost incurred during grading, farmers are encouraged to culture catfish in smaller production units as opposed to large ponds.**



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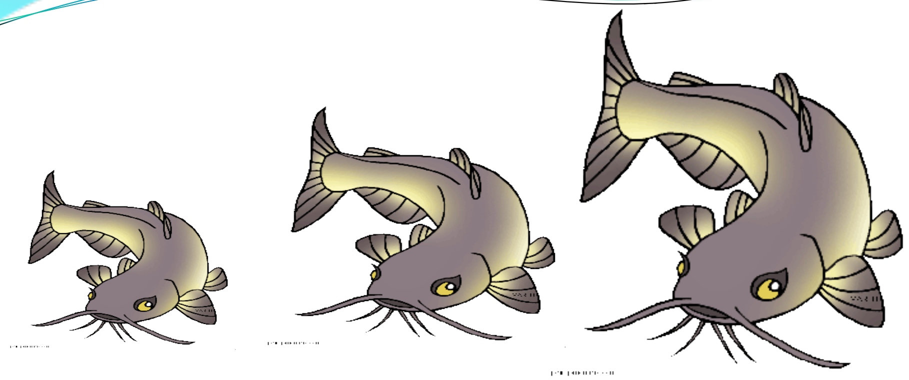

Thank You All

Brood mola stocking density in prawn and carp farming to increase household nutrition for rural farmers in southwest Bangladesh

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Freshwater prawn (*Machrobrachium rosenbergii*) and carp (*Labeo rohita*) polycuture are widely practicing in seasonal paddy fields (*ghers*) of southwest coastal region of Bangladesh. Farmers typically sell the prawns to fetch higher price in overseas market and carps are sold in the local market as cash crop. Meanwhile family members (particularly women and children) remain malnourished from lack of complete protein, vitamins and other minerals in their diet. The present investigation proposed to help mitigate this problem by incorporating nutrient enriched small fish (*Mola, Amblypharyngodon mola*) for home consumption in the current prawn-carp traditional gher farming system. A study was conducted on the farms of local producers for a period of 6 months. Mola was stocked at a rate of 1, 2 and 4/m^2 in treatment 1, 2 and 3 respectively ,with 5 replications for each treatment. Furthermore, 5 ponds were selected randomly where mola was not stocked and treated as control (treatment 4). In all the 4 treatments stocking density of prawn and carp were 2 and 0.1/m^2, respectively. Production of prawn was 455.58±14.69, 462.77±15.60, 456.28±13.94 and 362.25±17.84 kg/ha and carp was 588.11±16.47, 572.19±17.28, 586.75±15.39 and 502.92±16.84 kg/ha in T1, T2, T3 and T4 respectively. Treatment 4, lacking mola had significantly lower prawn and Rohu production compared to the other treatments. Further, mola production was higher in T2 (376.21±15.34 kg/ha) and T3 (397.66±18.41 kg/ha) groups compared to T1 (298.55±11.55 kg/ha). The study showed that the addition of mola has no adverse impact on prawn-carp production system, and may in fact improve prawn and carp production. Based on these results and the costs for initial stocking of mola, it is suggested that mola brood be stocked at a density of 2 fish/m m^2. Considering mola require no supplementary feed inputs for their growth, have a negative impact or may improve production of prawn and carp, and are a source of nutritious food, it is highly recommended that farmers incorporate mola in prawn-carp gher polyculture systems to enhance their nutrition and potential income opportunities.

Funded by the AquaFish Innovation Lab of the United States Agency for International Development (USAID) Cooperative Agreement No. EPP-A-00-06-00012-00 and by U.S. and Host Country partners.

Table1. Experimental design of prawn, carp and mola polyculture in gher/freshwater pond farming system

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

Table 2. Abstract - Production (kg/ha) of prawn, mola and ruhu from July 2015 to December 2015

Fish	**T1 (kg)**	**T2 (kg)**	**T3 (kg)**	**T4 (kg)**
Prawn	$455.58^a \pm 14.69$	$462.77^a \pm 15.60$	$456.28^a \pm 13.94$	$362.25^b \pm 17.84$
Mola	$298.55^a \pm 11.55$	$376.21^b \pm 15.34$	$397.66^b \pm 18.41$	Nil
Rohu	$588.11^a \pm 16.47$	$572.19^a \pm 17.28$	$586.75^a \pm 15.39$	$502.92^b \pm 16.84$

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

Table 3, Consumption of prawn, mola and rohu from July 2015 to December 2015

Fish	**T1 (kg)**	**T2 (kg)**	**T3 (kg)**	**T4 (kg)**
Prawn	$18.93^a \pm 1.1$	$13.2^b \pm 0.49$	$14.86^c \pm 0.6$	$9.98^d \pm 0.82$
Mola	$109.22^a \pm 2.25$	$118.55^b \pm 1.64$	$124.4^c \pm 2.03$	Nil
Rohu	$135.25^a \pm 4.01$	$125.69^a \pm 2.89$	$132.36^a \pm 2.78$	$130.67^a \pm 8.89$

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

Table 4. Cost benefit analysis for mola brood stocking

Treatments	Stocking Density(ind/h)	Weight (kg/ha)	Buying price (250Tk/kg)	Production (kg/ha)	Selling price (200Tk/kg)	profit (Taka)
T1	10000	36.8	9200	298.55	59710	50510
T2	20000	73.8	18450	376.21	75242	56792
T3	40000	148	37000	397.66	79532	42532

POLYCULTURE STRATEGIES WITH PRAWN, CARP AND MOLA TO INCREASE HOUSEHOLD NUTRITION FOR RURAL FARMER

US PI: Prof. Russell Borski, North Carolina University
BD Co- Investigator
Professor Dr. Khandaker Anisul Huq
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Background

Fisheries sector has been playing a vital role in Bangladesh
-In alleviating protein shortage (60% of animal protein)
- providing employment sources for young & women (10% of total population)
- role on local markets and enhance to earn foreign currencies
- contribute to food security & socioeconomic development (GDP 3.69%, 2016)

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

Cont……..

- Farmers typically sell the prawns in overseas markets and carps in domestic markets, meanwhile family members (particularly women and children) malnourished due to lack of complete protein, vitamins, and other minerals in their diets.
- Mola fish (a small indigenous species, SIS) small fish with big nutritional value.
- Every country has nutrient enriched SIS. (No additional cost for feed and management, continuous breeding, household consumption

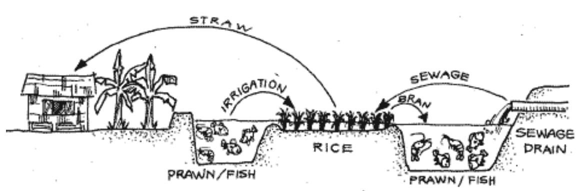
Macrobrachium rosenbergii

Amblypharyngodon mola

Labeo rohita

Cont……..

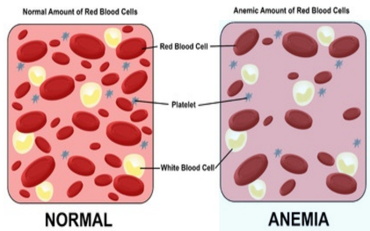
Integrated aquaculture in gher system (Paddy: Jan-April, Fish: June-Dec, Dike Vegetable: year round)



Nutritional contribution of mola fish

Cont……..

Iron deficiency



Vitamin A deficiency

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

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

Calcium deficiency

Rickets

Zinc deficiency

Acrodermatitis enteropathica

Objectives

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

Study location

Location: Dumuria Upazila, Khulna District, Southwest Bangladesh

Map of Bangladesh

Methodology

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

Experimental design for Exp. 1 (July to January)

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

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

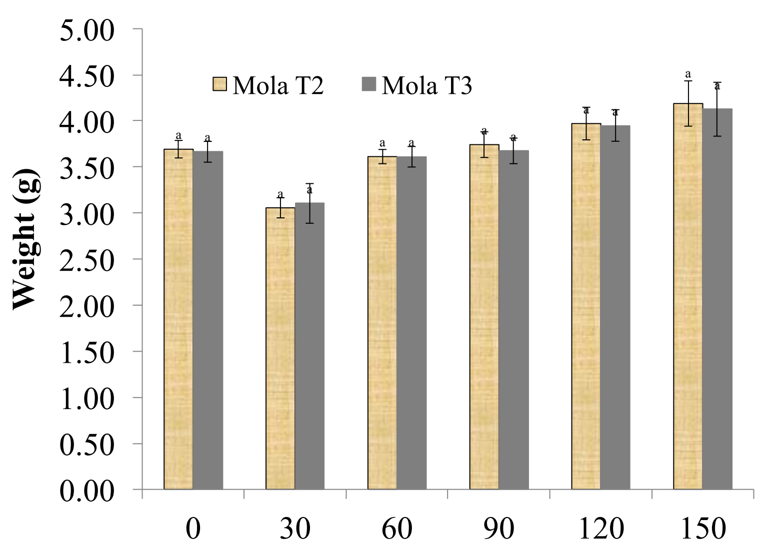
Pond preparation (April-May):(pond size .15-.30ha). drying, liming (250 kg/ha), water filling (1-1.5 m), fertilization urea 50 kg/ha, TSP 25 kg/ha, mixture of molasses 30kg and yeast 300 g/ha

- **Feeding**: Mega grower feed (30% crude protein) in the grow-out pond at 5% of their body weight, which was gradually decreased to 2% at the end. Feeding frequency was twice a day.
- **On-growing fertilization**: **organic fertilizer** (mixture of molasses 30 kg/ha and yeast powder 400 g/ha); **inorganic fertilizer** (urea 25 kg/ha, TSP 12.5 kg/ha).
- **Water quality**: pH, DO, transparency, alkalinity, nitrate nitrogen, phosphate phosphorus, and Chlorophyll-a were measured fortnightly.
- **Monitoring:** monthly growth performance and health checking
- **Monthly focus group discussion and on-farm training**

Result

Water parameters in prawn gher (July to January)

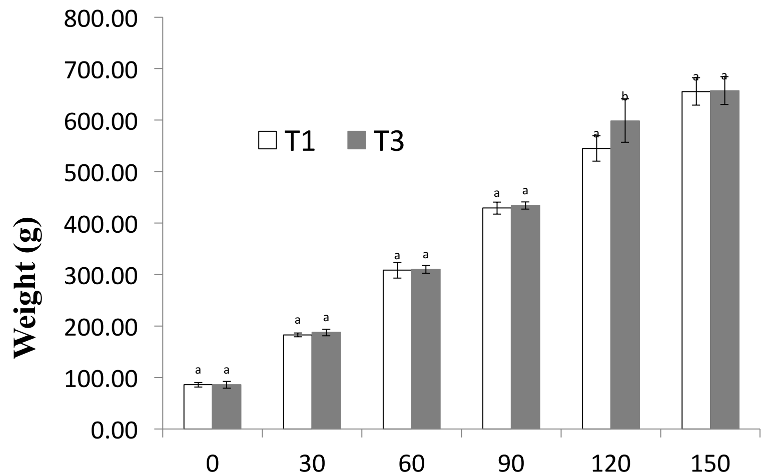
Parameters	T_1	T_2	T_3
Temperature (°C)	31.98±1.68	31.86±2.21	31.46±2.42
Transparency (cm)	26.2±5.45	27.2±4.66	27.0±7.63
pH	7.38±0.29	7.32±0.23	7.3±0.18
DO (mg/L)	5.68±0.51	5.22±0.36	5.76±0.84
Alkalinity (mg/L)	200±50	170±27.38	190±41.83
Ammonia (NH_3-N mg/L)	0.33±.03	0.34±.021	0.35±0.03
Nitrate Nitrogen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



Culture days of Mola

T2- Prawn 2/m², Mola 1/m²

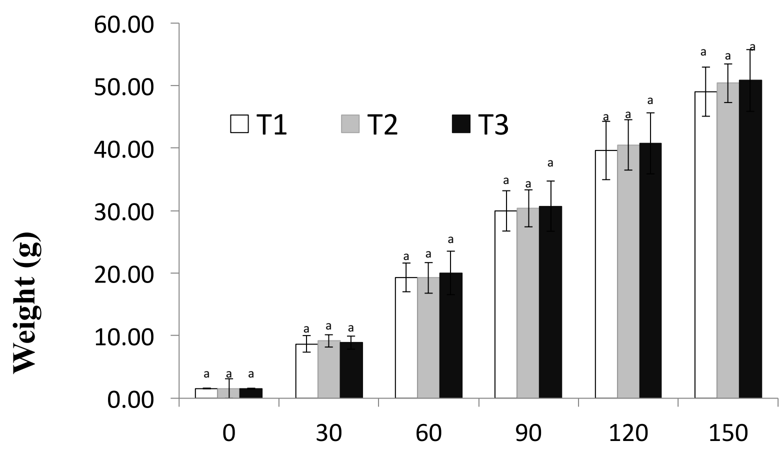
T3- Prawn 2/m², Rohu 0.1m², Mola 1/m²…



Culture days of Rohu

T1- Prawn 2/m^2, Rohu 0.1m^2

T3- Prawn 2/m^2, Rohu 0.1m^2, Mola 1/m^2…



Culture days of Prawn

T1- Prawn and Rohu, T2- Prawn, Mola

T3- Prawn, Rohu and Mola…

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

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

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

Video 1

Video 2

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

Consumption of prawn, rohu and mola

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

Exp 2: Methodology

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

Experimental design of exp. 2 (July to December)

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

Result

Water parameters in gher from July to December 2015

Parameters	T1	T2	T3	T4
Temperature (°C)	31.63±2.23	31.58±1.87	31.66±1.80	31.87± 1.94
Secchi depth (cm)	26.2±4.15	29.2±6.45	28.2±4.63	30.1±4.63
pH	7.7±0.68	7.18±0.39	7.18±0.29	7.3±0.18
DO (mg/L)	5.18±0.81	5.16±0.41	5.62±0.43	5.14±0.34
Alkalinity (mg/L)	223±33	218±33	189±29.31	210±31.73
Nitrate Nitrogen (mg/L)	2.46±0.72	2.96±0.72	3.16±0.64	3.29±1.02
Phosphate phosphorus PO_4P (mg/L)	0.51±0.41	0.46±0.31	0.53±0.12	0.49±0.2
Chlorophyll-a in µg/L	79.17±2.18	69.57±3.15	81.90±3.14	53.78±1.73

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

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

Fish	T1	T2	T3	T4
Prawn	455.58±14.69^a	462.77±15.60^a	456.28±13.94^a	362.25±17.84^b
Mola	298.55±11.55^a	**376.21±15.34^b**	397.66±18.41^b	Nil
Rohu	588.11±16.47^a	572.19±17.28^a	586.75±15.39^a	502.92±16.84^b

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

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

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

Exp-2: Consumption of prawn, mola and ruhu

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

Exp 3: Methodology

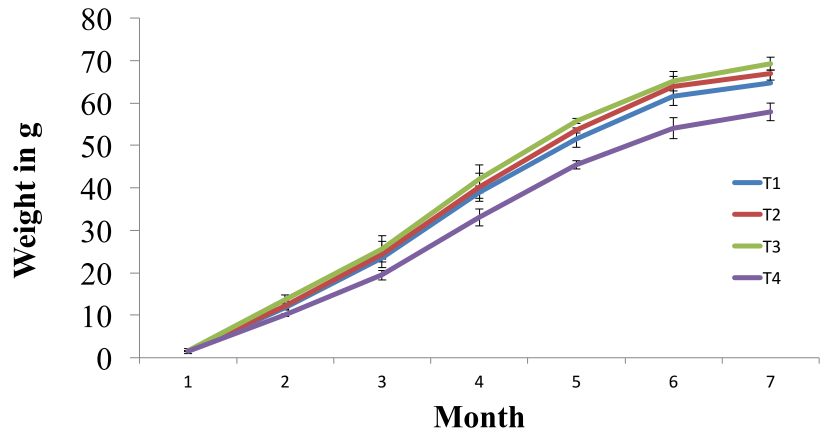
Effect of three different fertilizers/molasses on the production of prawn-rohu-mola in traditional gher farming system

Parameter	T_1	T_2	T_3	T4
Prawn	$2/m^2$	$2/m^2$	$2/m^2$	$2/m^2$
Rohu	$0.1/ m^2$	$0.1/m^2$	$0.1/m^2$	$0.1/m^2$
Mola	$2/m^2$	$2/m^2$	$2/m^2$	$2/m^2$
Fertilization application	N:P=28:7 kg/ha	Molasses (30kg) + Yeast (300g)/ha	50 % of T_1+ 50% of T_2	Nil
Replication	5	5	5	5

Result

Water parameters in gher from June to December 2016

Treatment	T1	T2	T3	T4
Temperature (^oC)	26.5 – 32.5	26.55-30.75	26.25 - 30.75	25.25 – 31.25
Secchi depth (cm)	25-27.5	24.5- 26.5	25.5 – 26.5	25.5-27.5
pH	7.2-8.0	7.1 -7.9	7.2 – 7.6	7.24 – 8.1
DO (mg/L)	5.1 – 5.3	5.03 -5.28	5.1 – 5.2	4.96 – 5.4
Alkalinity (mg/L)	208 - 242	206-232	196 - 221	210 - 251
Ammonia (mg/L)	0.27 – 0.36	0.22 – 0.37	0.29 – 0.33	0.21 – 0.39
Nitrate Nitrogen (mg/L)	2.2 – 2.76	2.87- 3.46	2.61- 3.36	2.89- 3.87
Phosphate phosphorus (mg/L)	0.31-0.67	0.46-0.61	0.25-0.57	0.47 – 0.51



Monthly weight of prawn from June to December

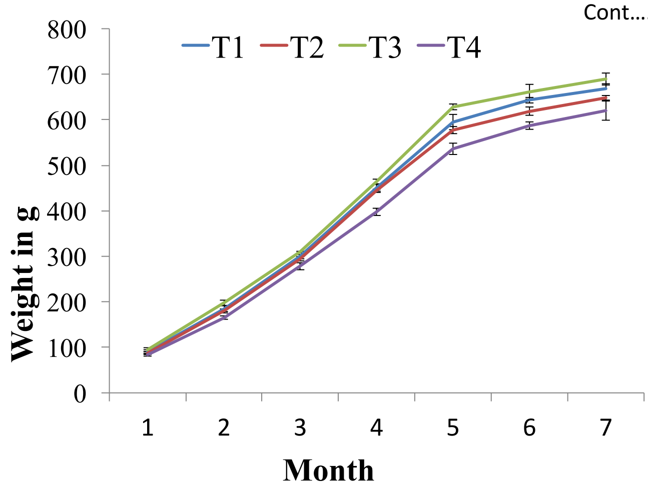
T1- Urea 50kg and TSP 25kg/ha

T2- Molasses 30Kg with 300g yeast/ha

T3- 50% T1 + 50% T2

T4- No fertilizer

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



Monthly weight of rohu from June to December

T1- Urea 50kg and TSP 25kg/ha

T2- Molasses 30Kg with 300g yeast/ha

T3- 50% T1 + 50% T2

T4- No fertilizer

Production (kg/ha) of prawn, rohu and mola from June to December 2016

Treatments	T1	T2	T3	T4
Prawn	459.12±14.6^{a}	471.8±15.6^{a}	508.8±13.9^{b}	396.8±17.8^{c}
Rohu	608±16.47^{ab}	589±17.3^{a}	633±15.4^{b}	547.6±16.8^{c}
Mola	401± 11.6^{a}	417 ±15.3^{ab}	440.4±18.4^{b}	348.4±23.3^{c}

Different superscript letters indicate the significant difference among the treatments ($P < 0.05$).

T1- Urea 50kg and TSP 25kg/ha

T2- Molasses 30Kg with 300g yeast/ha

T3- 50% T1 + 50% T2

T4- No fertilizer

Consumption (kg/ha) of prawn, mola and rohu from June to December 2016

Treatments	T1	T2	T3	T4
Prawn	16.93±1.1	24.2±0.5	32.87±0.6	22.98±0.8
Rohu	142.25±4.0	139.69±2.9	153±2.8	127±8.9
Mola	108.7 ± 2.15	113.5±1.6	121.6±2.0	102.3±16.9

Achievements

Exp-1

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

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

Exp-2

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

Exp-3

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

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

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

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

Outreach of AquaFish Innovation Lab Project in Bangladesh

Dissemination

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

  training (technologies transfer)
  community level orientation
  maintaining record books at farm level
  court-yard meeting
  development of communicating materials i.e. leaflets
  workshop.

- Mobilizing of input & output market actors to develop entrepreneurships and enhance on value chain.
- Following the cross-cutting issues like gender, resilience & sustainability
- Other developing countries may follow this kind of nutrient enriched small fish culture technology (**simple and low cost**) for household and local consumption.
- Not only cash profit but also nutritional aspect of the poor producer should be concerned.

Training, FGD

Demonstration

Challenges

- ❑ Challenges of available seed i.e. mola, prawn
- ❑ Mobilization of value chain actors (influence, market stability/mechanism)
- ❑ Natural hazards and its uncertainty (heavy rain fall, no rain, tidal surge, cyclone, salinity)
- ❑ HH Nutritional analysis depends on comprehensive factors
- ❑ Timing of fund its availability

Future plan

1. **Follow up training is going on for 500 gher farmers including the selected farmers**
2. **Training and mobilization of different producer and seed production group**
3. **Cross visit at farmers level**
4. **Linkage development workshop with value chain actors**
5. **Develop leaflet and hand book for farmers**
6. **AquaFish Innovation Lab project research fair**
7. **The achievement will be present in National and international conference/workshop for further dissemination**
8. **Develop exist strategy and mobilization of DoF for mainstreaming of research findings**

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AQUAFISH INNOVATION LAB

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Thank you
for kind attention

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Dyke vegetables on the experimental ghers

Semi-intensive polyculture of climbing perch with Indian carps

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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, drought or poor water quality. Currently, in Bangladesh production of Koi (*Anabas testudineus,* climbing perch) is limited to monoculture systems with intensive stocking and use of commercial-grade feeds. As feed can comprise up to 60% of total production costs, the current culture practices for these fish limit participation by small homesteads and therefore comprise a significant impediment to further expansion of this industry. Further, the use of high-levels of feed inputs has led to a persistent deterioration of pond water quality. We assessed 1) the feasibility and profitability of semi-intensive polyculture of Koi with Indian carps (Rohu and Catla) in ponds, and 2) whether Koi-carp polyculture is best with Rohu or Catla alone or when the two are combined. The study was carried out for 120 days in ponds at Bangladesh Agricultural University. The experiment was consisted of three treatments (T1, T2, T3) with four replicates each. Koi were stocked at the same density in all groups (5/m^2) and feed was applied based on Koi biomass at 50% (10% - 2.5% bw/day) of the rate typically used by industry. Treatment 1 was stocked with 0.8 Rohu/m^2 and 0.2 Catla/m^2, T2 with 1.0 Rohu/m^2, and T3 with 1.0 Catla/m^2. All ponds were fertilized weekly to enhance productivity of natural food for carps.

Weekly and fortnightly water quality parameters were measured and did not vary significantly the three treatment groups. There was no difference in weight gain or specific growth rate for any species between treatments or for survival rate for Koi. The survival rate for Rohu in T1 was significantly higher than T2 and for Catla in T1 than in T3. Both gross and net production parameters were significantly higher for Koi in T3 than in T1 or T2. Catla grown at a stocking rate of 1.0 fish/m^2 (T3) resulted in production parameters that were significantly higher than when stocked at 0.2 fish/m^2 (T1). There was no significant difference in production of Rohu between treatments. Feed conversion ratio (FCR) and BCR were similar among treatments. In conclusion, the results indicate that Koi can be polycultured with carps and this system produces significant positive returns on investment when fish are fed at half ration in fertilized ponds. While the best polyculture production may occur when Koi are solely cultured with Catla, Koi can also be cultured with either Rohu alone or both Rohu and Catla at a 4:1 ratio. Future studies are required to directly compare Koi monoculture and Koi-carp polyculture and the impacts of feed and fertilization inputs.

Table . Production parameters. Values are mean ± SD. Values with different letters are significantly different ($P < 0.05$). NA = not applicable.

	Treatment 1	*Treatment 2*	*Treatment 3*
Koi (*A.testudinius*)			
Stocking Weight (g)	2.94 ± 0.87	2.94 ± 0.87	2.94 ± 0.87
Harvest Weight (g)	129.24 ± 36.27	148.39±28.39	144.13 ± 15.79
Survival Rate (%)	72.64 ± 23.46	64.36±9.92	77.36 ± 11.74
Specific Growth Rate (%/day)	3.13 ± 0.25	3.26±0.17	3.24 ± 0.09
Gross Production (kg/ha)	4,325 ± 390^b	4,618 ± 374^b	5,459 ± 532^a
Net Production (kg/ha)	4,219.25±378.42^b	4,524 ± 381^b	5,346 ± 521^a
Rohu (*L. rohita*)			
Net Production (kg/ha)	1,102 ± 267	1,066 ± 186	NA
Catla (*G. catla*)			
Net Production (kg/ha)	344 ± 120 ^{b}	NA	922 ± 333^a

SEMI-INTENSIVE POLYCULTURE OF CLIMBING PERCH WITH INDIAN CARPS

Shahroz Mahean Haque[1] *, Moon Dutta, Imrul Kaisar, Mahbub Alam, Hillary Egna[2], and Russell Borski[3]

Introduction

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

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

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

❑ Koi (*Anabas testudineus*) is an excellent fish for growing in the shallow and seasonal ponds in Bangladesh

❑Air-breathing fishes (koi) provide a significant advantage for pond culture, as they tend to be resilient to harsh conditions, particularly during periods of low-oxygen, which can occur with high temperatures, drought or poor water quality; also tolerate extremely unfavorable water conditions associated mainly with turbid, stagnant waters

Currently, in Bangladesh production of Koi (*Anabas testudineus,* climbing perch) is limited to monoculture systems with intensive stocking and use of commercial-grade feeds.

As feed can comprise up to 60% of total production costs, the current culture practices for these fish limit participation by small homesteads and therefore comprise a significant impediment to further expansion of this industry.

Objectives

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

Evaluate whether Koi-carp polyculture is best with Rohu or Catla alone or when the two are combined.

To assess effectiveness of reduced feeding combined with pond fertilization and reduce pollution through reduce amount of feed application

Materials and Methods

Experimental Site

Fisheries Field Laboratory Complex,

Bangladesh Agricultural University,

Mymensingh

Duration of the Experiment

120 days

Experimental Species

Koi (*Anabas testudineus*), Rohu *(Labeo rohita),* Catla *(Gibelion catla)*

Pond no. : 12
Pond depth: 1.5 m

Experimental Design

Treatment / Factor	Treatment 1	Treatment 2	Treatment 3
Rohu (*L. rohita*)	0.8 fish/m^2	1.0 fish/m^2	None
Catla (*G. catla*)	0.2 fish/m^2	None	1.0 fish/m^2
Koi (*A. testudineus*)	5.0 fish/m^2	5.0 fish/m^2	5.0 fish/m^2
Fertilization	4:1 (N:P)	4:1 (N:P)	4:1 (N:P)
Replicates (n)	4	4	4
Pond Number	2,5,7,19	4,8,9,20	1,3,6,21

The experiment was consisted of three treatments (T1, T2, T3) with four replicates each. Koi were stocked at the same density in all groups (5/m^2) and feed was applied based on Koi biomass at 50% (10% - 2.5% bw/day) of the rate typically used by industry.

T 1 was stocked with 0.8 Rohu/m^2 , 0.2 Catla/m^2 and koi 5.0 fish/m^2

T2 with 1.0 Rohu/m^2, and koi 5.0 fish/m^2

T3 with 1.0 Catla/m^{2,} and koi 5.0 fish/m^2

All ponds were fertilized weekly to enhance productivity of natural food for carps. Weekly and fortnightly water quality parameters were measured

Pond Preparation

- ✓ Drying and Re-excavation
- ✓ Liming
- ✓ Water Filling
- ✓ Fertilization

Fingerling Collection and stocking

- ✓Koi (~2.94 g),
- ✓Rohu (~22.92 g) and
- ✓Catla (~30.70 g)

Feeding Strategy

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

◆ Feed was applied based on the body weight of Koi (10% - 2.5% bw/day)

Fertilization

- All ponds were fertilized with Urea and Triple super phosphate (TSP) at the rates of 4:1 as N: P.

Sampling

- **Fish sampling**
- **Water Sample Collection**
- **Plankton Sample Collection**
- **Benthos Sample Collection**

Sampling and Health Monitoring (koi)

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

Sampling and Health Monitoring (Rohu, Catla)

- Rohu and Catla were sampled on monthly basis
- Both of those fishes (Rohu and Catla) were caught by seine net
- Length and weight were measured by using a scale and digital balance

- Water quality parameter plays an important role in polyculture system. As fish is a cold-blooded animals, it's growth, reproduction, maturity, survival and production mostly dependent on water quality parameters

- Benthic community are important to the aquatic environment as they take part in the nutrient release from the bottom soil into the overlying water and also plays an important role in the growth and production of fishes because they are rich in amino acid, fatty acid, vitamins, and minerals

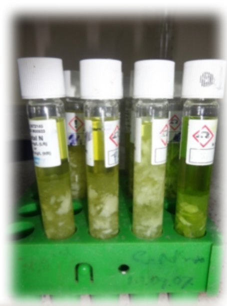
Water Quality Parameters Monitoring

Physical Parameters :

- ➤ Temperature (°C)
- ➤ Transparency (cm)

Chemical Parameters :

- ➤ Total Alkalinity (mg l^{-1})
- ➤ pH
- ➤ Dissolved Oxygen (mg l^{-1})
- ➤ Nitrate-nitrogen (mg l^{-1})
- ➤ Nitrite-nitrogen (mg l^{-1})
- ➤ Ammonia-nitrogen(mg l^{-1})
- ➤ Phosphate-phosphorus (mg l^{-1})
- ➤ Chlorophyll-*a* (µg l^{-1})



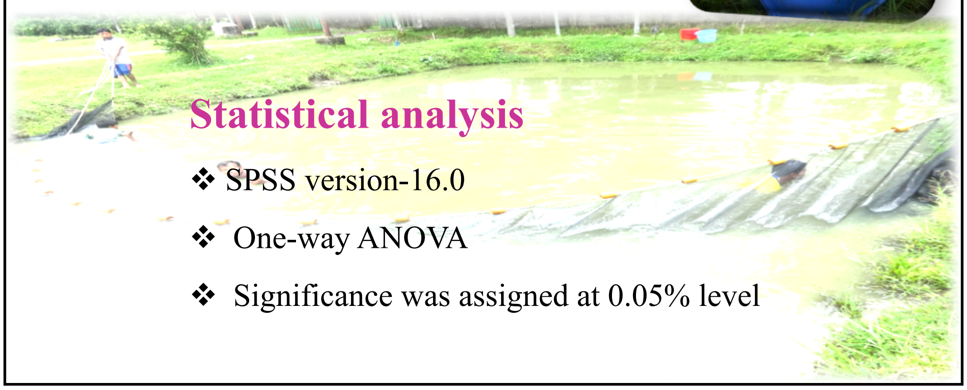
Plankton and Benthos collection and study

The plankton and benthic macro-invertebrate samples were collected fortnightly

Harvesting of Fish

- After 120 days of rearing, the fish were harvested from all the ponds
- Primarily the harvesting of fish was performed 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

Final Fish Sampling:
Length and weight of fish were measured



Statistical analysis

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

Analysis of Growth and Production Parameters

- **Weight gain (g)** = Mean final weight (g) – Mean initial weight (g)
- **Survival rate (%)** = $\frac{\text{No. of fishes harvested}}{\text{No. of fishes stocked}} \times 100$
- $\textbf{SGR}(\%\ \textbf{per day}) = \frac{logeW_2 - logeW_1}{T_2\text{-}T_1} \times \textbf{100}$
- **FCR (Food Conversion Ratio)** = $\frac{\text{Total feed used (kg)}}{\text{Total weight gain (kg)}}$
- **BCR (Benefit Cost Ratio)** = Gross return (Tk) ÷ Total investment (Tk)

Results

Water quality parameters recorded from different treatments (Mean ± SD)

Parameters	Treatment			Level of significance
	T_1	T_2	T_3	
Temperature (°C)	29.39±1.25	29.57±1.22	29.60±1.45	NS
Transparency (cm)	28.01±14.82	24.22±14.39	28.12±16.30	NS
Total Alkalinity (mg l^{-1})	136.33±39.83	141.59±34.48	135.96±36.32	NS
pH	7.88±0.48	7.89±0.57	7.79±0.46	NS
Dissolved Oxygen (mg l^{-1})	5.22±1.43	4.93±1.43	5.04±1.60	NS
Nitrate (mgl^{-1})	0.19±0.18	0.20±0.19	0.22±0.18	NS
Nitrite (mg l^{-1})	0.13±0.15	0.10±0.15	0.13±0.13	NS
Ammonia (mg l^{-1})	0.34±0.26	0.35±0.57	0.31±0.33	NS
Phosphate (mg l^{-1})	1.51±0.81	1.14±0.83	1.20±0.70	NS
Chlorophyll-a (µg l^{-1})	96.01±95.32	108.93±102.06	158.90±158.01	NS

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

Variable	Treatment 1	Treatment 2	Treatment 3	Significant level
Initial Weight (g)	2.94±0.87	2.94±0.87	2.94±0.87	NS
Final Weight (g)	129.24±36.27	148.39±28.39	144.13±15.79	NS
Weight Gain (g)	126.30±36.27	145.45±28.39	141.19±15.79	NS
Survival Rate (%)	72.64±23.46	64.36±9.92	**77.36±11.74**	NS
Specific Growth Rate, SGR	3.13±0.25	3.26±0.17	3.24±0.09	NS
Gross Production (kg ha^{-1})	4324.76±390^b	4617.63±374^b	**5459.23±517** ^{a}	**
Net Production (kg ha^{-1})	4219.25±378^b	4524.16±381^b	**5346.88±521** ^{a}	**
Feed Conversion Ratio, FCR	0.78±0.12	0.85±0.06	**0.77±0.12**	NS

Production Performance of Rohu (*Labeo rohita*) in Different Treatments

Variable	Treatment 1	Treatment 2	Treatment 3	Significant level
Mean Stocking Weight (g)	22.92±3.20	22.92±3.20	-	NS
Mean Harvesting Weight(g)	162.6±33.35	142.08±22.48	-	NS
Mean Weight Gain (g)	139.68±33.35	119.16±22.48	-	NS
Survival Rate (%)	99.69±0.63[a]	90.88±7[b]	-	**
Specific Growth Rate, SGR (% day^{-1})	1.62±0.17	1.51±0.13	-	NS
Gross Production (kg ha^{-1})	1282.11±268.31	1272.06±188.51	-	NS
Net Production (kg ha^{-1})	1101.52±267.44	1066.28±185.65	-	NS

Production Performance of Catla (*Gibelion catla*) in Different Treatments

Variable	Treatment 1	Treatment 2	Treatment 3	Significant level
Mean Stocking Weight (g)	30.7±10.29	-	30.7±10.29	NS
Mean Harvesting Weight(g)	243.85±92.72	-	198.7±44.10	NS
Mean Weight Gain (g)	213.15±92.72	-	168±44.10	NS
Survival Rate (%)	84.17±9.86 [a]	-	54.13±7.92 [b]	**
Specific Growth Rate, SGR (% day^{-1})	1.68±0.34	-	1.54±0.2	NS
Gross Production (kg ha^{-1})	394.57±116.59 [b]	-	1086.29±356.48 [a]	**
Net Production (kg ha^{-1})	343.51±120.07 [b]	-	922.12±333.45 [a]	**

Table: Combined Production Performance of Koi, Rohu and Catla in Different Treatments

Variable	Treatment 1	Treatment 2	Treatment 3	Significant level
Feed Conversion Ratio, FCR	0.78±0.12	**0.85±0.06**	0.77±0.12	NS
Gross Production (kg ha^{-1})	6001.44±1776.17	5889.69±1809.20	**6545.52±2374.8**	NS
Net Production (kg ha^{-1})	5664.28±1769 ^{ab}	5590.4±1869 ^{b}	**6269±2399^{a}**	**

Values of the parameter in each row with different superscripts (a and b) differs significantly ($p<0.05$)
NS: Not significant
**: Significantly different

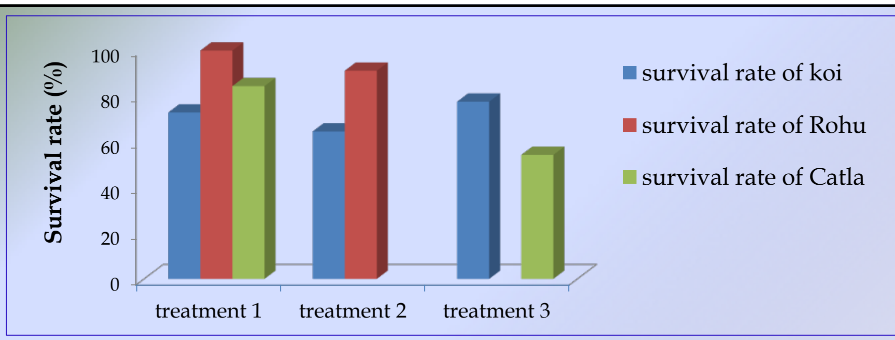


Figure: Mean survival rate of three fish species in three different treatments

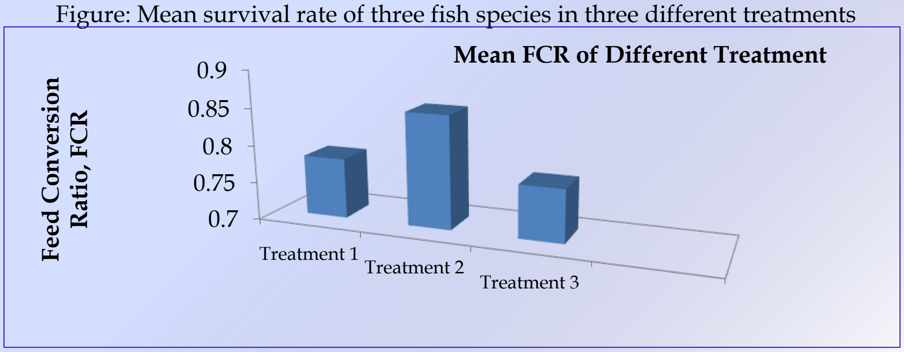


Figure: Mean FCR of different treatment

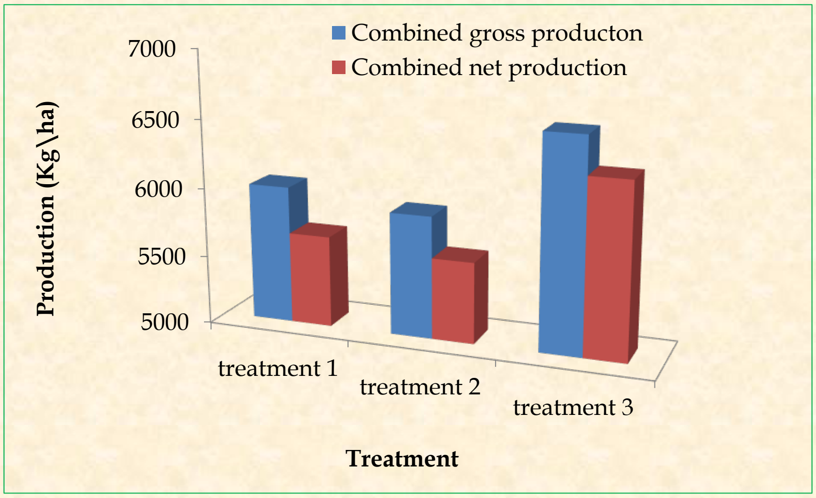


Figure: Combined gross and net production of three fish species in different treatment

Result

There was no difference in weight gain or specific growth rate for any species between treatments or for survival rate for Koi.

The survival rate for Rohu was significantly higher in T1 (Koi, catla and Rohu) than T2 (Koi + Rohu) and for Catla in T1 than in T3 (Koi + catla).

Both gross and net production parameters were significantly higher for Koi when cultured with catla alone (T3) than when cultured with both rohu and catla (T1) and rohu alone (T2)

Catla grown at a stocking rate of 1.0 fish/m^2 (T3) resulted in production parameters that were significantly higher than when stocked at 0.2 fish/m^2 (T1).

Feed conversion ratio (FCR) and BCR were similar among treatments.

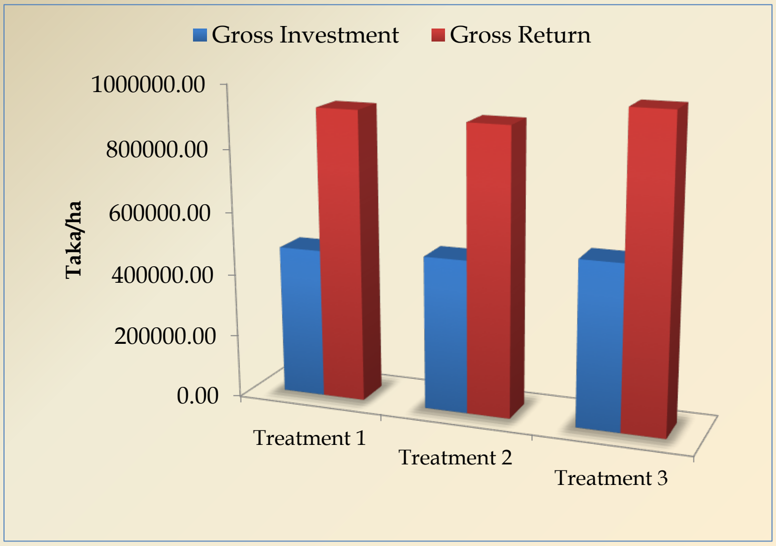


Figure: Gross investment and return from three different treatments

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

Items	Treatment (Taka/ha)			Significant level
	Treatment 1	Treatment 2	Treatment 3	
Financial Input				
Salt	5928	5928	5928	NS
Lime	8892	8892	8892	NS
Urea	7230.68	7230.678	7230.678	NS
TSP	5529.342	5529.342	5529.342	NS
Koi	98800	98800	98800	NS
Rohu	39520 [b]	49400 [a]	-	**
Catla	17784 [b]	-	88920 [a]	**
Feed	280900.8	302308.2	299757	NS
Labor and Others	10000.00	10000	10000	NS
Total Cost	474584.822	488088.22	525057.02	NS
Financial Return				
Koi	648713.39 [b]	692644.96 [b]	818884.97 [a]	**
Rohu	217959.173	216250.3896	0	NS
Catla	59185.64 [b]	0	162943.12 [a]	**
Total Return	925858.209	908895.3539	981828.088	NS
Net Return	451273.387	420807.1339	456771.068	NS
BCR (Benefit Cost Ratio)	1.95	1.86	1.87	NS

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

Conclusion

- Production of Koi, Rohu and Catla varied among the treatments
- Clean environment was observed due to addition of carp species in terms of nutrient loading
- The highest BCR value obtained in T_1 where koi, rohu and catla were cultured together
- The best polyculture production may occur when Koi are solely cultured with Catla, Koi can also be cultured with either Rohu alone or both Rohu and Catla at a 4:1 ratio.

Conclusion

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In conclusion, Koi can be polycultured with carps and this system produces significant positive returns on investment when fish are fed at half ration in fertilized ponds

Studies to compare Koi monoculture and Koi-carp polyculture and the impacts of feed and fertilization inputs are currently going on.

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Understanding seasonal price variation in the aquaculture sector in Uganda

James O. Bukenya*, Kelvin Lule, Moureen Matuha, Theodora Hyuha and Joseph Molnar
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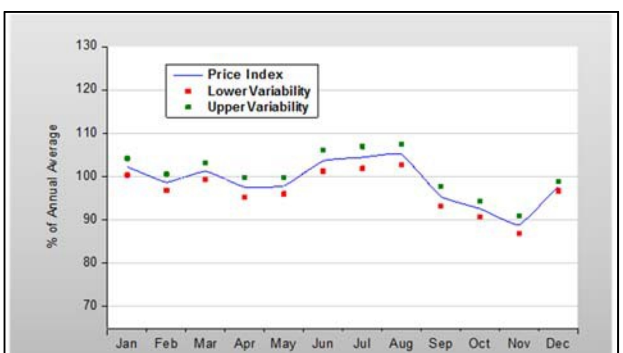
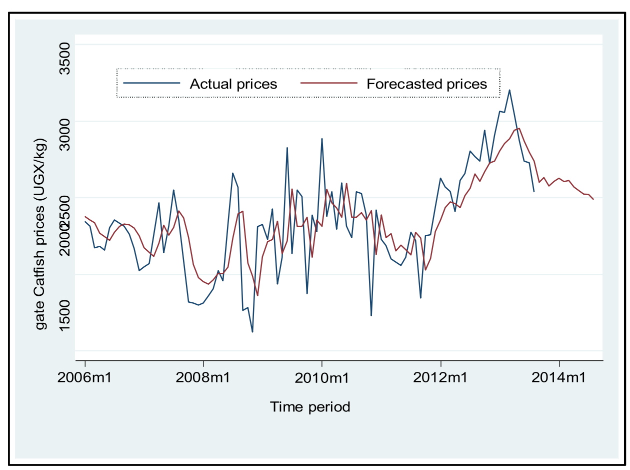
Price fluctuations in Uganda fish markets have become one of the main risks faced by fish producers. Price movements are for the most part risky, as the direction and force of the motions are largely unknown on a short-term basis, thus complicating production and investment decisions in the aquaculture sector. This paper explores the historical variations in catfish prices and attempts to forecast farm-gate price trends on a monthly basis. The motivation for examining seasonal price patterns and the eventual price forecasts is to allow aquaculture producers to make better-informed decisions and to manage price risk. The forecasts of catfish farm-gate prices are based on historical data from January 2006 to August 2013. Two types of information are extracted from the price data: 1) the monthly price variations relative to the annual average price or the monthly seasonal price indexes, and 2) the price variability within a month during the years included in the analysis.

Seasonal index was computed to measure how much the average for a particular month tends to be above or below the expected value. Figure 1 plot the average annual price and monthly price index, with the variability range indicated by points above and below the index values. For example, for January, the monthly price index of 102.25 means the average January price is 102.25% of the annual average price. The variability factor of 1.95 means that, statistically, the monthly index can vary approximately 2% points higher or lower than the monthly index. Thus, the January price in a particular year may be as high as 104.2% (102.25 + 1.95) or as low as 100.3% (102.25 – 1.95) of the annual average.

When dealing with aquaculture products with a short shelf life, successful forecasting can be an invaluable tool. In this paper, monthly farm-gate prices for catfish are forecasted based on historical data. Of the models developed and tested, a seasonal auto regressive integrated moving average (SARIMA) model outperformed other models in terms of forecasting accuracy on both in- sample and out-of-sample datasets. The results (Figure 2) show that the model can be used to forecast with a mean absolute percentage error (MAPE) of 14% which is considered acceptable for products with stochastic demand.



Price Index	102.25	98.70	101.24	97.52	97.86	103.64	104.43	105.12	95.40	92.56	88.85	97.76
Variability	1.95	1.85	1.92	2.26	1.85	2.41	2.50	2.42	2.24	1.78	2.02	1.06



UNDERSTANDING SEASONAL PRICE VARIATIONS IN THE AQUACULTURE SUBSECTOR IN UGANDA

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

Presented June 30, 2017 at the WAS Annual Conference, Cape Town, South Africa

Why undertake seasonal price analysis?

"… to develop a short-term projection model to facilitate evidence-based decision making for fish farmers/stakeholders".

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Why undertake seasonal price analysis?

- Many factors affect the timing of marketing decisions by fish farmers:
  - storage availability,
  - cash-flow needs,
  - expectations of future trends in price, etc.
- The latter includes price changes due to both expected changes in *fundamental market variables* and the *normal seasonal trends*.
  - ✓ Understanding the dynamics of seasonal price trends is paramount for successful marketing and management decisions for aquaculture enterprises.

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Objectives and Motivation

1. Estimate monthly variations in catfish farm-gate prices over the years (8-years period),
2. Develop and test seasonal price forecasting models for monthly catfish farm-gate prices.

- The motivation for seasonal price analysis and forecast is to allow aquaculture producers to plan and manage price risk.
  - ✓ By knowing the best-selling period, farmers would benefit if they produce and supply fish during the peak price periods/months.

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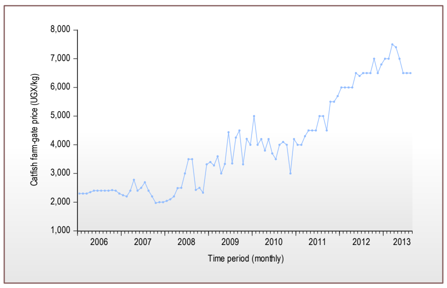
Time Series Data

- Catfish prices were collected from registered fish farmers in Kampala, Mpigi, Wakiso and Mukono districts from January 2006 to August 2013.

- Data were collected by the Aquaculture Management Consultants.



	Farm-gate Price	
	UGX/kg	US$/kg
Mean	4016.90	1.34
Median	3750.00	1.25
Maximum	7500.00	2.50
Minimum	1972.00	0.66
Std. Dev.	1650.49	0.55
Skewness	0.56	
Kurtosis	2.02	
Jarque-Bera	8.46	
Probability	0.01	
Observations	92	

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Obj. 1: Estimate monthly variations in catfish farm-gate prices

- Two types of information were extracted from the price data:

  1) Monthly price variations relative to the annual average price (i.e., monthly seasonal price indexes), and

The monthly price index is expressed as:

$$\sum I_m / n \text{, where } I_m = \frac{\text{Average monthly price}}{\text{Average annual price of year } t} \times 100$$

n = number of years covered by the data and t represent the particular year being considered.

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Obj. 1: Estimate monthly variations in catfish farm-gate prices

- Two types of information were extracted from the price data:

  1) Monthly price variations relative to the annual average price (i.e., monthly seasonal price indexes), and

  2) Price variability within a month during the 8-years under investigation.

Price variability

Certain times of the year may be more price volatile than others, and the difference between the maximum and minimum index for that month over the years will become wider.

This variability is based on the standard deviation of prices within that month. The average index plus or minus two standard deviation represents the range where the index for that month could be expected to fall 95% of the time.

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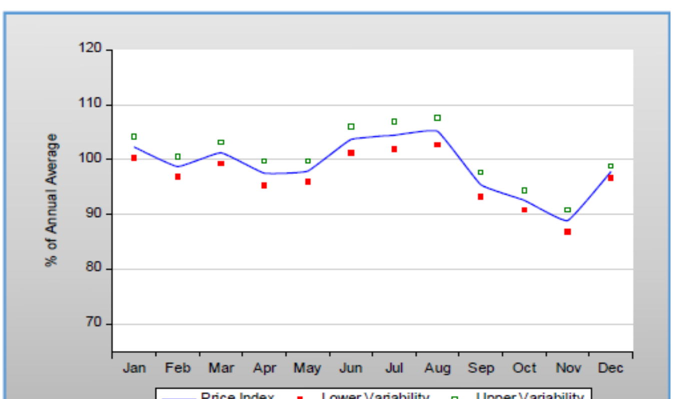
Estimated Catfish Monthly Price Index and Variability



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Price Index	102.25	98.70	101.24	97.52	97.86	103.64	104.43	105.12	95.40	92.56	88.85	97.76
Variability	1.95	1.85	1.9162	2.23	1.85	2.41	2.50	2.42	2.24	1.78	2.02	1.06

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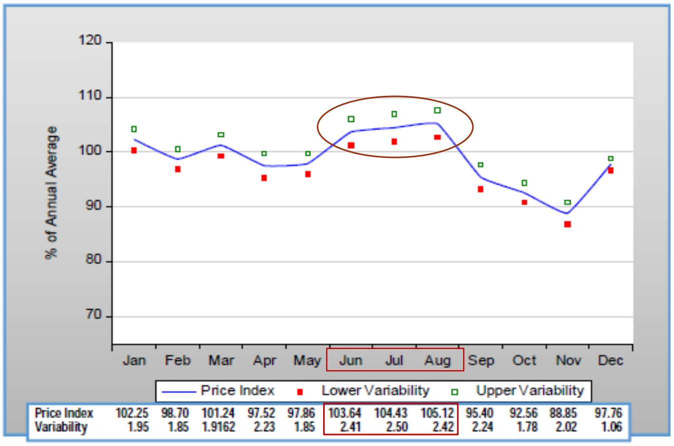
Estimated Catfish Monthly Price Index and Variability



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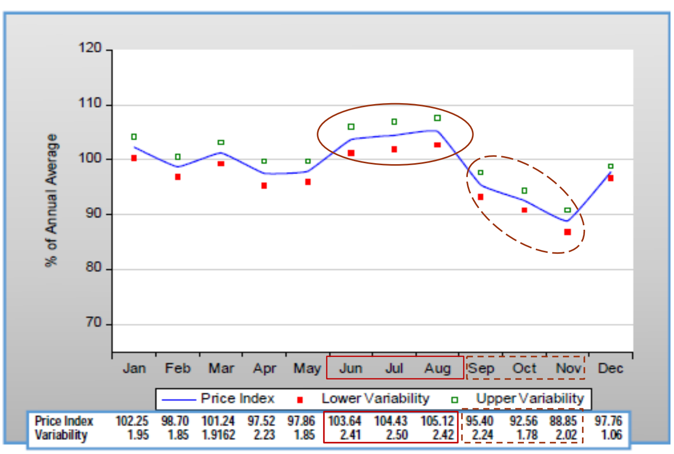
Estimated Catfish Monthly Price Index and Variability



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Obj. 1: Estimate monthly variations in catfish farm-gate prices

- What is the take home message:
  - ✓ The seasonal index show clusters of low- (Sept. Oct. Nov.) and high- (June, July Aug.) price-months.
  - ✓ The analysis can be used to develop market specific strategies to gain further market share.
  - ✓ The message to stakeholders (farmers, traders, policy makers) is that understanding price behavior across seasons and over time is essential as fish demand varies over species, seasons and markets.

Obj. 2: Develop and test seasonal price forecasting models

- The Box-Jenkins methodology was used:

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

Seasonal Autoregressive Integrated Moving Average

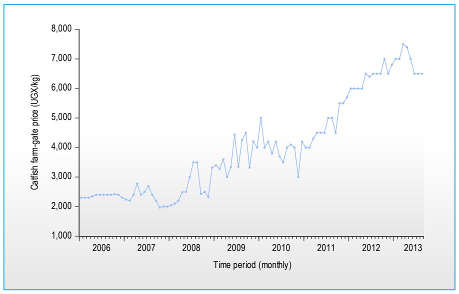
SARIMA (*p,d,q*)(*P,D,Q*)*s*

(*p,d,q*): Non seasonal part of the model; (*P,D,Q*): Seasonal part of the model

Where,

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

1) Identification: Stationarity Diagnostic in Level



Correlogram of CFPRICES

Date: 06/15/17 Time: 21:39
Sample: 2006M01 2013M08
Included observations: 92

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.945	0.945	84.867	0.000
		2	0.919	0.244	166.04	0.000
		3	0.892	0.043	243.27	0.000
		4	0.857	-0.075	315.39	0.000
		5	0.823	-0.040	382.79	0.000
		6	0.781	-0.111	444.17	0.000
		7	0.749	0.032	501.25	0.000
		8	0.705	-0.092	552.50	0.000
		9	0.667	-0.010	598.83	0.000
		10	0.633	0.031	641.10	0.000
		11	0.599	0.018	679.35	0.000
		12	0.561	-0.056	713.35	0.000
		13	0.524	-0.021	743.46	0.000
		14	0.479	-0.134	768.88	0.000
		15	0.441	0.002	790.73	0.000
		16	0.404	0.006	809.28	0.000
		17	0.371	0.043	825.12	0.000
		18	0.338	-0.002	838.44	0.000
		19	0.309	0.046	849.72	0.000
		20	0.271	-0.113	858.56	0.000
		21	0.246	0.063	865.92	0.000
		22	0.210	-0.112	871.39	0.000
		23	0.178	-0.030	875.35	0.000
		24	0.158	0.084	878.53	0.000
		25	0.134	0.053	880.85	0.000
		26	0.113	-0.018	882.52	0.000

- The ACF dies down slowly implying that the price series are nonstationary.
- Need to achieve stationary through differencing.

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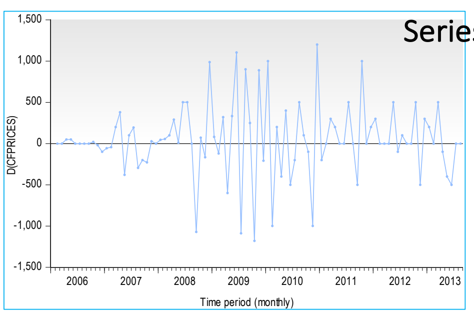
1) Identification: Stationarity Diagnostic in Differenced Series



Correlogram of D(CFPRICES)

Date: 06/15/17 Time: 19:55
Sample: 2006M01 2013M08
Included observations: 91

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.413	-0.413	16.006	0.000
		2	0.012	-0.191	16.020	0.000
		3	0.024	-0.061	16.074	0.001
		4	-0.085	-0.121	16.783	0.002
		5	0.094	0.011	17.662	0.003
		6	-0.079	-0.055	18.284	0.006
		7	0.142	0.122	20.324	0.005
		8	-0.052	0.065	20.600	0.008
		9	-0.035	0.002	20.726	0.014
		10	-0.074	-0.132	21.299	0.019
		11	0.091	0.018	22.176	0.023
		12	-0.034	-0.023	22.302	0.034
		13	0.108	0.131	23.572	0.035
		14	-0.085	-0.012	24.358	0.041
		15	0.001	-0.001	24.358	0.059
		16	-0.033	-0.068	24.480	0.080
		17	-0.003	-0.004	24.482	0.107
		18	-0.048	-0.141	24.752	0.132
		19	0.075	0.004	25.416	0.147
		20	-0.152	-0.232	28.185	0.105
		21	0.132	0.042	30.299	0.086
		22	-0.051	-0.030	30.614	0.104
		23	-0.044	0.011	30.855	0.126
		24	-0.022	-0.177	30.916	0.156
		25	-0.035	-0.070	31.074	0.187
		26	0.226	0.141	37.699	0.065

- Stationarity achieved after first difference.

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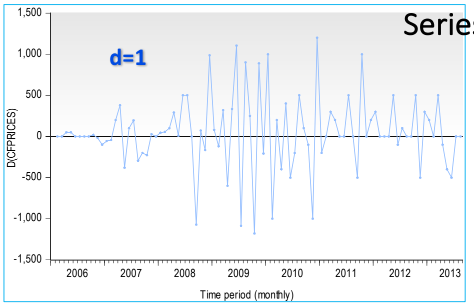
1) Identification: Stationarity Diagnostic in Differenced Series



Correlogram of D(CFPRICES)

Date: 06/15/17 Time: 19:55
Sample: 2006M01 2013M08
Included observations: 91

q=1 p=1

	AC	PAC	Q-Stat	Prob
1	-0.413	-0.413	16.006	0.000
2	0.012	-0.191	16.020	0.000
3	0.024	-0.061	16.074	0.001
4	-0.085	-0.121	16.783	0.002
5	0.094	0.011	17.662	0.003
6	-0.079	-0.055	18.284	0.006
7	0.142	0.122	20.324	0.005
8	-0.052	0.065	20.600	0.008
9	-0.035	0.002	20.726	0.014
10	-0.074	-0.132	21.299	0.019
11	0.091	0.018	22.176	0.023
12	-0.034	-0.023	22.302	0.034
13	0.108	0.131	23.572	0.035
14	-0.085	-0.012	24.358	0.041
15	0.001	-0.001	24.358	0.059
16	-0.033	-0.068	24.480	0.080
17	-0.003	-0.004	24.482	0.107
18	-0.048	-0.141	24.752	0.132
19	0.075	0.004	25.416	0.147
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24	-0.022	-0.177	30.916	0.156
25	-0.035	-0.070	31.074	0.187
26	0.226	0.141	37.699	0.065

- Stationarity achieved after first difference.

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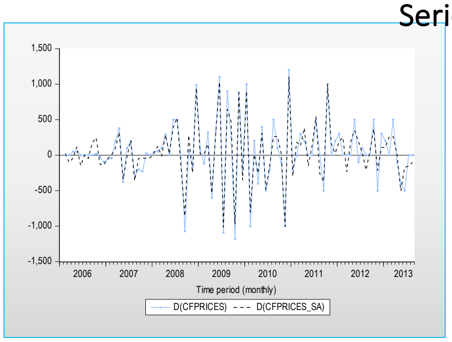
1) Identification: Stationarity in 1st Differenced/Seasonally Diff. Series



Correlogram of D(CFPRICES_SA)

Date: 06/15/17 Time: 20:05
Sample: 2006M01 2013M08
Included observations: 91

	AC	PAC	Q-Stat	Prob
1	-0.415	-0.415	16.189	0.000
2	0.003	-0.204	16.190	0.000
3	0.045	-0.048	16.388	0.001
4	-0.031	-0.034	16.483	0.002
5	0.004	-0.020	16.484	0.006
6	0.022	0.015	16.534	0.011
7	0.056	0.094	16.850	0.018
8	0.019	0.116	16.887	0.031
9	-0.059	0.013	17.252	0.045
10	-0.070	-0.118	17.759	0.059
11	0.188	0.119	21.480	0.029
12	-0.233	-0.141	27.316	0.007
13	0.204	0.084	31.841	0.003
14	-0.143	-0.097	34.075	0.002
15	0.059	0.002	34.460	0.003
16	-0.010	-0.007	34.471	0.005
17	-0.072	-0.071	35.067	0.006
18	0.035	-0.050	35.209	0.009
19	-0.010	-0.038	35.220	0.013
20	-0.100	-0.142	36.407	0.014
21	0.092	0.002	37.441	0.015
22	0.007	0.006	37.447	0.021
23	-0.027	0.080	37.538	0.029
24	-0.139	-0.247	39.983	0.021
25	-0.008	-0.127	39.991	0.029
26	0.223	0.137	46.459	0.008

- Spikes at seasonal lag 12 and 24 dies down at other seasonal lags.

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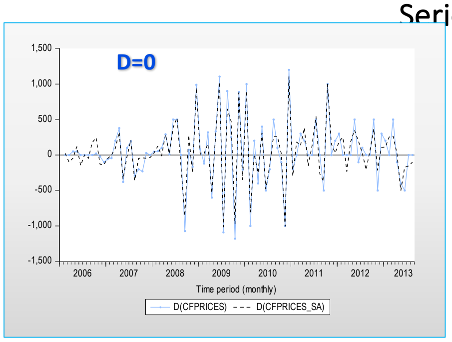
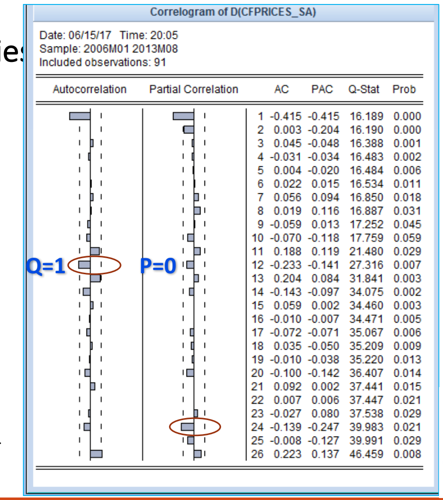
1) Identification: Stationarity in 1st Differenced/Seasonally Diff.

Serie





Correlogram of D(CFPRICES_SA)

Date: 06/15/17 Time: 20:05
Sample: 2006M01 2013M08
Included observations: 91

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4	-0.031	-0.034	16.483	0.002
5	0.004	-0.020	16.484	0.006
6	0.022	0.015	16.534	0.011
7	0.056	0.094	16.850	0.018
8	0.019	0.116	16.887	0.031
9	-0.059	0.013	17.252	0.045
10	-0.070	-0.118	17.759	0.059
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16	-0.010	-0.007	34.471	0.005
17	-0.072	-0.071	35.067	0.006
18	0.035	-0.050	35.209	0.009
19	-0.010	-0.038	35.220	0.013
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21	0.092	0.002	37.441	0.015
22	0.007	0.006	37.447	0.021
23	-0.027	0.080	37.538	0.029
24	-0.139	-0.247	39.983	0.021
25	-0.008	-0.127	39.991	0.029
26	0.223	0.137	46.459	0.008

- Spikes at seasonal lag 12 and 24 dies down at other seasonal lags.

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Obj. 2: Develop and test seasonal price forecasting models

- The Box-Jenkins methodology was used:
  1) *Identification*—Checking for stationary and select order of AR and MA parameters.
  2) *Model selection and estimation*—Seasonal and non-seasonal parameters.
  3) *Diagnostic checking and model validation*—Checking ACF and Inverse Roots plot of the residuals.
  4) *Forecasting* – In-sample and out-sample using selected model.

Seasonal Autoregressive Integrated Moving Average

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

Where,

p = AR = **1**,
d = differencing = **1**,
q = MA = **1**,
P = SAR = **0**,
D = seasonal difference = **0**,
Q = SMA = **1**,
s = Seasonal period = **12**

Suggested Model:

SARIMA (1,1,1) (0,0,1)12

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2) Model Selection and Estimation

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

Model	DF	AIC	BIC
$(1,1,0)(0,0,1)_{12}$	4	1338.21	1348.25
$(1,1,0)(1,0,0)_{12}$	4	1339.74	1349.78
$(1,1,0)(1,0,1)_{12}$	5	1336.98	1349.53
$(1,1,1)(0,0,1)_{12}$	5	1335.56	1348.11**
$(1,1,1)(1,0,0)_{12}$	5	1337.27	1349.82
$(1,1,1)(1,0,1)_{12}$	6	1334.86**	1349.92

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Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (BIC)

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Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	53.92268**	12.66242	4.258481	0.0001
AR(1)	0.116559	0.220851	0.527773	0.5990
MA(1)	-0.572016**	0.184696	-3.097063	0.0026
SMA(12)	-0.392383**	0.106068	-3.699333	0.0004
R-squared	0.258061	Mean dependent var	44.98257	
Adjusted R-squared	0.232179	S.D. dependent var	408.4772	
S.E. of regression	357.9297	Akaike info criterion	14.64198	
Sum squared resid	11017777	Schwarz criterion	14.75308	
Log likelihood	-654.8890	Hannan-Quinn criter.	14.68678	
F-statistic	9.970820	Durbin-Watson stat	1.979552	
Prob(F-statistic)	0.000010			

SARIMA (1,1,1) (0,0,1)12

Non seasonal part of the model AR(1) & MA(1)

Seasonal part of the model SMA(12)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	70.64316**	11.70813	6.033686	0.0000
AR(1)	0.108730	0.211294	0.514591	0.6084
SAR(12)	0.315928**	0.110643	2.855396	0.0056
MA(1)	-0.632748**	0.171522	-3.689028	0.0004
SMA(12)	-0.887421**	0.029651	-29.92928	0.0000
R-squared	0.443514	Mean dependent var	53.39806	
Adjusted R-squared	0.413022	S.D. dependent var	435.9070	
S.E. of regression	333.9679	Akaike info criterion	14.52192	
Sum squared resid	8142023.	Schwarz criterion	14.67299	
Log likelihood	-561.3550	Hannan-Quinn criter.	14.58240	
F-statistic	14.54509	Durbin-Watson stat	1.971844	
Prob(F-statistic)	0.000000			

SARIMA (1,1,1) (1,0,1)12

Non seasonal part of the model AR(1) & MA(1)

Seasonal part of the model SAR(12) &SMA(12)

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Obj. 2: Develop and test seasonal price forecasting models

- The Box-Jenkins methodology was used:

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Seasonal Autoregressive Integrated Moving Average

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

Where,

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

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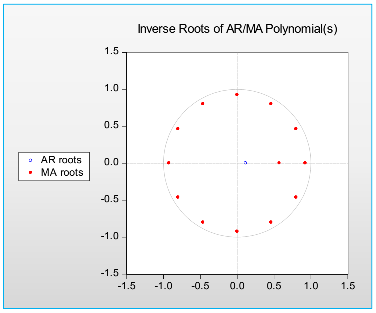
3) Diagnostic Checking and Model Validation for SARIMA (1,1,1) (0,0,1)12



The ARMA Process is stationary and invertible.

- There is no significant spike in ACF and PACF implying that the residuals are white noise (i.e., no serial correlation left in the residuals).

Correlogram of Residuals

Date: 06/19/17 Time: 13:19
Sample: 2006M03 2013M08
Included observations: 90
Q-statistic probabilities adjusted for 3 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.000	0.000	3.E-06	
		2	-0.015	-0.015	0.0201	
		3	0.017	0.017	0.0480	
		4	-0.024	-0.024	0.1027	0.749
		5	0.048	0.049	0.3282	0.849
		6	0.109	0.108	1.5035	0.681
		7	0.099	0.103	2.4806	0.648
		8	-0.016	-0.014	2.5074	0.775
		9	-0.048	-0.047	2.7384	0.841
		10	-0.086	-0.091	3.5036	0.835
		11	0.085	0.079	4.2655	0.832
		12	0.093	0.076	5.1794	0.818
		13	0.094	0.085	6.1373	0.804
		14	-0.088	-0.099	6.9746	0.801
		15	-0.067	-0.054	7.4729	0.825
		16	-0.050	-0.039	7.7487	0.860
		17	-0.068	-0.071	8.2799	0.874
		18	0.008	-0.041	8.2881	0.912
		19	-0.033	-0.070	8.4182	0.935
		20	-0.127	-0.129	10.335	0.889
		21	0.026	0.080	10.414	0.918
		22	-0.027	0.018	10.503	0.939
		23	-0.026	-0.002	10.588	0.956
		24	-0.164	-0.220	13.946	0.872
		25	0.032	0.033	14.077	0.899
		26	0.114	0.174	15.762	0.865
		27	-0.199	-0.161	20.974	0.640
		28	0.010	-0.015	20.986	0.693
		29	0.044	0.058	21.254	0.729
		30	0.025	0.103	21.342	0.770
		31	-0.012	0.034	21.362	0.810
		32	-0.005	-0.047	21.366	0.845
		33	0.066	0.063	21.989	0.854
		34	0.076	0.061	22.854	0.854
		35	0.085	0.152	23.941	0.847
		36	-0.020	-0.017	24.003	0.874

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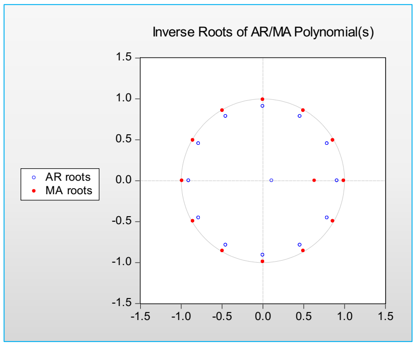
3) Diagnostic Checking and Model Validation for SARIMA (1,1,1) (1,0,1)12



The ARMA Process is stationary and invertible.

Correlogram of Residuals

Date: 06/19/17 Time: 14:43
Sample: 2007M03 2013M08
Included observations: 78
Q-statistic probabilities adjusted for 4 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.003	-0.003	0.0007	
		2	-0.003	-0.003	0.0015	
		3	0.011	0.011	0.0118	
		4	-0.035	-0.035	0.1136	
		5	-0.021	-0.021	0.1507	0.698
		6	0.019	0.018	0.1807	0.914
		7	0.081	0.082	0.7549	0.860
		8	-0.031	-0.031	0.8387	0.933
		9	-0.029	-0.031	0.9132	0.969
		10	-0.081	-0.083	1.5111	0.959
		11	0.043	0.051	1.6873	0.975
		12	-0.024	-0.022	1.7408	0.988
		13	0.071	0.068	2.2206	0.987
		14	-0.144	-0.163	4.2446	0.936
		15	-0.051	-0.043	4.5006	0.953
		16	0.003	0.006	4.5016	0.973
		17	-0.135	-0.118	6.3575	0.932
		18	-0.059	-0.083	6.7153	0.945
		19	-0.055	-0.073	7.0328	0.957
		20	-0.249	-0.283	13.684	0.622
		21	0.011	0.033	13.697	0.688
		22	-0.005	-0.040	13.700	0.748
		23	-0.076	-0.100	14.350	0.763
		24	-0.127	-0.210	16.209	0.704
		25	0.051	0.034	16.511	0.740
		26	0.089	0.073	17.451	0.738
		27	-0.214	-0.241	23.042	0.458
		28	0.098	0.017	24.232	0.448
		29	0.052	-0.008	24.576	0.486
		30	0.056	0.044	24.991	0.519
		31	-0.012	-0.027	25.010	0.574
		32	-0.039	-0.159	25.216	0.616

- We observe a spike in ACF and PACF at lag 20 implying that the residuals are not white noise (i.e., presence of serial correlation in residuals).

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Obj. 2: Develop and test seasonal price forecasting models

- The Box-Jenkins methodology was used:
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Seasonal Autoregressive Integrated Moving Average

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

Where,

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

Selected Forecasting Model:

SARIMA (1,1,1) (0,0,1)12

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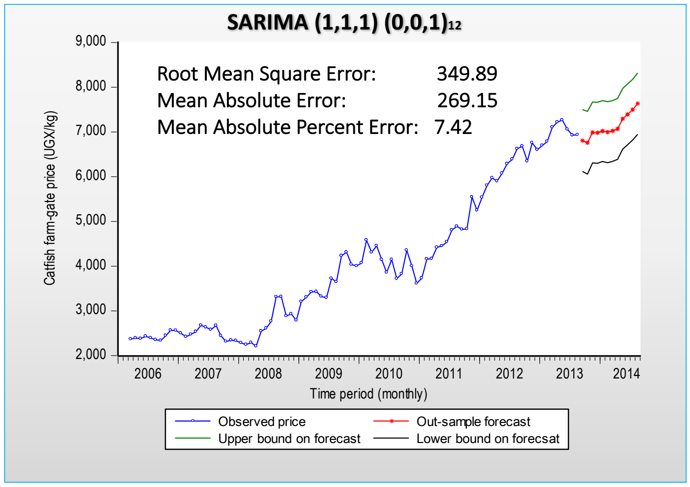
4) Seasonal out-sample forecast results



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Out-sample Forecast

SARIMA (1,1,1) (0,0,1)$_{12}$			
Time period	Forecast UGX/kg	Lower bound	Upper bound
2013m9	6973	6282	7665
2013m10	6871	6170	7571
2013m11	7003	6321	7685
2013m12	7018	6337	7700
2014m1	7044	6364	7725
2014m2	7025	6344	7707
2014m3	7036	6358	7715
2014m4	7078	6400	7757
2014m5	7260	6582	7939
2014m6	7361	6683	8039
2014m7	7461	6782	8140
2014m8	7464	6779	8148

Cluster of Low-price months
Sept., Oct., and Nov.

Cluster of High-price months
June, July and Aug.

Conclusions

- While prices in a specific year do not always follow the seasonal pattern; the seasonal price index provides useful information regarding long-term price patterns that can be used for decision making.
- The results show clusters of low- (Sept., Oct. & Nov.) and high- (June, July & Aug.) price months over the studied and forecasted periods.
- Seasonal price analysis can help producers develop marketing strategies as well as adjust production to meet the selected marketing strategy.
  - ✓ It is worthy noting however, that as price pattern may not be similar in all markets, local level market prices must be used in making decisions on production, harvesting and sales.
- Study Limitations:
  - ✓ Data and coverage.
  - ✓ Sample size.

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Acknowledgments

Funding for this research was provided by the

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Consumer preferences and consumption patterns for fishing Uganda

Halasi G Z*, Hyuha T.S, Chimatro S.K, Egna H, Molnar J.J., Ekere W, Elepu G., and Walekwa P.
Department of Agribusiness and Natural Resource Economics , Makerere University, P.O. Box 7062 Kampala, Uganda
gidongohz@gmail.com

The current government policy on aquaculture is promotion of the subsector to compliment the dwindling capture supplies from the wild to improve food fish, nutrition and eradication of poverty. Much as the government is pursuing this policy there exist limited information on the consumer behavior between captured and farmed fish. The objective of the study was to establish consumer preferences and consumption patterns for the two categories of fish. This study was carried out in the purposively selected districts representative of Uganda fish consuming community living near major landing sites, that is, Nebbi, Kampala, Busia, Kasese, Kisoro and Kabale . A total of 250 consumers were randomly selected and interviewed using a structured questionnaire. Descriptive statistics and regression analysis were the methods used to analyze the data.

The results show that the consumers' average age was 33years having a household size of 6.74persons and earning 628,200UGx monthly. Distance to fish source was 3.49km while 70% of the respondents had eaten fish as a protein source for an average of 23 years. 92.5% bought tilapia which was mainly (62.2%) captured fish. When buying fish, 70% of fish consumers considered fish species as the most important attribute. The majority (55%) of consumers purchased their fish from traditional markets and the rest from road side markets and landing sites. On average, consumers bought fish about 6 times per month, resulting in total consumption of 13.86 kgs. Thirty two percent of the fish consumers perceived the fish obtained from shallow muddy waters as of low quality, while 32% perceived farmed fish as more bonny and small (300gms) compared to capture fish which are fleshy and averaged a weight of 500gm and above. Many consumers (67.5%) preferred smoked fish and mainly (75%) prepared fish by boiling method.

Econometric results show that annual household income and education level significantly affected fish consumption patterns. In view of the results, it is recommended that researchers should breed fleshy easy to farm fish species which can grow to 500gm preferred by consumers. In order to address the issue of muddy fish smell, there may be a need to design fish production systems that avoid fish proximity with mud during the production process.

CONSUMER PREFERENCES AND CONSUMPTION PATTERNS FOR FISH IN UGANDA

By

Halasi G Z, Hyuha T S, Ekere W, Elepu G, Walekwa P, Molnar J J, Chimatiro S K and Egna H.

Presented at World Aquaculture conference in Cape Town 2017

Background

The Ugandan Government(GOU) has a policy to promote the fish sector in the areas of production, processing, marketing and consumption along the value chain(NDP,2010).

This is compliment the dwindling capture supplies from the wild to improve; food fish, nutrition and eradication of poverty.

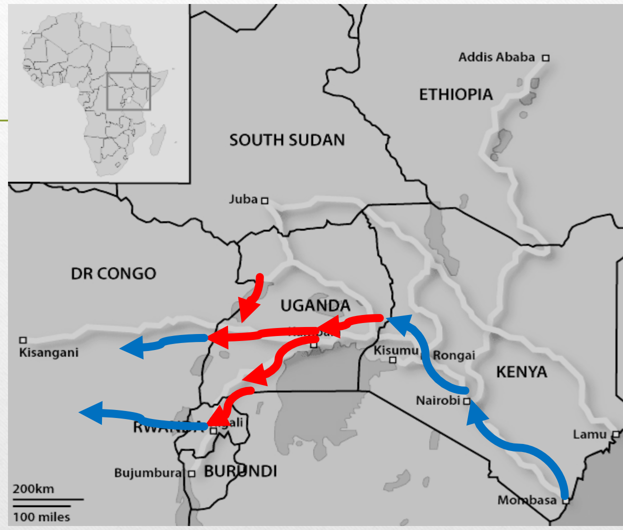
Much as the GOU is pursuing this policy there exist limited information on the consumer behavior on fish.

Bukenya et al. (2013), Hyuha et al.(2011) and Ssebisubi(2010) concentrated on production and marketing. Ondonkara(1985) and NARO (2000) did consumption more than 16 years ago.

However, farmers or traders marketing fish need to understand what the current final fish consumers wants.

Producers can base on these findings to structure their production strategies

Map showing study area



Objectives

1. To Characterize fish consumers in Uganda
2. To Establish consumer preferences / consumption patterns for fish in Uganda
3. To establish determinants influencing consumption patterns for fish in Uganda

Methodology

Data collection

This study was carried out in the purposively

Selected districts i.e. Busia, Kampala, Kasese, Kisoro and Kabale and Nebbi .

A total of 250 consumers were randomly selected

Focus group discussions & Interviews using a semi structured questionnaire were done.

Data Analysis

Descriptive statistics and regression analysis were used to analyze the data.

Characteristics of fish consumers in Uganda

Description(n=250)	Value(UGx)	Value (US$)
Age	41.3 years	
Education level	7.6	
Number in house hold	6.7	
Distance to selling point	3.5 km	
Occupation	Peasant-64.7%, Business-26.3 Civil servants-9.0%	
Period been eating- Farmed fish Captured fish	4.0 years 24.5 years	
Monthly expenditure on fish	98,546.00UGx	28.16
Expenditure per month	628,200.00UGx	179.49

Preferences of fish consumers in Uganda

Description		%	Remarks
Can differentiate farmed from captured fish	Yes No	29.0 71.0	Those near lakes know
Preferred production system	Lake Pond Cage river	88.1 7.1 2.4 2.4	Cage system is still new
1st choice species preferred for buying	Tilapia Nile perch Lungfish Silverfish others	75.2 12.1 6.1 3.6 3.0	Tilapia is more delicious of them all
Preferred tilapia capture source	George Albert Victoria Edward	36.0 28.0 20.0 16.0	The fish has a nice salty Feeling in George
Preferred fish sex	Female Male Just buy	53.0 07.0 40.0	Females are fleshy, fatty & have eggs

Preferences of fish consumers in Uganda cont.

Description		%	Remark
Most important attribute	Species Price Liked by all Freshness form	61.2 18.3 8.1 7. 0 5.4	Some species i.e. tilapia have almost turned traditional
Preferred body part	Middle Head Tail	63.6 30.3 6.1	Muscles are preferred
Satisfied with fish in market	Yes No	21.2 78.8	Always small sized fish
Silver fish is eaten by both rich & poor households	Yes No	93.2 6.8	Medicine, nutritious cheap
Factory fish bone remains ***(mungongo wazi)*** are good for H'H consumption	Yes No	7.2 92.8	Better soup Eaten as last resort

Consumption Patterns of fish consumers in Uganda

Description		Capture
Fish availability at selling location per months		12.8 times / month
Consumption per annum		24.05 kg
Fish forms consumed	Smoked Fresh Live Sun dried Salted	57.1 18.4 16.5 5.9 2.1
Fish Preparation method	Boiling Fried Pasted Deep fried	66.7 18.5 11.2 1.9
Fish species most bought	Tilapia N/Perch Catfish	81.9 14.4 3.7

Consumption Patterns of fish consumers in Uganda

Description(n=250)		Capture (%)
Where eat fish	Home only Away home only Both home & away	57.9 3.7 38.4
Purchase fish from	Markets Roadsides fish stalls Landing site/ponds	57.0 29.2 13.8
Believes farmed fish is always <300gm & bonny	Yes No.	70.0 30.0
Believes capture fish is always fleshy & > 400gm	Yes No	71.2 28.8
Better fish management can improve farmed fish quality	Yes No	77.3 22.7
Best way to Improve H'H fish consumption	Increase H'H income Increase fish S'S Price reduction	55.2 25.6 19.2

Determinants of fish consumption Pattern

Variable(n=250)	Coefficient
Amount spent on substitutes	0.104***
Number of times fish available at selling point	0.126**
Education level	0.248*
Eats fish away from home	0.132*
Perceived fish quality	0.257*
Period eating fish	0.451
Number in house hold	0.278
Age of respondent	0.686
Distance to selling point	0.491
Has income generating activity	0.379
Adjusted Rsquare 0.44	
***significant at 1%, ** significant at 5%, * significant at 10%	

Conclusion

- Consumption of fish substitutes, reduces pressure on capture fisheries
- Fish consumer attitudes towards farmed fish have been negative because they perceive the size to be too small and not fresh
- Consumers prefer female fish due to its being relatively fleshy, fatty body and possession of eggs, though MAAIF promotes tilapia female sex reversal to males.
- Consumers are not happy with immature capture fish always available on the market.
- Eating fillet boney remains(***mugongo wazi***) is an act of desperation.
- Silverfish is liked and eaten by the rich and poor.
- The rate at which fish is available influences the fish consumption patterns.

Recommendation(s)

- As government and other stakeholders promote production / consumption of fish emphasis should also be given to its substitutes
- Research needs to be done to promote female tilapia with a fleshy & fatty body alongside having it not to producing.
- Proper fish farm management to produce large, high quantity & quality farmed fish is key to change negative attitudes of these fish consumers
- Nutritionists need to take careful look at how households consume their fish. The consumption pattern may be only beneficial to the household head leaving family malnourished.
- Need to aggressively promote consumption of silverfish to reduce pressure on big sized fish(Nile perch) which can bring Uganda foreign exchange.

Funding for this research was provided by the

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Women involvement in coastal activities and community based mariculture in Zanzibar, Tanzania

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Women play various roles along the coast of Zanzibar, Tanzania which contributes to their socio-economic wellbeing. Usually women have traditionally been involved in gleaning the coast, collecting shells of different types as well as collection of sea cucumber, also crab harvesting and recently seaweed farming. Of late they are also actively involved in processing and selling fish and from 2003 in bivalve farming and from 2006 in half pearl farming including jewelry making using shells. Despite their involvement in activities of this sector, women's operations are often small-scale and their incomes small as compared to their men counterparts. They are also faced with various constraints. This paper elaborates the different activities women do and how they have been empowered economically through attempts to culture bivalves, half pearls and making jewelry using shells in a sustainable manner using no take zones and a new methodology of spat collectors which was introduced through the Aquafish project. Also, how they have become stronger though collaborative efforts in enhancing these Mari culture initiatives. The achievements, challenges obtained up to now and the future directions are presented. This case studies could be useful examples for other countries facing similar problems to try.

WOMEN INVOLVEMENT IN COASTAL ACTIVITIES AND COMMUNITY BASED MARICULTURE IN ZANZIBAR,TANZANIA

Narriman S. Jiddawi and Maria Haws
IMS HILO

AQUA FISH COLLABORATIVE RESEARCH SUPPORT PROGRAM

UNIVERSITY OF HAWAI'I HILO

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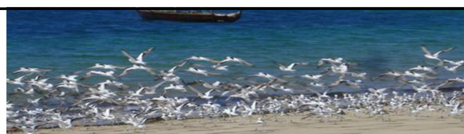


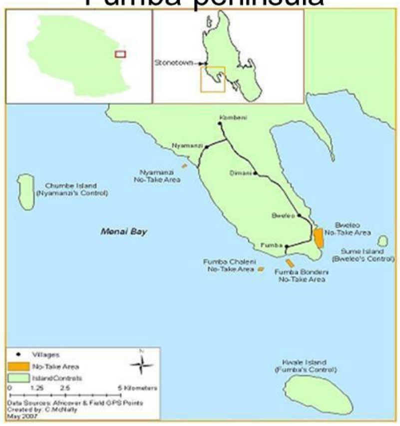
Tanzania has a coastline of about1400km

Zanzibar (Unguja and Pemba is on the East coast of Tanzania)

Coastal activities are related to weather condition tides, social activities, local beliefs.

Study site

Fumba peninsula



Unguja island

Introduction

- Analysis about the distinct roles played **by male** and **female** members of the community has aroused concern and it is **generally agreed that women** in Zanzibar, occupy an inferior position in society and that a heavy burden has been placed on them in comparison with men counterparts.

- Several factors seem to contribute to the inferior position and suppressed rights and privileges of women in society. **Tradition and culture, social and religious norms** and values; **economic factors** all contribute to the lowering of the status of women in society

Introduction

- Women generally work for long hours in most coastal communities.
- The men's job is to bring in money or food to support the family but the in traditional society, women are obliged to take care of the family; feed them, cloth them, train and educate them regardless of their men counterpart's contribution
- They bear the moral obligation of doing all the domestic work of cooking, washing, cleaning, sweeping, fetching water and the fuel wood they use in cooking with hardly any men participation

Despite the numerous tasks and responsibilities and the important role women play they continue to play very significant roles in the socio-economic development of society and the state Women play various roles which contributes to their socio economic well being e.g:

- Seaweed farming, Collection of sea-cucumbers
- Collection of shells, Bivalve farming
- Octopus fishing, Processing and selling fish

To address these problems (especially their low income) it was realised there was a need to introduce new alternative livelihoods to empower them economically through :

- Half-pearl culture
- Jewellery making using shells

The main objective was:

To empower the women economically by providing new livelihood and reduce pressure on marine resources

SEAWEED **FARMING**

Bivalve fence farming from 2003 - Mcnight Project

Fish (milk fish) and bivalves ponds in Makoba and Bumbwini

A new initiative - pearl farming in Unguja Ukuu, 2017

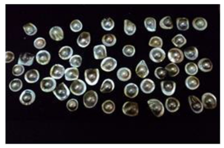
A new project :Sea power Pilots with Zanzibar women producers (F.Msuya, N.Jiddawi, C. Brugere, Ritha M and B. Nyonje. 2017)

Improved seaweed farming technology for livelihoods, women' empowerment and environmental protection in Mungoni;

Tubular nets technology:

- **Cost-effectiveness**-Once made tubular nets take more than 2 years before they can be replaced. Ropes take 6months
- **Reduced impact on women's workload and exposure to hazards**: farming materials are transported on boats, not by head. Women do not sit on seawater, no chance of getting stung, cuts from sharp shells
- **Positive contribution to: local livelihoods and economy** -more production per unit area (0.35kgmore); fish catches under the tubular net rafts
- **Women's empowerment**- working with men at equal terms. Sharing harvest
- **Ecosystem health**- not trampling on organisms, no destroying fish nurseries, no tree cutting-no pegs used.

Pearl farming



- Started in 2006. Introduced through SUCCESS project
- The type of mollusc used to produce the half peals are bivalves such as *Pteria, Isognomon* and *Pinctada* species. It is still ongoing

1st pearls harvested in Zanzibar in 2008

How do the pearl farming become sustainable

Spat is a very young pearl oyster

- If too many adults are taken for pearl farming, they will become very rare or disappear
- One way to prevent this is through spat collection, hatchery, no take zone
- Easy way to provide a lot of young oysters
- Less effort than diving
- More reliable once methods are worked out
- Young oysters produce better pearls
- Avoids harming adult oysters which should be left to breed

The first bivalve hatchery in Tanzania (under Woodshole support) was installed at IMS in in March 2010

The idea for the hatchery was motivated by interest from the local community in expanding the production of indigenous shellfish for food, for pearl farming, and for jewelry making using shells

Monitoring in Community managed no-take areas in Fumba

Photo credit : N.S.Jiddawi

Presenting monitoring results to community members

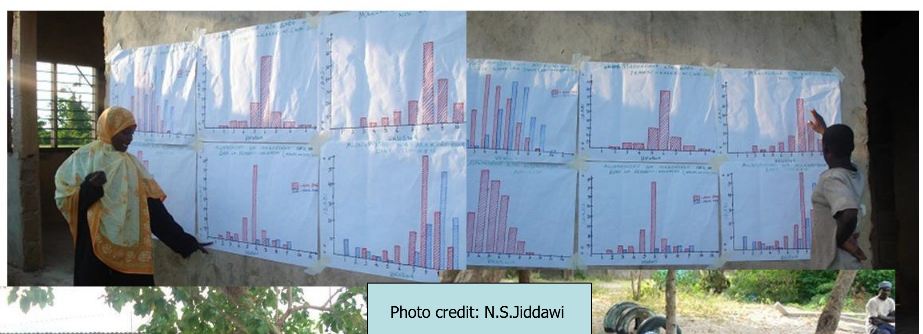


Photo credit: N.S.Jiddawi

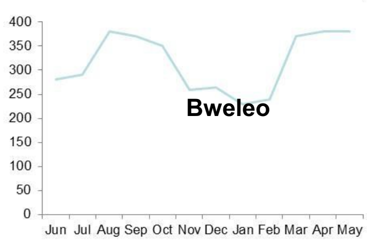
Spat collection

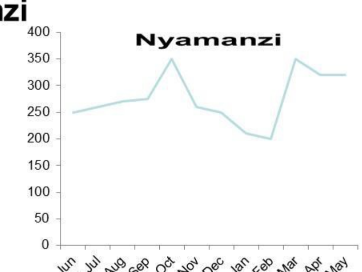
- The spat collection experiment involving women was done from May 2016 to June 2017 and produced a total of 3354 *Pinctada margaritifera* spat and 3861 *Pteria* spats at Bweleo and Nyamanzi respectively

The spat collectors were hung on rafts

New Spat collectors

Monthly numbers of spat settlement at Bweleo and Nyamanzi





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

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

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

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


Cultural changes for women

Woman are learning how to swim at Bweleo

Funding for this research was provided by the

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Analysis of fish trade in the eastern corridor: The case of central Uganda

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Fishing in Uganda is one of the few livelihood activities that hold great potential for income generation and poverty reduction especially among the individuals or households living in both near and far away from water resources in Uganda. However, the fisheries subsector has of recent suffered a setback due to dwindling fish supplies from the lakes and rivers and an infant subsector. Compared to other branches of agriculture, fisheries industry has received less research, especially in the area of socioeconomics, particularly marketing. This study set out to contribute to this knowledge gap. The main objective of the study was to examine the market structure, conduct and performance of aquaculture subsector.

The study was conducted in the districts of Mpigi, Mukono, Wakiso and Kampala -the major fish producing and consuming markets in Uganda. A pretested structured questionnaire was used to collect data from a randomly selected sample of 232 of fish traders. The collected data were then coded and analyzed by employing SPSS and STATA computer programs. Both descriptive and econometric methods were used to analyze the data. A Structure conduct and Performance (SCP) framework was adopted; a concentration ratio and Hirschman Index (HHI) were computed.

The results show that fish trade is dominated by males at wholesale (26.7%) level while female dominate (38.4%) at retail level. The results also show that there are significant differences between the two gender categories. Location had significant influence on fish trade and urban area was more favored. The computed Concentration ratio of 0.799 implied that a few traders dominate the fish market. The computed HHI index was 0.5 reinforcing the preceding findings. Thus, there seems to be limited competition among fish traders leading to inefficiencies. Econometric results revealed that the significant factors affecting marketing efficiency include: gender, transport costs, selling price and the district of origin for fish.

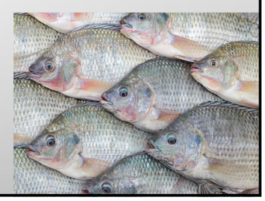
There is a need for policies geared towards improving gender relation, infrastructure in terms of roads to reduce transport costs and improving market information relayed to the farmer. To improve market structure, efforts to reduce barriers such as high taxes to market entry should be made.

ANALYSIS OF FISH TRADE IN THE EASTERN CORRIDOR: THE CASE OF CENTRAL UGANDA

By:

Asero Diana, Hyuha Theodora, Egna Hillary, Chimatiro Sloans. K, Molnar Joseph. J, Ekere William

World Aquaculture Society Conference,26th-30th June 2017, Cape town, South Africa



Introduction

- Whereas several studies have been conducted on the fisheries sub sector, a few of these studies have covered socio economics,
- Ssebusibi (2011), focused on analysis of small scale fisheries value chain in Uganda and focused on aquaculture production and market structure.
- Fish marketing sector is faced by various drawbacks:
- Suffers from uncoordinated marketing systems due to inefficiencies in the market system coupled with poor market structure
- Knowledge of the structure, conduct and performance would be vital in developing trade offs that will help the traders get profits and consumers pay the right price for their fish and the fish products.

Research objectives

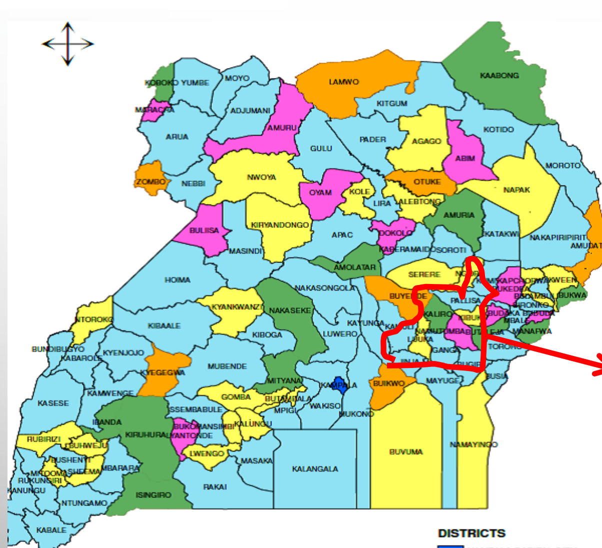
General objective

- ❑ To examine the market structure, conduct and performance of fish traders in central Uganda.

Specific objectives

- ❑ To determine the degree of market concentration among fish traders
- ❑ To assess the market conduct of the fish traders in selected districts
- ❑ To determine the market performance in terms of level of marketing efficiency of fish traders
- ❑ To determine the factors affecting market efficiency among fish traders in the selected districts.

UGANDA STUDY DISTRICTS

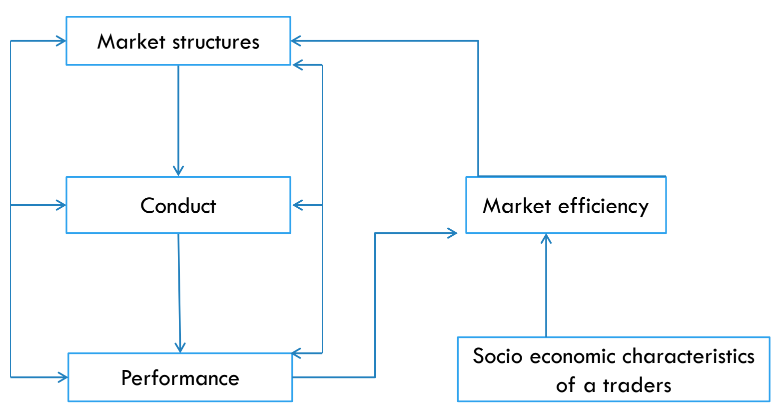


STUDY DISTRICTS
- Kampala
- Wakiso
- Mukono
- Mpigi

Methodology

- ❑Fish traders were randomly selected from landing sites, roadside sellers and wholesalers
- ❑A total of 232 traders was covered
- ❑ A pretested structured questionnaire was used to collect data
- ❑The collected data were then coded and analyzed by employing SPSS and STATA computer programs.
- ❑Both descriptive and econometric methods were used to analyze the data.

Conceptual framework



Socio demographic characteristics of the fish traders

Characteristic	Category of trader		P- value
	Retailer	wholesaler	
Age	34.91	33.89	0.4893
Education	7.53	9	0.0124
Market experience	7.88	8.79	0.3341
Initial capital required to start business	1,294,116	6,814,116	0.0004

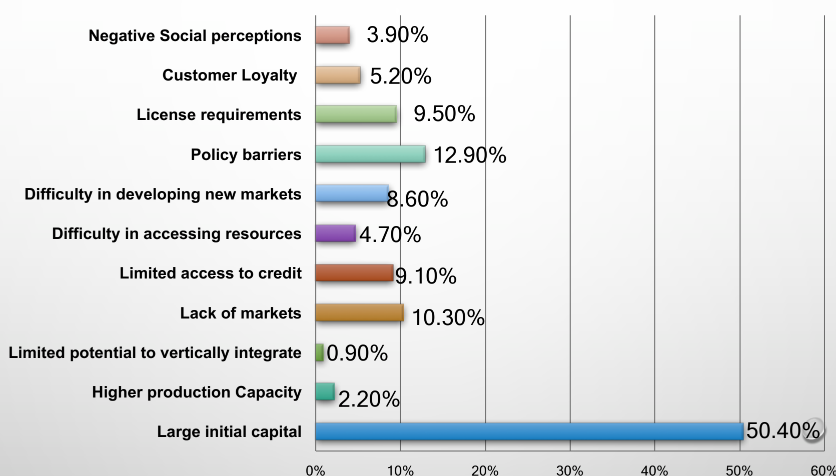
Socio Economic ……..

	Category of fish trader		Pearson Chi2	P- Value
Gender	**Retailer**	**Wholesaler**		
Female(n=107)	38.36	7.76	27.4158	0.000
Male (n=125)	27.16	26.72		
Location of trader outlet				
Roadside	24.09	1.36		
Town	34.55	21.82	42.5452	0.000
Mobile	1.82	0.45		
Rural	3.64	10.00		
Exporter	1.36	0.96		

Market structure of fish traders

- The concentration ratio was 0.779 as calculated implying that there were a few traders in the fish markets.
- The computed Herfindal Hirschman Index HHI index was above 0.5 reinforcing the preceding findings.
- Thus, there seems to be limited competition among fish traders leading to inefficiencies.

Barriers to entry

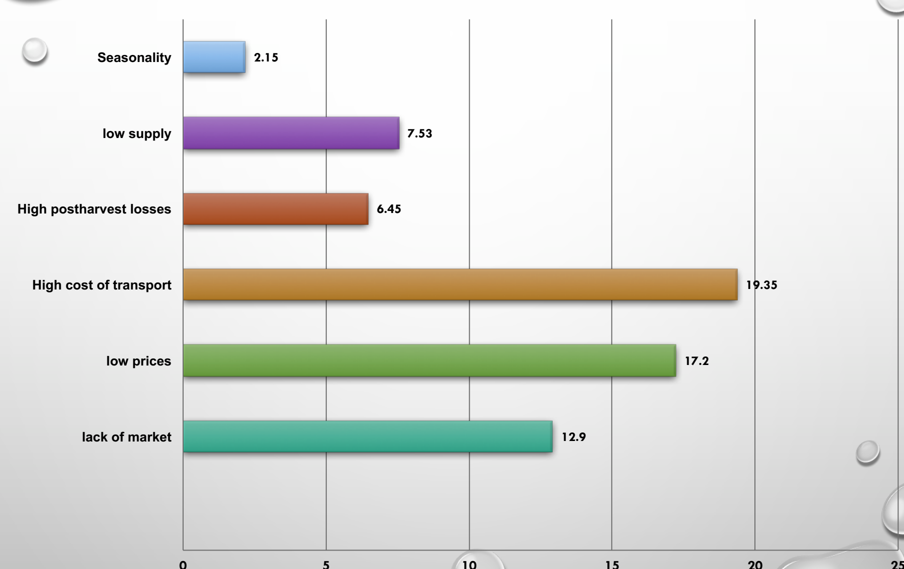


Market conduct

- Pricing strategies

Pricing strategies	Frequency	Percentage	Standard deviation
Price penetration	33	14.22	0.350
Price skimming	44	18.97	0.393
Lead pricing	4	1.72	0.130
Cost plus pricing	108	46.55	0.499
Break even pricing	2	0.86	0.093
Geographical pricing	4	1.72	0.130
Perceived pricing	23	9.91	0.299
Volume pricing	50	21.55	0.412
Single pricing	92	39.66	0.490
Discounts pricing	46	19.83	0.399
Loss leader pricing	31	13.36	0.341

Market constraints faced by the fish traders



Marketing margins and marketing efficiency

	Selling price (Ug.shs/kg	Purchase price (Ug.shs/kg)	Profit Margin	Marketing Margin	Marketing Efficiency
Retailers	8654.61	5451.463	3,203.125	25.72	29.49
Wholesalers	9441.88	7550.1	1891.87	7.07	2.07

- The computed marketing margins and efficiency reveal that the retailers received higher marketing margins and more efficient than the wholesalers

Multiple linear regression

Percent Marketing Efficiency	Coef	Standard Error	P > | t |
Age of the trader	-1.0126	1.078	0.348
Market experience of trader	5.4904	1.692	0.001
Gender of trader	-31.633	20.79	0.130
Storage costs	0.0002	0.000	0.393
Transport costs	-0.0006	0.000	0.011
Hiring Labour costs	0.0001	0.000	0.000
Selling Price	0.0155	0.001	0.000
Purchasing Price	-0.0171	0.002	0.000
Education	-0.0715	2.347	0.976
Wakiso	31.735	29.01	0.276
Kampala	-17.449	26.42	-69.51
Mukono	6.8839	36.57	-65.19
Cons	2.3410	47.82	0.961
F(12, 219)	19.45		
Prob > F	0.000		

Conclusion

- From the study, it can be concluded that fish trading is an important livelihood economic activity in Uganda
- Fish trading is dominated by males
- The fish markets have a few traders given the calculated concentration ratio of 0.779 and HHI indices above 0.5
- The most used pricing strategy used by traders was cost plus pricing
- Fish traders who were retailers were more efficient than their wholesale counterparts.

Recommendations

- There is need to come up with strategies on how to reduce transport costs incurred by the fish traders
- To improve on market structure, efforts should be made to reduce on barriers to entry especially reduce taxes and also look into trade license requirements
- Government should set up policies that allow traders to borrow money at a favorable rate hence boost their businesses and also increase on the number of traders in the market hence cutting down on their monopoly powers
- There is need for policies geared towards gender relation especially towards women traders since they play a key role in fish trade.

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Implementing a mobile-based application for marketing and technical support: Developing a sustainable system for fish farmers in Uganda

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Mobile phones have a rapid diffusion rate and facilitate farmers' access to information, helping increase their bargaining power, control over external events, develop new skills and grow revenues. For instance, in Tanzania the arrival of mobile phones, transformed agricultural business performance at all points by augmenting farmers' access to education and vital market information. Matuha (2015) found that fish farmers use mobile phones to access technical guidance from intermediary farmers, obtain market information, accomplish mobile banking and receiving, contact family members and make plans for procurement of fish farming inputs. Factors that seemed to discourage mobile phone use included: lack of electricity, poor network coverage, high calling credit and maintenance costs, lack of awareness and promotion. On the other hand, information regarding stocking and harvesting, feeding management, pond construction and management, disease management, water quality management, broodstock management and market prices were information topics most needed by fish farmers.
Several different business models have emerged in efforts to provide technical support to African farmers with cell phones. Each varies in the level of public sector control, business model, cost, and flexibility. One commercial model invites farmers to subscribe to a fish-focused network of producers managed by a service provider who moderates the transactions and may be compensated by subscription fees, transaction fees, or commissions. The entrepreneur firm builds and supports a network of suppliers, producers, and buyers whose transaction costs support the network. The source of technical information may be uncertain, but the responsiveness to technical questions may be rapid because the entrepreneur is motivated to keep and grow the number of participants. This is the approach we take in Uganda. The purpose of this paper is to describe the implementation of a mobile-based application for fish farmers, participation processes, and services provided. The conclusion considers how ICT advances food security and development by empowering farmers and linking them to each other, extension, and input suppliers.

Feed the Future Innovation Lab for
Collaborative Research on Aquaculture & Fisheries

IMPLEMENTING A MOBILE-BASED APPLICATION FOR MARKETING AND TECHNICAL SUPPORT: DEVELOPING A SUSTAINABLE SYSTEM FOR FISH FARMERS IN UGANDA

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Mobile revolution *moving from ear to hand*

- Mobiles most widely distributed computers
- Even poor countries ~66% access
- "more-than-voice" services
- Platform for other services
- Boosting innovation
- Mobile applications ("apps")

Mobile is new communication channel to farmers

- Complements other extension methods
  - One-on-one
  - Group—meetings, trainings
  - Media—radio, newspaper
  - Publications—leaflets, manuals

Mobile is new communication channel to farmers

- Extension connection
- Institutions lag private sector and personal practice
- Extensionists often not enabled or trained to use tools
  - Organizations lack capacity to provide support
  - Cannot not use what you do not understand

The purpose

- Implementation of a mobile-based application for fish farmers
- Participation processes
- Application preview

Fish species cultured in Uganda

- Nile tilapia (*Oreochromis niloticus*)
- African Catfish (*Clarias gariepinus*)
- Common carp (*Cyprinus carpio*)
- Indigenous species (e.g. lungfish)

POPULATION COVERED BY MOBILE CELLULAR NETWORKS IN UGANDA(%)

2010 Penetration Rate 31% of 35 million Uganda Population.

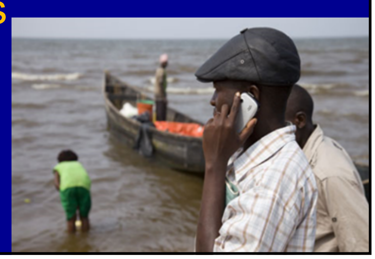
Rank	Operator	Technology	Subscribers (in millions) 2009	Ownership
1	MTN	GSM, CDMA, GPRS, EDGE, WiMAX, HSDPA	5.222	MTN (97%)
2	Airtel	GSM, GPRS	2.377	Bharti Airtel (100%)
3	UT Mobile	CdmaOne, GSM, UMTS, HSDPA	1.65	Uganda Telecom Limited
4	Warid	GSM, GPRS, EDGE, WiMAX	1.20 [	Warid Telecom
5	Orange Uganda	GSM, GPRS	0.350	Orange SA (53%)
6	Essar	GSM, GPRS	*licensed 1 June 2009*	Essar Group (90%)

Source: Wikipedia

Mobile Application for Uganda Fish Farmers

Mobile Use by Farmers in Aquaculture

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



Mobile Phones Connect

- Timing harvest for best price
- Improve middleman functioning
- Transfer cash by text message
- "Branchless microbanking system"
- Allows remote areas cash access

Farmer's Own Words 1/3

- *"Through mobile phones, I have been able to to call a fellow fish farmers that have been in the business or contact the middle men to locate for market, however, we end up selling at a loss since we have to pay the middle men. The government should really help us".*

Farmer’s Own Words 2/3

- *“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”*

Farmer's Own Words (3/3)

"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"

Tanzania (Timuray 2014)

- Arrival of mobile phones transformed agricultural business performance at all points
- Augmented farmers' access to education and vital market information

Uganda (Matuha 2015)

- Fish farmers use mobile phones to access technical guidance from intermediary farmers
- Obtain market information
- Accomplish mobile banking
- Contact family members
- Procure of fish farming inputs

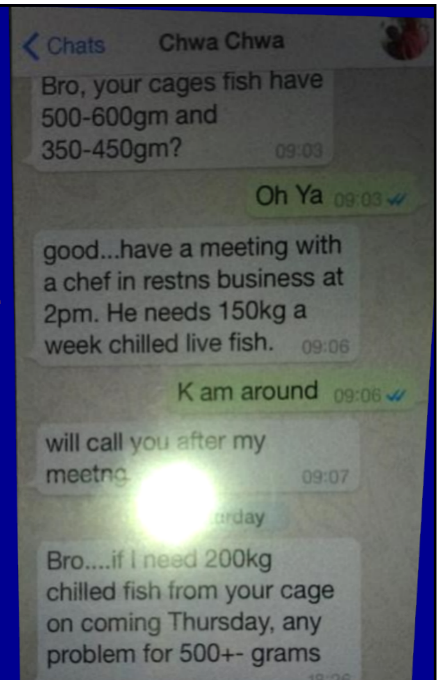
Factors discourage mobile use

- Lack of electricity
- Poor network coverage
- High calling credit costs
- High maintenance costs
- Lack of awareness and promotion

Topics most needed by fish farmers (Matuha 2015)

1. Stocking and harvesting
2. Feeding management
3. Pond construction and management
4. Disease management
5. Water quality management
6. Broodstock management
7. Market prices
8. Arranging transactions

Buyer meeting seller on cell phone



Farmer-to-farmer coordination

- Arrange for fish farming inputs
- Receive calls from colleagues
- Farmers indicated that mobile phones provide monetary savings

Findings

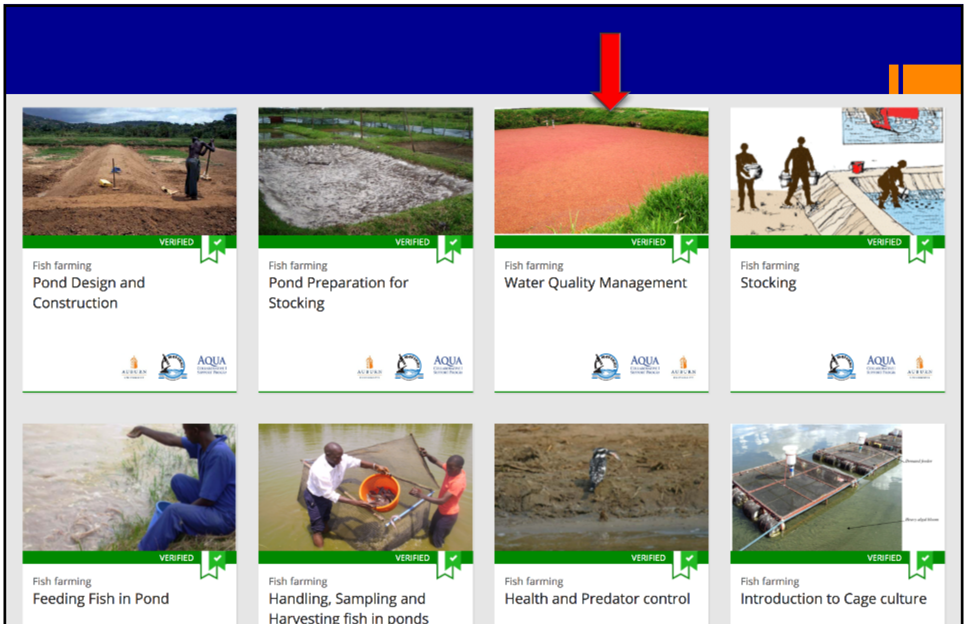
- Marketing information
  - To contact a few of the lead fish farmers to attain market price for their seeds and ready fish
  - To gain market pricing prior to negotiations before they travel
- Technical assistance
  - Used cellphone to contact fellow fish farmers for guidance
  - Gain knowledge of use from TV, Radio, friends and newspapers
  - Extension officers are not always available to help them

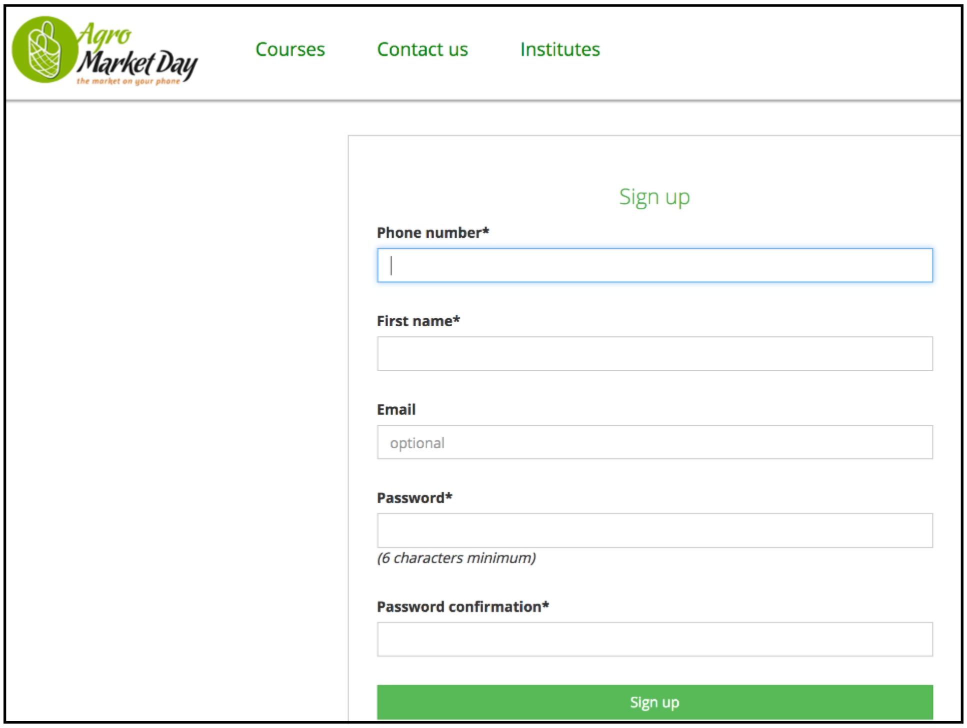
Mobile payments

- To receive or make payments
- To transfer and save money
- Mobile money banking

ICT Advances Food Security and Development

- By Empowering Farmers
  - To each other
  - To extension
  - To input suppliers
  - To markets

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Phone number*
First name*
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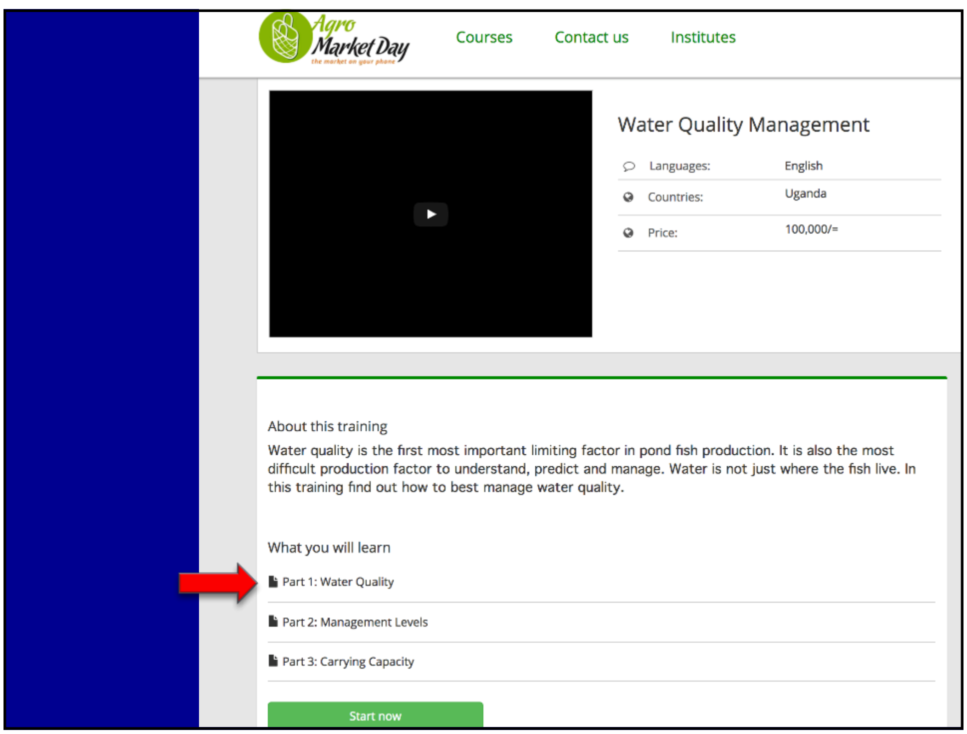
Password confirmation*
Sign up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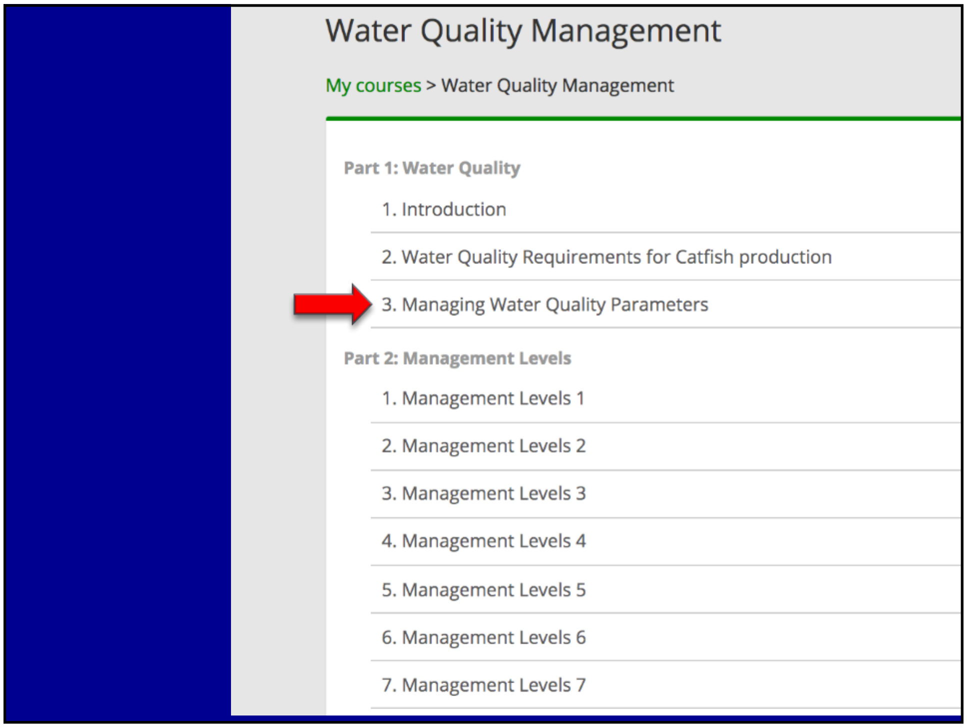
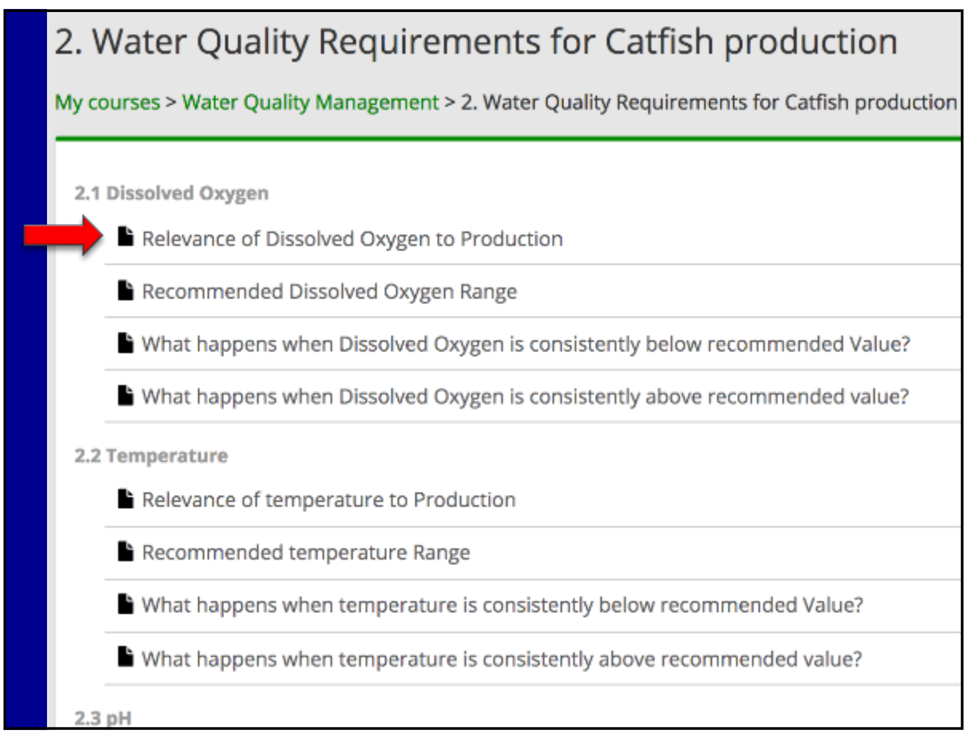
Institutes
Water Quality Management
Languages: English
Countries: Uganda
Price: 100,000/=
About this training
Water quality is the first most important limiting factor in pond fish production. It is also the most difficult production factor to understand, predict and manage. Water is not just where the fish live. In this training find out how to best manage water quality.
What you will learn
Part 1: Water Quality
Part 2: Management Levels
Part 3: Carrying Capacity
Start now


Water Quality Management
My courses > Water Quality Management
Part 1: Water Quality
1. Introduction
2. Water Quality Requirements for Catfish production
3. Managing Water Quality Parameters
Part 2: Management Levels
1. Management Levels 1
2. Management Levels 2
3. Management Levels 3
4. Management Levels 4
5. Management Levels 5
6. Management Levels 6
7. Management Levels 7


2. Water Quality Requirements for Catfish production
My courses > Water Quality Management > 2. Water Quality Requirements for Catfish production
2.1 Dissolved Oxygen
Relevance of Dissolved Oxygen to Production
Recommended Dissolved Oxygen Range
What happens when Dissolved Oxygen is consistently below recommended Value?
What happens when Dissolved Oxygen is consistently above recommended value?
2.2 Temperature
Relevance of temperature to Production
Recommended temperature Range
What happens when temperature is consistently below recommended Value?
What happens when temperature is consistently above recommended value?
2.3 pH

Recommended Dissolved Oxygen Range

What happens when Dissolved Oxygen is consistently below recommended V

What happens when Dissolved Oxygen is consistently above recommended v

2.2 Temperature

Relevance of temperature to Production

Recommended temperature Range

What happens when temperature is consistently below recommended Value

What happens when temperature is consistently above recommended value

2.3 pH

Relevance pH to Production

Recommended pH Range

Relevance of Dissolved Oxygen to Production

My courses > Water Quality Management > 2. Water Quality Requirements for Catfish production > Relevance of Dissolved Oxygen

2.1 Dissolved Oxygen

Relevance of Dissolved Oxygen to Production

- Fish breathe in oxygen for their metabolism.
- Dissolved oxygen is needed to oxidize potentially toxic metabolic wastes into less toxic forms (e.g. ammonia (NH_3) to nitrite (NO_{2-}) and then nitrate (NO_{3-})

- Bacteria in ponds that help transform wastes into less toxic products need oxygen for metabolism.
- Phytoplankton use oxygen at night during respiration.

Previous Next

Subscription processes

- *Not yet fully determined*
  - Annual fee
  - Small message costs (100USH)
  - Buyers pay registration fees
  - Buyers pay transaction fee

Marketing and sustaining the application

- AIDA model
  - Awareness—*current phase*
  - Interest – *crystallized offer*
  - Desire – *clear benefits & advantages*
  - Action – *sign-ups & usage*


GO FISH
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Aquaculture and food security: An assessment of fish farming households in Ghana

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Fish farming has become an important part of the Ghanaian economic development plan for the past ten years. Its importance was further enhanced with the setting up of the Ministry of Fisheries and Aquaculture Development in 2013 to give more emphasis and support to the industry. Several international organizations like the World Bank, Food and Agriculture Organization (FAO), UK's Department for International Development (DFID), the New Partnership for Africa's Development (NEPAD) and local ones like Ghana Association of Women Entrepreneurs (GAWE) and Rural Wealth (RW) have all contributed to the development of this industry through financial support and capacity building.

In spite of these efforts and contributions, there is little assessment on the influence of participating in fish farming on the nutritional quality of such households. We hypothesize that fish farming households have higher food consumption scores than non-fish farming households. The assumption is that engaging in fish farming will increase income flow and access to fish for the household. Thus, the main objective of this study was to identify the direction of impact of fish farming on household food security and the pathways of impact. We adopted the Propensity Score Matching (PSM) approach in a logit framework to evaluate participation in fish farming. The dependent variable was World Food Program's (WFP) Food Consumption Score (FCS), a proxy for food security. Socio-economic variables including *wealth index*, *ecological zone* and demographic characteristics of the household head including *Age, education in years, peri-urban, marital status, employment status, sex, household income per capita,* and *household size* were used a regressors. Our data sources are the 2013 Ghana Living Standard Survey (GLSS) and field data collected from in Ashanti and Brong Ahafo regions in June/July 2014.

Results showed that the average FCS for fish farming households was 69 while that of non-fish farming household (control group) was 57. On the margin, the probability of adopting fish farming increased with wealth index, residents of peri-urban area, ecological zone and household size but decreased with household income per capita. The average treatment effect on the average fish farming household (ATT) showed an increase in food security score by 14 points which translates into consuming fish at least twice in a week (=8), roots and tuber or cereals (=2), pulses and legumes once (=3) and vegetables or fruits (=1) once in a week. We infer that fish farming increases the diversity and frequency of food consumed through direct consumption and not so much through the income effect. Post-estimation analysis showed that households in the savannah zone with an opportunity to engage in fish farming especially in the rural areas have a higher probability of improving their food security status.

An Assessment of Household Food Security in Fish Farming Communities in Ghana

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Background

- Importance of aquaculture in Ghanaian economic development because of its income-generation, employment and food security dimensions.
- Government separated Fisheries and Aquaculture from the Food and Agriculture to give more emphasis.
- Financial and technical contributions from USAID, FAO, DFID, World Bank, NEPAD, RW and GAWE particularly in cage culture.
- Production from cage culture increased from 4,912 MT to 24,249MT from 2009 to 2012 and less than 2,000 MT from ponds and tanks.

Aquaculture in Ghana

- Dominated by small scale subsistence farmers
- Practiced in all regions except the three Northern Regions of Ghana.
- Tilapia and African catfish are the main species farmed with Tilapia constituting about 90% of total farmed fish production.
- Production growth as a results of increase in quality fingerlings, feed and technical know-how from training.

Fish Farming & Food Security in Ghana

- Fish is a the major source of protein (60%) in a typical Ghanaian diet.
- It is the cheapest source of protein in Ghana followed by chicken.
- Per capita fish consumption is 28kg/annum, the highest in West Africa.
- The sector supports 2.6 million rural dwellers and contributed 1.6% to the 2016 GDP of Ghana.

Fish Farming & Food Security in Ghana

- Food security is highly influenced by household socio-economic factors (Income, occupation, market price, household size and composition, education, tastes and preferences) and ineffective market systems (Abebaw et al. 2012; Hailu, 2012).
- Even though fish is consumed in small quantities most of the time, they have been identified to contribute significantly to nutritional quality of poor household diets (Thilsted et al. 2014).
- Another study by Kassam (2014) however observed that there were no significant differences in terms of impact of adoption between fish farming and non-fish farming households.

Objectives

- Measure the impact of adopting fish farming on the nutritional quality (food security) in fish farming households in Ghana.
- Identify household socio-economic factors that influence adoption of fish farming in Ghana.

Food Security Metrics

- Different measures of household food security as a result of its dynamic nature (Vigani et al., 2014)
- Common HH food security indicators include HFIAS, HDDS, FCS, HHS, CSI, rCSI and SAFS (Maxwell et al., 2013).
- Saaka & Osman, (2013) – Tamale, Ghana : FCS, HFIAS & HDDS
- Kabunga et al (2011) – Kenya : HFIAS
- Nyyssola & Pirttila (2014) – Mozambique : FCS

Data

- Source: Survey from farmers in Ashanti and Brong Ahafo regions and Round 6 of the Ghana Living Standards Survey.
- Sample: 4011 Fish farming and non-fish farming Households
- Dependent variable: Food Consumption Score (FCS)

$$FCS = \sum y_i \quad (1)$$

- Independent variables: Fish farming adoption, Household wealth, household income/capita, age, education, marital status, male, household size, agro-ecological zone and peri-urban area.

WFP calculation of FCS

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	Vegetables 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

FCS Thresholds for grouping households

Profiles	Threshold	Threshold with oil eaten and sugar eaten on daily basis (~7 days/week)
Poor food consumption	0 - 21	0 - 28
Borderline food consumption	21.5 - 35	28.5 - 42
Acceptable food consumption	>35	>42

Methodology: Propensity Score Matching (PSM)

- Stage 1:Logit Regression (Adoption decision)

$$y_1 = \beta_0 + \beta_i x_i + u_i \qquad (1)$$

- Stage 2: Average treatment effect (ATT) with Nearest neighbor and kernel-based algorithms

$$\begin{aligned} ATT &= E(Y_1\text{-}Y_0 \mid \text{F=1}) \\ &= E[E(Y_1 - Y_0 \mid \text{F=1}, P(X))] \\ &= E\left[E\left(Y_1 \mid \text{F=1}, P(X)\right) - E(Y_0 \mid \text{F=1}, P(X)) \mid F = 1\right] \\ &= E\left[E\left(Y_1 \mid \text{F=1}, P(X)\right) - E(Y_0 \mid \text{F=0}, P(X)) \mid F = 1\right] \qquad (2) \end{aligned}$$

Testing the Quality of Estimates

- Covariate Balancing
  - $SB(X) = \frac{100(\overline{X_{F=1}} - \overline{X_{F=0}})}{\sqrt{P_{F=1}^{2} + P_{F=1}^{2}}/_{2}}$
  - $Bias\ ratio = \left(1 - \frac{SB_{POST}}{SB_{PRE}}\right)$ (3)

- Robustness Test (Rosenbaum Sensitivity Analysis)
  - $\frac{1}{e^{\varphi}} \leq \frac{P_m/_{(1-P_m)}}{P_n/_{(1-P_n)}}$ (4)

RESULTS AND DISCUSISON

Logit Regression

Variable	Coefficient	Std. Error	Av. Marginal effects
Wealth index_sqr	0.382**	0.005	0.012
Wealth index	0.802***	0.107	0.000
Education	-0.024	0.02	-0.001
Age	0.001	0.01	0.000
Monthly Income	-0.003***	0.000	-0.000
Peri-urban	0.953***	0.230	0.030
Male	0.608	0.390	0.019
Household size	0.099***	0.020	0.003
Married	0.074	0.410	0.002
Ecological zone	0.319*	0.170	0.010
Employed	-0.214	0.590	0.020
constant	61.68	5.91	10.43

*** 1%, ** 5%, * 10%

Average Treatment Effect on Treated (ATT) Results

Variable	Matching Algorithm	Treated	Control	ATT	BSE	T-ratio
FCS	NNM (1)	69.77	54.23	15.54	1.71	9.11
	NNM (5)	69.77	54.28	15.54	1.44	10.78
	KBM (0.03)	69.77	55.30	13.86	1.38	10.31
	KBM (0.06)	69.50	55.64	13.86	1.34	10.35

Post-estimation Analysis

Fish farming = 1, Peri-urban = 0 (rural), Male = 0 (Female), Ecology = 3 (Savannah)

FCS thresholds	Predicted Probability
Poor	0.001*
Borderline	0.036*
Acceptable	0.963***
Observations	4,000

*** 1%, ** 5%, * 10%

Conclusion

- Fish farming adoption decision is influenced by wealth, household size, ecological zone and resident in a peri-urban area and income of households.
- Fish farming improves household nutritional quality through direct consumption from own production.
- FCS increases food security in fish farming households by a week (15.5 points).

Policy Recommendations

- Resource allocation in annual budget to develop aquaculture to enhance job creation and food security in the three Northern regions.

- Encourage women in the rural areas to engage in the production process of fish farming.

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A latent-class analysis of household demand for seafood in Ghana

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Fish is an integral part of Ghanaian diets and it contributes over 60 percent of the animal protein for human consumption. It is the cheapest source of animal protein with the average Ghanaian consuming more fish than meat products. The per capita consumption of fish is about 25kg per annum, which is one of the highest in Sub-Saharan Africa. It is commonly consumed by low income and subsistence households. A survey conducted between 1987 and 1999 showed that fish accounted for 13 to 19 percent of urban household average food budget and 17 to 29 percent for rural households. In 1998/1999, the expenditure on fish as a proportion of expenditure on animal protein was 53 percent for urban households and 55 percent to 79 percent for rural households. The fifth round of the Ghana Living Standards Survey showed that fish accounted for 27 percent of the overall household food budget. According to European Commission(EU), consumption patterns in developing countries are beginning to follow the pattern in developed countries which is mainly, decreased daily consumption of animal protein particularly meat but increased fish consumption.

The literature suggests that changes in income per capita and health-related factors have been driving animal protein consumption in both developed and developing countries. Other drivers include ethical factors, environmental and economic issues, availability and urbanization, as well as socio-economic and demographic factors. This study therefore examines the effect of price and income, socio-demographic factors, as well as cultural, health and lifestyle factors on household demand decisions for seafood. This study will provide insights into lifestyle factors that influence the demand decision of households and aid producers in the marketing process in targeting consumers in certain demographic groups.

Data from the 2013 round six of the Ghana Living Standards Survey (GLSS 6) will be used to assess the determinants of seafood demand. The proposed methodology is the Latent Class Linear Regression Approach to help capture the heterogeneity among the households and any unobserved factors underlying the demand decision process.

A Latent Class Analysis of Households' Attitudes towards Seafood Consumption

Akua S. Akuffo
Kwamena K. Quagrainie
Purdue University

Background

- Increased consumption across major agricultural commodities (oilseeds, vegetable oils, sugar, meat, eggs, fish and milk) (EC, 2015).
- Accelerated growth has been observed in oilseeds, cereals and vegetables but declining in meat and eggs (EC, 2015).
- Drivers of increased demand are growth in population and per capita income. Other drivers are seasonality, availability, and geographic location Darko, 2011; House, Hanson and Sureshwaran, 2003; Essuman, 1992).
- Studies on population growth shows consumption patterns follow population growth and even exceeds it (EC, 2015).

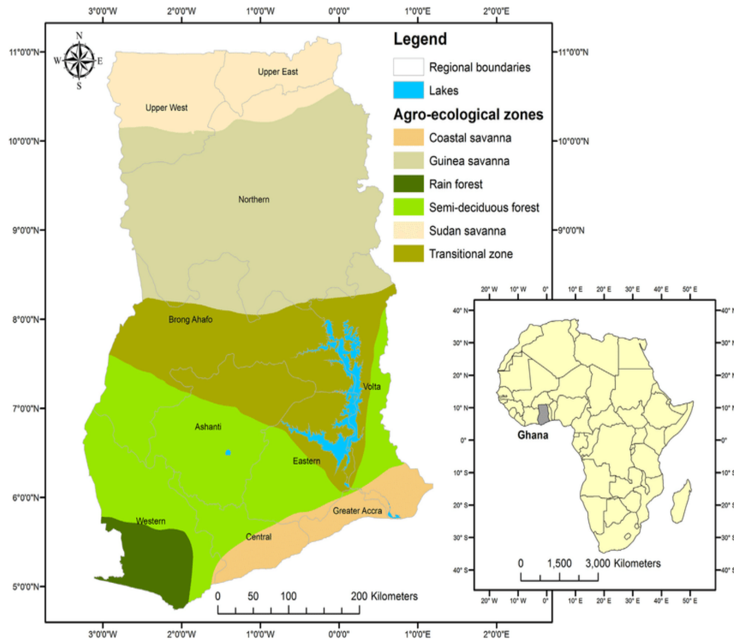
Fish Consumption in Ghana

- Per capita fish consumption on the average is about 25kg, one of the highest in West Africa (Odei, 2015).
- Seafood expenditure in the urban and rural Ghana accounted for 13-19% and 17 to 29% respectively between 1987 and 1999 (GSS, 2002).
- In terms of animal protein, seafood expenditure accounted for 53% in urban households and 55-79% in rural households (GSS,2002).
- Residents along the coast of Ghana consume more smoked and fresh fish (Heinbuch, 1994).

Fish Consumption in Ghana

- Certain type of fish (black-colored catfish) area taboo in some locations and cultures in Ghana (Akuffo, 2014).
- Beef, mutton, pork, goat meat and guinea pig are sold fresh or in their live state (Heinbuch, 1994).
- Most consumers in the rural areas prefer fish over other the animal protein sources because of economic reasons (price and income).
- While those in the urban areas prefer fish in addition to economic reasons, health, taste and preferences (Heinbuch, 1994).

Map of Ghana



Objectives

- Examine the effects of cultural, lifestyle and geographical location on household seafood consumption.
- Comparing seafood expenditures to other animal protein sources.
- Capture heterogeneous nature of seafood consumption by using a class assignment model.

Data

- Source: Round 6 Ghana Living Standards Survey (GLSS 6)
- Sample size: 2185 households
- Dependent variable: Household Fish expenditure
- Independent Variable: Market prices for red meat, chicken and pork, household demographics, location, seasons, religion, ethnicity, household monthly income.

Methodology

- Latent Class Linear Regression

$$\ln[y_i|\mathrm{c}] = \alpha + \pi_c ln\rho_i + \gamma_c lnm_i + \beta_c X_i + \varepsilon_i \quad (1)$$

- Where y_i is seafood expenditure, ρ_i market prices of red meat, pork and chicken, m_i is household income, X_i are household demographics (age, married, employed, male, religion, location, ethnicity and season)and c is class.

$$P[class\ c|k_i] = N[\beta_c' x_i, \sigma_c^2] = F_{ic} = \frac{\exp(\theta_c', k_i)}{\sum_{c=1}^{C} \exp(\theta_c', k_i)}, \theta_C = 0 \quad (2)$$

- k_i is age and employed

One Class Regression Results

Variables	Coefficient	BSE	T-ratio
Monthly income	0.154***	0.029	5.286
Married	0.181***	0.042	4.318
Male	-0.551***	0.040	13.822
Ewe	0.238**	0.103	2.314
Ga	0.352	0.119	2.946
Muslim	-0.284	0.087	-3.248
Forest	0.207	0.056	3.686
Constant	2.316	0.226	10.239

Two-Class Regression Results

Peri-Urban Households

Variables	Coefficients	BSE
Fish price	0.078*	0.037
Poultry price	-0.053***	0.024
Red meat price	0.107**	0.023
Pork price	-0.053	0.033
Education	-0.016***	0.005
Monthly income	0.126***	0.021
Married	-0.040	0.031
Male	0.010	0.030
Akan	0.118**	0.054
Ewe	0.067	0.071
Ga	-0.110	0.086

Urban Households

Variables	Coefficients	BSE
Fish price	0.002***	0.000
Poultry price	-0.001***	0.000
Red meat price	0.001***	0.000
Pork price	0.001***	0.000
Education	0.000**	0.000
Monthly income	-0.001***	0.000
Married	0.002***	0.000
Male	-0.004***	0.001
Akan	0.007***	0.001
Ewe	0.013***	0.001
Ga	0.002	0.001

Two-Class Regression Results

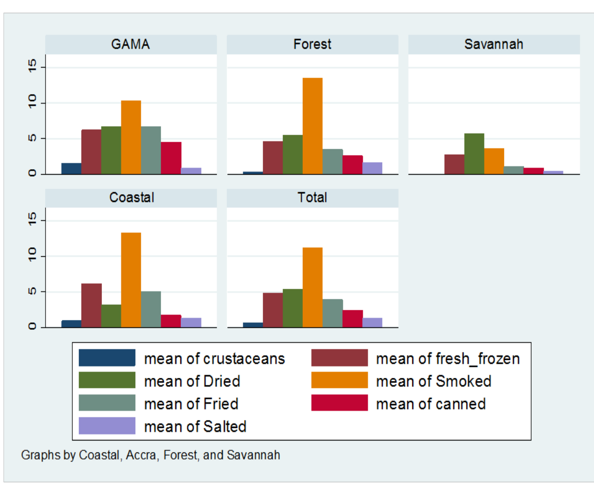
Peri-Urban Households

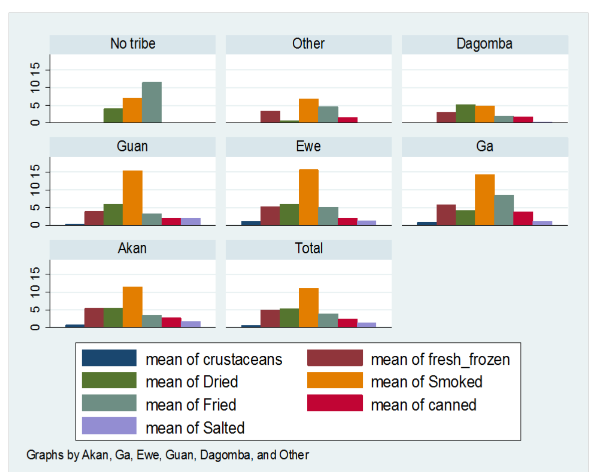
Variables	Coefficients	BSE
Guan	-0.035	0.077
Dagomba	-0.053	0.033
Muslim	-0.060	0.061
Christian	0.039	0.046
Coast	-0.049	0.055
Forest	0.173***	0.041
Savannah	0.182***	0.058
Q1	0.129***	0.042
Q2	0.026	0.051
Q3	0.137***	0.042
Constant	2.959***	0.170

Urban Households

Variables	Coefficients	BSE
Guan	-0.029***	0.002
Dagomba	0.003***	0.001
Muslim	0.000	0.001
Christian	0.001*	0.000
Coast	0.001*	0.000
Forest	-0.003***	0.000
Savannah	0.003***	0.001
Q1	-0.006***	0.000
Q2	-0.001***	0.000
Q3	0.003***	0.001
Constant	0.008***	0.002

Post-estimation Analysis





Conclusion

- There are two seafood-expenditure classes, the peri-urban and the urban households.
- Demand is price-inelastic in both classes.
- Fish, poultry and pork are complementary goods in peri-urban households while fish and red meat are substitutes in urban households.
- Peri-urban households are Akan Christians located in the forest and savannah areas.
- Fish consumption increases during the 3rd quarter of the year when prices are low.

Conclusion

- Urban households are a mix of the ethnic groups, Akan, Ewe and Dagomba.
- Religion is not a significant factor in seafood consumption in urban households.
- Fish consumption also increases in the third quarter of the year.
- Education decreases fish consumption in peri-urban households but has no impact in urban households.

Recommendation

- The geographical location and common ethnic affiliations of that location should be considered by producers in consumer targeting and market segmentation for seafood in Ghana.

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Marketing strategy of farmed fish in central Uganda

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Aquaculture sector in Uganda currently contributes a small proportion (16%) to the total fish supply. Due to increased demand for fish both domestically and internationally and in the face of dwindling supplies from the lakes and rivers, interest in aquaculture industry has heightened due to a shift from demand for home consumption to becoming a commercial enterprise. Thus, the industry has become increasingly market-driven and therefore the linkage between production and consumption is gaining interest to policy makers. As commercial fish producers, they need to be equipped with the right information in order to make strategic decisions aimed at profit maximization. However, there is limited research work carried out in the country to inform the policy. The paper looks at marketing and pricing strategies, fish farmers use to sell their fish while remaining competitive.

The data used in this study were collected from a sample of 126 commercial fish farmers in 2015. The sample was randomly drawn from a list of fish traders/farmers generated at the district level of Wakiso, Mpigi and Mukono, in Central Region of Uganda. Data collected were cleaned, coded, and entered using SPSS spreadsheet package. The data were analyzed using descriptive statistics and econometric methods.

The results show that the respondents had a mean age of 49 years with a household size of 5.3 persons. Most of them had attained an education level of 12.2 years, implying completing O level education. Furthermore, the respondents had adequate experience of 7 years in fish farming/trade. The results also showed that majority (93.7%) of the respondents interviewed sold fish, an indication of high level of commercialization. The majority (64%) of traders practiced personal (individual) selling while 29.3% sold in a group. Those who sold individually cited the following reasons; lack of competition, convenience and opportunity to bargain with buyers. No product branding, sales promotion nor packaging was practiced. The primary sources of price and market information for the fish farmers/traders were fellow farmers (36%) followed by market traders (23%).and fisheries extension workers (16%). In terms of pricing strategies, the majority of farmers adopted single pricing strategy as a way to minimize loses. This strategy was followed by price penetration in cases where the respondent was more commercialized and had the requisite infrastructure. This followed by Cost-plus pricing.

Based on the results, they point to the need for fish farmers/traders to not solely rely on single pricing, but adopting multiple pricing and marketing strategies which would enable them take advantage of niche markets. This can only be possible when they have easy access to capital to invest in the required infrastructure such as the iced vehicles and producing required fish size demanded by the market.

Marketing & Pricing Strategy of Farmed Fish in Central Uganda

by

Hyuha T.S., Ekere W., Halasi G.Z. Molnar J.J. and Egna H.

Presented at World Aquaculture Society Conference
at International Convention Center ,Cape town South Africa
between 26-30th June 2017

Introduction

- Aquaculture in Uganda contributes an insignificant proportion of total fish production.
- However, there is an increasing demand for fresh fish in urban and peri-urban areas in the face of dwindling supply from the wild.
- Therefore an increase in fish supply is the solution to fill the gap.
- Past Production studies (Bukenya et, al; Hyuha et al.201,) carried out show the industry is profitable
- How ever, Fish feeds constraints still face sector and , marketing studies still remain limited.

Introduction cont'd

- The missing link is therefore that farmers have to understand marketing and pricing strategies to adopt in serving different niche markets.

- Thus, main objective of this study was to understand how fish farmers could develop an efficient marketing strategy to reach the consumer

- The specific objectives of this study were:

  - To characterize fish farmers in aquaculture subsector

  - To determine the existing market segments of farmed fish in central Uganda.

  - To determine the marketing strategies used for farmed fish in Central Uganda

What is a marketing strategy?

- A marketing strategy involves identifying who your target market(s) are and what are their aspirations. We should remember that "*Consumers do not buy what you sell. They buy what has value to them". The Consumer is the King*
- As a fish farmer, he/she has to identify what a consumer values(wants) and then develops the marketing mix to meet their expectations in order to stay in the business.
- With a short value chain and its perishable nature, marketing strategy for fish needs careful consideration

Methodology

- Three districts from Central Uganda were purposely selected
- Random sampling technique were used to select the fish farmers from the selected districts of Mukono, Wakiso and Mpigi being Aquafish project area.
- A final sample size of 126 fish farmers who had harvested fish in the previous fish cycle prior to the date of study were used
- Used a structured questionnaire and variables captured were: socio economic and socio demographic characteristics, production practices, marketing aspects, constraints and suggestions .
- Descriptive statistics .

Characteristics of the fish farmers

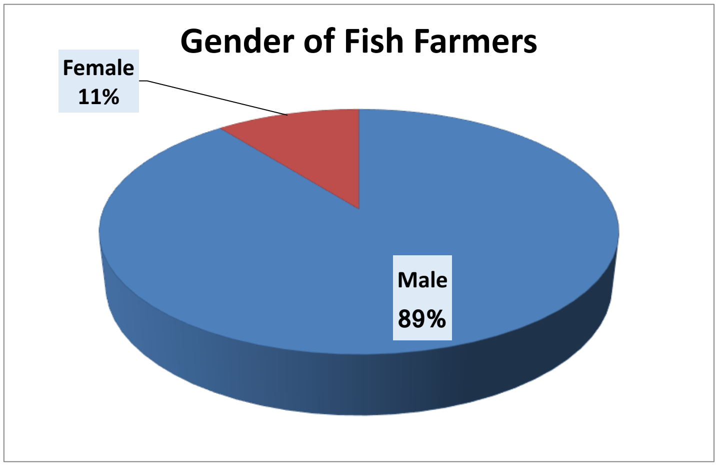
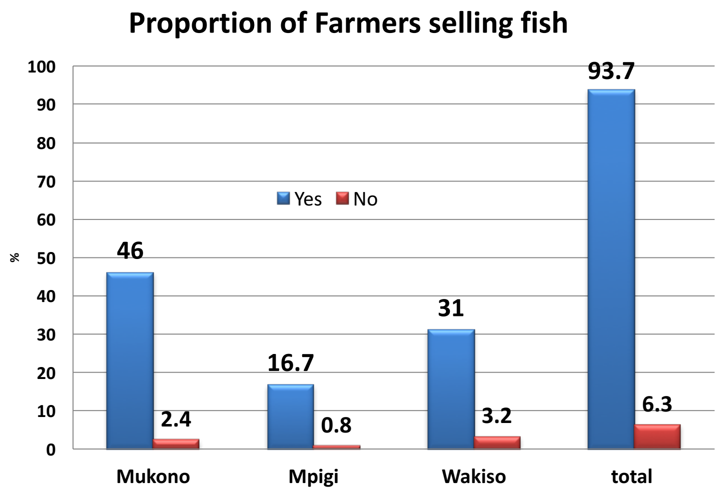


TABLE 1: CHARACTERISTICS OF FISH FARMERS

Characteristics	Mukono	Mpigi	Wakiso	Total
	Mean	Mean	Mean	Overall
Age (Years)	49.4	50.4	46.9	48.7
Education(yrs)	11.3	13.2	13.1	12.2
Hsld size	4.7	6.2	5.8	5.4
No.of ponds in the last cycle	3.0	4.3	3.5	3.4
No.of ponds harvested the last cycle	1.7	2.2	2.3	2.0
Experience in fish farming(yrs)	7.1	7.4	6.5	6.9

FIGURE 1: Status of marketing of fish among farmers:

- Overall 93.7% of the fish farmers do sell fish while 6.3% don't.



Reasons for Not selling

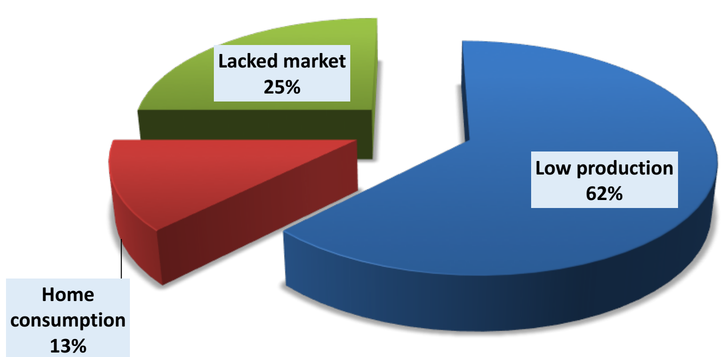


Table 2:Sales Strategies used by fish farmers

Characteristics	Mukono %	Mpigi %	Wakiso %	Total= 116 %
Individual	28.4	12.9	23.3	64.7
Group	18.1	3.4	7.8	29.3
Both	3.4	0.9	1.7	6.0

Table 3: Reasons for preference of individual marketing

Reasons for preference for marketing	Mukono	Mpigi	Wakiso	Total
Good payment	6.25	0	21.74	10.29
Buyers come at the farm	15.63	15.63	26.09	19.12
No competition	50	0	13.04	27.94
Convenient	9.38	15.38	17.39	13.23
Lack of farmer group	12.5	61.54	13.04	27.94
Pay in cash	6.25	0	4.35	4.41
Difficulty in marketing	0	7.69	4.35	2.94

Table 4: Type of Sales Promotions practiced

Discount factors	Type of fish	
	Tilapia **%(n=41)**	***Catfish*** **%(n=21)**
Bargaining power	9.8	19.1
Buying in bulk	63.4	47.6
Urgent need of money	14.6	14.3
Size of fish	9.8	9.5
Relationship with the customer	2.4	9.5

- **Sales promotion and advertising create awareness**
- **Farmers need to practice these to increase market share**

Table 5: Pricing strategies used by fish farmers

Pricing strategy	Mukono n=61	Mpigi n=21	Wakiso n= 40	Total n=122
Price penetration	11.48	42.86	37.5	**25.41**
Price skimming	4.93	19.05	15	10.66
Lead pricing	3.28	19.05	5	4.10
Break even pricing	13.11	4.76	2.50	8.20
Geographical pricing	3.28	4.76	2.50	3.28
Perceived pricing	6.56	14.29	22.50	13.11
Volume pricing	11.48	38.10	20	**18.85**
Single pricing	**54.10**	**52.38**	**35**	**47.54**
Loss leader pricing	0	5	11.48	9.81
Discounts offer	1.64	38.10	20	13.93

Proportion who grade

Grade	Percentage who Grade			
	Mukono	Mpigi	Wakiso	Total (N=123)
Yes	28.5	13.8	24.4	66.7
No	20.3	3.3	9.8	33.3

Criteria for Grading

Grade Criteria	Percentage			
	Mukono	Mpigi	Wakiso	Total (N=82)
Weight / Size	41.5	17.1	34.1	66.7
Species	1.2	3.6	2.4	7.2

Processing of Fish

Process	Mukono %	Mpigi %	Wakiso %	Total %(n=120)
Yes	1.7	2.5	5.8	10
No	45.8	15.0	29.2	90

Reasons why farmers do not process fish

Reasons	Mukono %	Mpigi %	Wakiso %	Total %(n=86)
Low production	7.0	7.0	14.0	27.9
Lack of processing skill	24.4	5.8	5.8	36.0
Time wasting	1.2	0.0	5.8	7.0
Available market needs fresh fish	10.5	5.8	3.5	19.8
Lack market for processed products	3.5	0.0	5.8	9.3

Processing of aquaculture products is still negligible but growing. Processing plants deal in specialized fish products and are geared to serve primarily overseas market.

Table 8:Constraints faced by fish farmers during marketing

Problem	Frequency	Percentage
Low price of fish and fish products	28	25.9
Small fish size	7	6.5
No value addition	3	2.8
Lack of market	13	12.0
Inadequate fish production	13	12.0
High transport costs	11	10.2
Un honored orders	1	0.8
Inadequate capital	1	0.8
Competence in the competition	2	1.9
None	29	26.9

Table 9: Strategies to access better markets

Suggestions to access better markets

Suggestion	Mukono %	Mpigi %	Wakiso %	Total %(n=69)
Invest in iced vehicles	5.8	5.8	2.9	14.5
Provision of enough Capital	13.0	4.3	2.9	20.3
Form strong fish farming groups	11.6	0.0	2.9	14.5
Promote awareness of better markets	23.2	1.4	10.1	34.8
Easy access of permits	0.0	1.4	0.0	1.4
Produce the required fish size	8.7	0.0	5.8	14.5

Recommendations

- Need to boost the fish supply
- fish farmers need work in groups to access technical information
- Farmers need to join information platforms such as that by Infotrade and upcoming market information exchange platform initiated under AquaFish Innovation Lab

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