Innovative Fish Feeds and Nutrient Input Systems for Small-Scale Aquaculture in Africa and Asia

by Caleb Price*, Paris Edwards, Jenna Borberg, Haley Demmin, Kathryn Goetting, and Hillary Egna. Oregon State University, Corvallis, Oregon.

Introduction

The high cost and variable quality of fish feed remains a barrier to profitability of small-scale aquaculture operations, and is exacerbated by the common practice of overfeeding. While high quality fish feeds are critical to optimal fish growth and production, feed ingredients such as fishmeal, soy, corn, and wheat are globally traded commodities vulnerable to price fluctuations that can negatively impact farmers. Feed accounts for the greatest production cost for farmers, comprising about 80% of total costs in grow-out systems.

The AquaFish Innovation Lab has been researching feed formulations, ingredients, and feed strategies on semi-intensive fish farms in Africa and Asia in order to reduce production costs and maximize profit for small-scale farmers. Strategies under development include:

- Improved low-cost, alternative feeds that incorporate the use of locally produced, high quality protein sources.
- Polyculture techniques such as multi-trophic species cultivation with cage culture.
- Alternative input practices, such as reduced feeding regimes.

These techniques increase access to quality feed ingredients, improve feed efficiency, increase profits for farmers, and increase the sustainability of small-scale aquaculture.

Kenya

Problem: Lack of quality, pelleted feeds presents primary constraint to aquaculture industry.

Research/Solution: Formulate and manufacture pelleted fish feed using locally-sourced feed ingredients in western Kenya.

Three diets have been formulated with the following ingredients: 1. Fish meal (65% - Dagaa (silver cyprinid) 2. Cottonseed meal 3. Rice bran 4. Sunflower oil and 5. Astaxanthin premix (8%) to compound 28.1%, 30.9% and 32.8%. Digestible crude protein percentages for the formulations are 22.5%, 25.6% and 27.2% respectively, and the lipid contents are 12.3%, 16.3 and 12.0%. The feeds contain between 9 and 11.7% fiber.

These mixtures will be pelleted using a mill to improve the uptake efficiency of the feed. Pelleting alone is expected to improve FCR from 4:1 to 3:1 and better. The formulations themselves will be tested for growth success against standard commercial feed.

Nepal

Problem: Expensive feeds limit economic returns to fish farmers

Solution/Research: Test the success of carp polyculture with small indigenous species (SIS), while also increasing periphyton growth in-pond.

Experiments are underway to test the success of carp polyculture with small indigenous species (SIS), Periphyton provides an additional source of food for carp and improves water quality. Comparisons of growth outcomes from carp culture, carp-SIS polyculture, and other polyculture systems with and without periphyton enhancement will help determine best practices for optimal growth, yield, and profitability for farmers.

Trials conducted in 12 earthen ponds at the Aquaculture and Fisheries Department Farm were completed in April of 2015. The two most successful treatments (Carp/SIS/periphyton polyculture with 50% feeding and Carp/SIS polyculture with feeding) are being tested at 16 fish farms in the Chitwan district, and at 22 fish farms in the Nawalparasi district.

The results of these on-farm trials will provide valuable data on the feasibility of this polyculture technology for application and transfer to fish farmers across the region to improve the economic performance of their aquaculture operations.

Proven Feed Reduction Techniques:

Early AquaFish research helped pioneer the development and use of feed reduction regimes while maintaining normal production levels. Two successful strategies that remain incorporated throughout AquaFish's current research and capacity building portfolio include greenwater technology and alternate-day feeding. These approaches are not only more cost effective than traditional practices, but they also reduce environmental impacts by lessening the amount of eutrophic effluent entering the surrounding environment that can result from excess feed.

Greenwater Technology

- When carefully managed, an aquaculture pond will naturally produce food items for fish, thereby reducing the need for supplemental feeding. This approach to optimizing pond production is referred to as "greenwater technology" because of the color of phytoplankton blooms in fishponds – an indication of the high level of primary productivity.
- AquaFish researchers found that farmers using greenwater technology in suitable locations can produce up to 7000 kilograms of fish per hectare per year (kg/ha/yr) with optimal fertilizer inputs. A culture operation that uses supplemental feeds in addition to greenwater technology can surpass farms that spend much more using feed inputs alone.

Alternate Feeding Strategies

- AquaFish research on alternate-day feeding with Nile tilapia (Oreochromis niloticus) in the Philippines achieved FCR's close to 1 and reduced feed costs by 40% while still producing similar size fish.
- Building off of this early success, AquaFish researchers turned their attention to milkfish (Chanos chanos), a euryhaline herbivore grown throughout Asia. Alternate-day feeding trials produced fish of similar size while achieving an FCR of 2.25 and saving 31.7% on feed, compared to the daily feed regime.
- This simple technology is easy to implement and requires very little training, making it an ideal option for small-scale farmers.

Tanzania

Problem: Fish farmers in Tanzania are unable to obtain affordable high quality protein sources due to competition for feed sources from other agriculture sectors and from human consumption.

Research/Solution: Evaluate maggot and earthworm meal as alternative protein sources in Nile tilapia (Oreochromis niloticus) diets.

The chemical composition of maggots (Musca domestica), earthworms (Lumbricus terrestris), and fish meal were determined for crude protein, fat, crude fiber, and ash. Based on results, nine feed formulations were developed using mixtures of fish meal, maggot meal, earthworm meal, and cotton seed cake.

All formulations contained approximately 30% crude protein. A feeding experiment was conducted to evaluate the growth performance, feed utilization, and cost effectiveness of the nine feeds on Nile tilapia. Data collection has been completed and analyses are underway.

Bangladesh

Problem: High costs and negative environmental impacts of common aquaculture practices

Solution/Research: Use integrative polyculture to reduce costs and minimize environmental impacts.

Shing/carp polyculture represents new market opportunities and increased access to valuable nutrition for farmers and communities.

Current growth studies evaluating the polyculture of carps - Rohu (*Labeo rohita*) and Catla (*Catla catla*) - with Shing (*Heteropnuestes fossilis*) in fertilized and unfertilized ponds under 25% and 50% reduced daily feeding suggest that both carps can be co-cultured with Shing with little impact to production. The efficiency of multi-tropic cultivation and the benefits to water quality, efficient nutrient use, and reduced feed inputs provides significant additional benefits and income to farmers.

Preliminary results indicate highest economic returns were realized in a polyculture system with all three species (Rohu, Catla, and Shing) with 50% reduced daily feeding and pond fertilization (Table 1, data submitted by Dr. R. Borski, NCSU).

Table 1. Preliminary Results from a Study of a Novel Approach for the Semi-Intensive Polyculture of Indigenous Air-Breathing Fish With Carps in Bangladesh.

EXPERIMENTAL DESIGN			
Parameter	**Treatment 1**	**Treatment 2**	**Treatment 4**
Rohu (L. rohita)	0	80 (0.8/m^2)	80 (0.8/m^2)
Catla (C. catla)	0	20 (0.2/m^2)	20 (0.2/m^2)
Shing *(H. fossilis)*	500 (5/m^2)	500 (5/m^2)	500 (5/m^2)
Fertilization	0	0	4:1 (N:P)
Feeding Protocol	100% Satiation	100% Satiation	50% Satiation
Replicates (n)	3	4	4
RESULTS			
Variable	**Treatment 1**	**Treatment 2**	**Treatment 4**
Shing *(Heteropneustes fossilis)* (Bloch)			
Mean Weight Gain (g)	23.60±3.45	19.49±3.50	23.31±5.09
Survival Rate (%)	53.00±6.36	47.50±5.02	53.35±2.00
Specific Growth Rate, SGR (%)	1.83±0.08	1.72±0.10	1.82±0.13
Net Production (kg ha^{-1})	622.63±155.25	457.14±99.46	614.44±134.09
Rohu (*Labeo rohita*)			
Mean Weight Gain (g)	N/A	283.05±106.61	258.16±119.29
Survival Rate (%)	N/A	90.63±9.92	92.19±3.73
SGR (%)	N/A	1.54±0.22	1.48±0.27
Net Production (kg ha^{-1})	N/A	1970.80±575.10	1903.90±936.21
Catla (*Catla Catla*)			
Mean Weight Gain (g)	N/A	341.30±117.88	362.10±119.54
Survival Rate (%)	N/A	96.25±7.50	91.25±4.79
SGR (%)	N/A	1.53±0.20	1.56±0.18
Net Production (kg ha^{-1})	N/A	640.91±197.96	652.26±220.21
Combined Results			
Feed Conversion Ratio, FCR	15.23±3.26	2.35±0.61	1.37±0.49
Net Production (kg ha^{-1})	622.63±155.25	3068.85±774.45	3170.60±805.46
Net Return	-103827.39	294484.88	542215.43
BCR (Benefit Cost Ratio)	0.82	1.55	2.37

All photos courtesy of AquaFish Innovation Lab

The Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries
The Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries is funded under USAID Leader with Associates Cooperative Agreement No. EPP-A-00-06-00012-00 and by the participating US and Host Country partners

email: aquafish@oregonstate.edu **website:** http://aquafishcrsp.oregonstate.edu

AFS, Portland, Oregon, August 2015