Alternative Feeds For Freshwater Aquaculture Species In Vietnam

Sustainable Feed Technology/Study/09SFT01UC

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INTRODUCTION

Aquaculture is growing rapidly in Vietnam and has the potential to do the same in Cambodia. Production of pangasiid catfish in the Mekong Delta of Vietnam alone exceeded 1 million metric tons in 2008. While some of the food provided to these fish, especially at the larger commercial farms, is pelleted feed from commercial feed mills, many small farmers still use "trash fish" from the Mekong in preparing feed by hand at the farm. In Cambodia, catfish culture is still at the small-farm stage and trash fish comprise the basic feed for the industry (which is considerably smaller in Cambodia than in Vietnam).

As aquaculture expands in Vietnam and Cambodia, the fish called snakehead is becoming popular to culture because of its high value in the market. There are actually two species currently being cultured, *Channa striata*, the snakehead murrel, and *Channa micropeltes*, the giant snakehead. While culture of these is permitted (and growing) in Vietnam, it is prohibited in Cambodia (except for some experimental work) due to its dependence on small fish in the diet. Catfish culture has available commercial pellet diets, so getting farmers to switch from small fish to pellets is a socioeconomic issue. On the other hand, pelleted diets do not yet exist for snakehead in Vietnam. There have been very few studies conducted on feed and feeding in Cambodia (Heng et al. 2004). There is no tradition of on-farm feed formulation that can be widely used in aquaculture systems. Pond fertilizer techniques are well understood by farmers but organic manures are scarce since they are needed for agricultural crops. The market price for farmed fish, especially in relation to the cost of feed, is a major problem. Prices are very low when fish are plentiful from capture fisheries and consumers prefer wild captured fish to cultured fish.

In the Mekong Delta in Vietnam domesticated snakehead (*Channa micropeltes* and *C. striata*) are fed with small-sized/low value fish (of both marine and freshwater origin). In Cambodia wild giant snakeheads (*Channa micropeltes*) are generally cultured in smaller cages of less than 200 m^3. Feed represents more than 70% of the total operational cost and the main type of feed for wild giant snakehead culture in Cambodia is small-sized/low value fish of freshwater origin (So et al., 2005).
During phase 1 of this project (2007-2009), we determined species composition, size and chemical composition of the main freshwater trash/low-value fish species used as feed for finfish aquaculture in the Mekong Delta of Vietnam. We also developed weaning methods so that small, hatchery-reared snakehead can be quickly adapted to pelleted diets. (When snakehead are collected from the wild by fishermen for aquaculture, it is difficult to impossible to get them to feed on pelleted diets in captivity; the transition must be done in the early life stages.). We then determined that *Channa striata* snakehead survive as well on pelleted diets in which up to 50% of the fish meal has been replaced by soybean meal as they do on pelleted diets made purely of fish meal. On the other hand, growth was equivalent only up to the point of 30% replacement of fish meal with soybean meal, if only the appropriate amino acids are added to the soybean diets; however, that level was increased to 40% replacement when we also added phytase to

break down the phytin in soybean meal. The addition of taurine to the diets did nothing to increase growth above that seen at the 30% soy replacement alone. Next, we determined that *Channa micropeltes* snakehead survive as well on pelleted diets in which up to 50% of the fish meal has been replaced by soybean meal as they do on pelleted diets made purely of fish meal. On the other hand, growth was equivalent only up to the point of 40% replacement of fish meal with soybean meal when we also added phytase to break down the phytin in soybean meal. Finally, we demonstrated that a mixed fish meal, soybean meal and cassava meal diet (with phytase added) can undergo replacement with rice bran at replacement levels up to 30% with no reduction in survival or growth. Cassava is a locally produced crop that may be easier and cheaper to obtain than soybean meal.

The objective of the current (phase 2) portion of this study was to provide information on alternative diets for snakehead, especially those diets that incorporate locally available plant materials, in order to build a long-term sustainable industry. Through an economic analysis of costs of the diets (based on costs of fish meal and plant proteins vs. trash fish) and the risks of the unavailability of trash fish in the future, the information provided from this study will allow decisions to be made about the development of feed mills for local production of diets for the snakehead industry.

To meet the objective, a series of formulated feed experiments were conducted at the wet laboratory and hapas at College of Aquaculture and Fisheries (CAF) of Cantho University (CTU). Furthermore, we conducted on-farm trials in An Giang and Dong Thap provinces to test the optimal formulated feed for snakehead culture from the CTU trials under actual farm conditions. Specific tasks that were conducted were:

(i) Evaluation of the chemical composition of marine trashfish in order to determine its value as a feed ingredient.
(ii) Determine weaning methods with formulated feeds for snakehead *C. micropeltes*
(iii) Conduct pilot trials on weaning methods with both(*Channa striata* and *C. micropeltes* larvae
(iv) Conduct farm trials on grow-out of *Channa striata* fed with trash fish vs formulated feed
(v) Conduct farm trials on grow-out of *Channa micropeltes* fed with trash fish vs formulated feed
(vi) Conduct studies on the replacement of trashfish by rice bran and rice bran + cassava meal in feed for *Channa striata*
(vii) Conduct grow-out of *Channa striata* on demonstration farms to show local farmers the value of utilizing formulated feed
(viii) Conduct a survey of snakehead farmers using formulated feed in An Giang and Dong Thap provinces to determine the reasons for using formulated feed

RESULTS

2.1 Study 1: Evaluate the chemical composition and quality of trashfish

Introduction

In order to conduct some of the trials in this project, it was necessary to know the chemical composition and quality of the trash fish that would be used for feeding the experimental fish. Both fresh-water and marine trash fish are available in Vietnam. The composition and quality of trash fish in phase 1 of this project were analyzed.

Methods

Sampling was done at three different distribution sites and farm sites (An Giang province). Marine trash fish samples were collected at distribution sites and farm sites on the same day, and then stored on ice and sent to the College of Aquaculture and Fisheries, Can Tho University for analysis of chemical composition (protein, lipid, moisture and mineral) and TVB-N (Total Volatile Base Nitrogen) analysis. Fresh-water trash fish samples were also collected at the distribution sites.

Results and Discussion

The results showed that protein content of marine trash fish was higher, about 17.0%, than that of freshwater trash fish (15.5%); by contrast, lipid content of marine trash fish (2.22%) was lower than that of freshwater fish (6.2%).

Table 2.1.1. Chemical compositions of trash fish based on wet matter (%)

Trashfish	Moisture (%)	Crude ash (%)	Crude Protein (%)	Crude Lipid (%)
Marine trash fish	73.6±1.50	6.93±0.24	17.0±0.19	2.22±0.21
Freshwater trash fish	71.1±0.41	5.50±0.31	15.5±0.27	6.20±0.48

TVB-N values of marine trash-fish samples collected from distribution sites and farm sites were 99.2 ± 12.0 and 119.0 ± 17.8 mgN/100g, respectively (Fig. 2.1). Pike and Hardy (1997) presented evaluation standards for the freshness of fish. TVB-N value must be lower than 14 mgN/100gfor fish to be categorized as fresh, from 14 to 30 mgN/100g to be considered moderately fresh and fish with TVB-N values over 50 mgN/100g are categorized as stale. Our analysis showed that all of marine trash fish samples were in stale condition according to classification of Pike and Hardy (1997). The reason why trash fish samples showed high values of TVB-N is the long storage duration in transportation from the fishermen to the distribution sites (normally three days or more). In fishmeal processing, TVB-N values in trash fish ranged from 22-143 mgN/100g (Pike and Hardy, 1997). Moreover, after three days of storage on ice, there was an increase in TVB-N value in all samples collected from distribution sites and farm sites (159±17.7 and 139±17.3 mgN/100g, respectively). Randomly sampling trash fish for TVB-N analysis, Tran Thi Thanh Hien et al. (2006) indicated that marine trash fish used for Tra catfish were of bad quality, ranging from 84-148 mgN/100g and averaging 113.2 ± 25.6 mgN/100g for 11 samples collected.

Fresh-water trash fish exhibited low TVB-N values (15.7 ± 0.51mgN/100g) on the day of catching and sampling. The samples looked fresh at the time of analysis and fish were collected and analyzed on the days when they were caught. There was an increase in TVB-N value after three days of storage (43.5 ± 1.1 mgN/100g). According to classification of Pike and Hardy (1997) the fresh-water trash fish were therefore still fresh after three days of storage.

2.2. Study 2: Pilot trials on weaning method using formulated feeds for snakehead larvae

Introduction

First feeding is one of the critical periods in fish larval rearing. Zooplankton such as *Brachionus, Moina* and *Daphnia* are frequently used as food resources in fresh-water larviculture and for ornamental fish. They contain a broad spectrum of digestive enzymes such as proteinase, peptidase, amylase, lipase and even cellulase that can serve as exo-enzymes in the gut of the fish larvae (Lavens and Sorgeloos 1996). The quantity and quality of food given, including the types of food used in each of the developmental stages, can also be critical in larval rearing and most importantly can affect economic aspects. Larval rearing has been successful for freshwater and marine fish larvae using brine shrimp *Artemia* sp (Léger et al., 1986), for walking catfish *Clarias macroceplalus* using *Moina* (Fermine et al., 1991) or for European

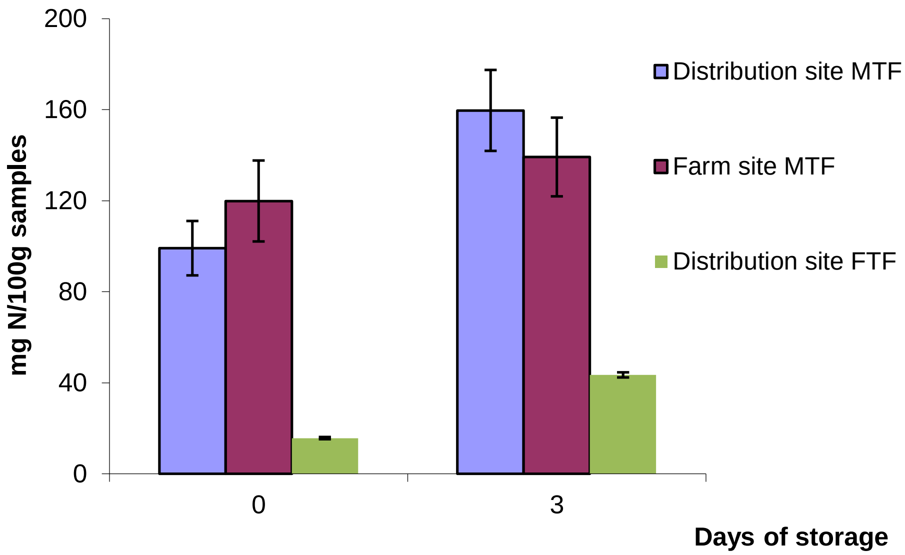


Fig 2.1.1. The freshness of marine trash-fish (MTF) samples collected from distribution and farm sites and fresh water trash fish (FTF) samples collected at distribution sites (n=3). Bars indicate standard errors.

catfish *Silurus glanis* using *Tubifex* worms (Ronyai and Ruttkay, 1990). Some catfish (*Clarias gariepinus* and *Heterobranchus longifilis*) can also be reared exclusively on formulated diet (Appelbaum et al., 1988). However, rearing larvae on formulated diets often resulted in lower growth and survival rate than rearing them on live foods or trash fish. So the present study aims at comparing growth performance and survival rate of *Channa striata* larvae when weaning from live feed to formulated diets.

Methods

After yolk absorption at 3 days after hatching (dah), larvae were fed with *Moina*. The experimental treatments were initiated when the larvae were 10 days after hatch (dah). The experiment was carried out with 9 treatments with three replicates of each treatment. Larvae were stocked at 200 individuals/tank. Trash fish was replaced by experimental feed at 20, 30 or 40 dah at rates of either 10% perday, 10% every two days, or 10% every three days) until larvae were receiving 100% experimental feed per day. Larvae were fed at 7am,10am, 2pm and 5pm.

The temperature varied from 25.92-27.81^{o}C, tending to be higher around noon; dissolved oxygen varied from 4.39 - 5.56 mg/L; pH was around 7; and N-NH_3 and NO_2. were <0.001 and <0.1 ppm. All values are in typical ranges for *C. micropeltes* larval culture in Vietnam.

Table 2.2.1. Environmental parameters

Treat.	Temperature (^oC)		Dissolved Oxygen (ppm)		pH		NH_3 (ppm)	NO_2^- (ppm)
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon		
20-1	25.92±0.36	27.79±0.38	5.50±0.32	4.45±0.26	7.47±0.05	7.47±0.06	<0.011	<0.1
20-2	25.98±0.36	27.77±0.37	5.53±0.38	4.39±0.32	7.47±0.04	7.46±0.05	<0.011	<0.1
20-3	26.05±0.38	27.81±0.37	5.53±0.32	4.40±0.42	7.45±0.04	7.46±0.05	<0.011	<0.1
30-1	26.09±0.32	27.79±0.38	5.53±0.34	4.41±0.35	7.45±0.05	7.44±0.07	<0.011	<0.1
30-2	26.06±0.36	27.75±0.38	5.53±0.33	4.47±0.44	7.45±0.04	7.44±0.07	<0.011	<0.1
30-3	25.97±0.33	27.75±0.38	5.47±0.39	4.40±0.46	7.44±0.04	7.45±0.07	<0.011	<0.1
40-1	25.93±0.30	27.76±0.40	5.56±0.36	4.45±0.42	7.45±0.04	7.45±0.05	<0.011	<0.1
40-2	26.03±0.31	27.76±0.38	5.54±0.28	4.46±0.42	7.47±0.04	7.45±0.06	<0.011	<0.1
40-3	25.93±0.28	27.77±0.39	5.54±0.31	4.44±0.52	7.45±0.04	7.43±0.05	<0.011	<0.1

Data measurement and calculation

During the experiment, any mortalities were removed daily and counted. At the end of experiment, all fish were counted and final body weight (FBW, mg) and wet weight gain (WWG, mg) were determined. From those data, we calculated survival rate (SR), daily weight gain (DWG), feed intake (FI), feed conversion ratio (FCR), protein efficiency ratio (PER), and economic conversion ratio (ECR). In addition, we calculated the mortality rate (based on number of actual mortalities removed from the experiment) and cannibalism rate (based on the initial number of fish stocked minus the number of mortalities removed minus the survivors at the end; i.e., all fish unaccounted for and presumed to have been cannibalized). Differences among treatments were determined by one way ANOVA with means separated using Duncan's Multiple Range test at p = 0.05 using SPSS 13.0.

Results

Experiment 1: Pilot trials on weaning method using formulated feeds for snakehead (Channa micropeltes) larvae

The survival rate increased as weaning was delayed (Table 2.2.2).. Within the same weaning time (i.e., 20, 30, or 40 dah), the survival rates tended to increase with increased number of days allowed for weaning, although significant differences were only seen at 40 dah. The non-cannibalism mortality rate was not significantly different among treatments, except for fish weaned at 20 dah over two- or three-day periods. *Channa micropeltes* raised in captivity still retain many characteristics of wild fish. They cannibalize each other if they are not graded weekly. The cannalism rate was highest (44.8%) in treatment 20-1 and differred significantly from the other treatments at $p<0.05$ (Table 2.2.2).

Non-acceptance of formulated feed was observed only among fish weaned at 20 dah (Table 2.2.3). Larvae weaned at 30 and 40 days gave the value of 0% in feed non-acceptance rate. Larvae which did not accept formulated diets became thin and skinny and died gradually or were eaten by larger fish.

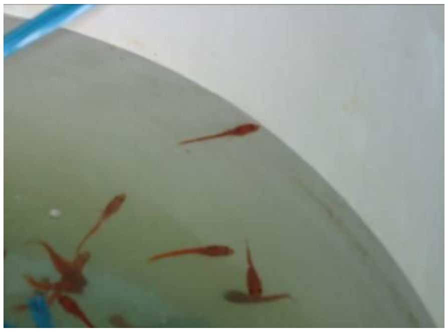
Table 2.2.2. Survival rate, non-cannibalism mortality rate, and cannibalism rate. Values (mean±SD) in the same column followed by the same letter are not significantly different.

Treatments	Survival rate (%)	Non-cannibalism mortality rate (%)	Cannibalism rate (%)
20-1	30.5 ± 3.28[a]	24.7 ± 6.53[a]	44.8 ± 5.13[c]
20-2	37.5 ± 11.2[ab]	47.2 ± 13.6[bc]	15.3 ± 4.25[b]
20-3	37.2 ± 9.65[ab]	54.7 ± 11.5[c]	8.17 ± 6.17[ab]
30-1	60.8 ± 11.4[cd]	29.5 ± 8.26[ab]	9.67 ± 3.55[ab]
30-2	63.0 ± 8.19[cd]	21.8 ± 8.50[a]	15.2 ± 1.53[b]
30-3	69.3 ± 19.9[cd]	18.5 ± 14.9[a]	12.2 ± 5.01[ab]
40-1	57.0 ± 18.3[bc]	30.3 ± 14.7[ab]	12.7 ± 5.69[ab]
40-2	73.8 ± 14.3[cd]	21.2 ± 12.7[a]	5.00 ± 1.80[a]
40-3	80.8 ± 2.93[d]	13.3 ± 4.54[a]	5.83 ± 2.02[a]

Figure 2.2.1. Larvae with large fish eating small fish

Table 2.2.3. Rates at which fingerlings did not accept formulated feed**.** Values (mean±SD) in the same column with different letters are significantly different (P<0.05).

Treatments	Rate of feed non-acceptance (%)
20-1	15.7±6.01[b]
20-2	14.7±1.76[b]
20-3	10.5±7.81[b]
30-1	0.00[a]
30-2	0.00[a]
30-3	0.00[a]
40-1	0.00[a]
40-2	0.00[a]
40-3	0.00[a]



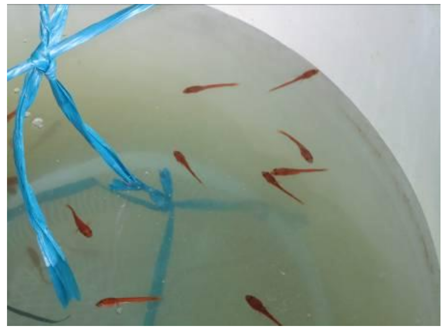


Figure 2.2.2. Larvae with thin body did not accept experimental feed. Larvae in treatment 40-3 gave the highest values in weight gain (8.6 g) and and daily weight gain (0.17 g/day) and differed significantly from those in other treatments at $p<0.05$ (Table 2.2.4).

Table 2.2.4. The growth of larvae in the *C. micropeltes* weaning experiment. Values (mean ± SD) in the same column followed by the same letter are not significantly different.

Treatment	Wi (g)	Wf (g)	WG (g)	DWG (g/day)
20-1	0.37±0.01	4.82±0.56^{bc}	4.46±0.56^{bc}	0.09±0.01^{bc}
20-2	0.37±0.01	4.20±0.65^{bc}	3.83±0.65^{bc}	0.08±0.01^{bc}
20-3	0.38±0.01	4.70±0.47^{bc}	4.33±0.48^{bc}	0.09±0.01^{bc}
30-1	0.37±0.01	3.01±0.25^{a}	2.64±0.25^{a}	0.05±0.00^{a}
30-2	0.37±0.00	3.73±0.60^{ab}	3.36±0.60^{ab}	0.07±0.01^{ab}
30-3	0.37±0.01	4.42±0.12^{bc}	4.05±0.11^{bc}	0.08±0.00^{bc}
40-1	0.37±0.01	5.24±0.82^{c}	4.86±0.82^{c}	0.10±0.02^{c}
40-2	0.37±0.01	7.23±0.79^{d}	6.86±0.78^{d}	0.14±0.02^{d}
40-3	0.37±0.01	8.97±1.07^{e}	8.60±1.08^{e}	0.17±0.02^{e}

The size disparity among fish in the different treatments can be seen in Fig. 2.2.3, which groups the fish into 5-g size classes for enumeration.

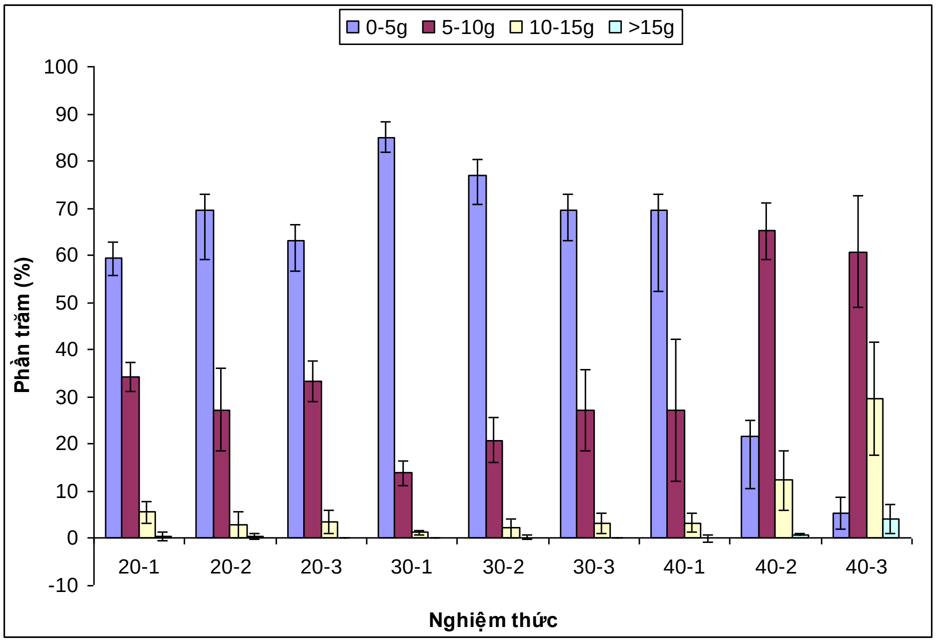


Figure 2.2.3. Size variation of snakehead fed with different diets

Figure 2.2.4. Size disparity of *Channa micropeltes* at the end of experiment

In general, the best weaning strategy that is apparent from this experiment is to wean giant snakehead beginning at 40 dah and using a three-day transition to formulated feed. Since this strategy yielded about 81% survival of the fish, some improvement ot this strategy may be possible, but our results are considered quite acceptable for snakehead culture in Vietnam.

Experiment 2: Pilot trials on weaning method using formulated feeds for snakehead *(Channa striata)* larvae on farms.

Introduction

During phase 1 of this project, we conducted weaning trials with *Channa striata* in the facilities at CTU to determine the optimal strategy for weaning this important species. One critical factor in convincing snakehead farmers to use formulated feed is the availability of snakehead fingerlings that have been weaned to pellets in the hatchery. Wild snakehead or snakehead that have been reared in a hatchery without weaning cannot be weaned to pellets once they are in the grow-out facility. In the current trial, we wanted to test our optimal weaning strategy under actual farm conditions.

Methodology

The experiment was carried out in An Giang and Dong Thap provinces simultaneously at one farm in each province. The fish (6 - 7 g/fish in initial weight) were assigned to 6 hapas (50 m^2/hapa) placed in a 1,000 m^2 pond, 180 fish/m^2 in stocking density. Each treatment was triplicated and experimental period was 10 days.

The experiment contained two treatments. In treatment 1, fish were fed with 100% trash fish during experimental period (control treatment). In treatment 2, on the first day, fish were fed 100% trash fish. Beginning the following day, the percentage of trash fish was reduced at a rate of 10% per day and replaced by formulated feed until trash fish was completely replaced by formulated feed on the 10^{th}day. During the experimental period, fish were fed 3 times per day to satiatation. Fish were weighed and counted on the 10^{th} day to calculate the survival rate (SR) and the growth rate. Temperature, oxygen and pH were measured daily. Water quality parameters were in the normal range for snakehead culture in Vietnam (Table 2.2.5). Temperature in the morning ranged from 28.0 – 29.5 ^oC while temperature in the afternoon was higher (29.5 – 32^oC). There was a small fluctuation in pH between the morning (6.7-7.5) and the afternoon (7.0 – 7.7). Dissolved oxygen was low in the morning (2.5 – 4 ppm) and higher in the afternoon (4.0 – 5.2 ppm).

Table 2.2.5. Temperature (^oC), pH and Oxy (ppm) of Study 1 in An Giang province

Provinces		**Temperature (^oC)**	**pH**	**Oxy (ppm)**
An Giang	Morning	28.5 - 29.5	6.8 - 7.5	3.00 – 4.00
	Afternoon	30.0 - 32.0	7.0 - 7.7	4.50 - 5.20
Dong Thap	Morning	28.0 - 29.5	6.7 - 7.3	2.5 - 4
	Afternoon	29.5 - 32.0	7.1 - 7.7	4.0 - 5.0

Results

Survival and Growth

No significant differences were observed between treatments in either survival rate or daily weight gain ($p>0.05$). Thus, snakehead fingerlings can be weaned by formulated feed in replacing trash fish at the rate of 10%.day^{-1} (Table 2.2.6).

Table 2.2.6. Survival rate (%), body weight (g.fish^{-1}) and daily weight gain (g.day^{-1}) of *Channa striata* fed trash fish (TF) or weaned to formulated feed (FF) at two farms in An Giang and Dong Thap provinces. Data are means of three replicates per treatment ± SE. Means for TF and FF in the same column for a given province with the same superscript in each treatment are not significantly different ($p<0.05$).

Provinces	Diets	SR	Initial weight	Final weight	WG	DWG
An Giang	TF	84.5±1.55^a	7.69±0.20^a	11.2±0.28^a	3.50± 0.28^a	0.50±0.04^a
	FF	81.7±1.19^a	7.69±0.10^a	10.9±0.19^a	3.16±0.19^a	0.45±0.03^a
Dong Thap	TF	76.0±2.61^a	6.25±0.04^a	10.6±0.27^a	4.36±0.27^a	0.55±0.03^a
	FF	72.5±0.13^a	6.25±0.08^a	10.4±0.16^a	4.10±0.10^a	0.51±0.01^a

Experiment 3: Weaning formulated feed for giant snakehead *(Channa micropeltes)* fingerling

Introduction

Following the laboratory experiment to determine the optimal strategy for weaning *C. micropeltes* to formulated feed (described above), we wanted to try the strategy on an actual farm. Such trials are necessary to convince farmers that they can wean this species under farm conditions.

Methodology

The experiment was carried out in An Giang province. The fish (1 - 2 g/fish in initial weight) were assigned to 6 hapas (50 m^2/hapa) in a 1,000 m^2 pond, 180 fish/m^2 in stocking density. Each treatment was in triplicate and the experimental period was 30 days.

The experiment contained two treatments. In the treatment 1, fish were fed 100% trash fish during the experimental period (control treatment). In treatment 2, on the first day, fish were fed 100% trash fish. Beginning the following day, the percentage of trash fish was reduced by 10% per day and replaced by formulated feed until trash fish was completely replaced by formulated feed on the 10thday. During the experimental period, fish were fed 3 times per day to sanitation. Fish were weighed and counted after 30 days to calculate the survival rate (SR) and the growth rate. Temperature, oxygen and pH were measureddaily. Environmental factors were in a suitable range for snakehead fingerlings. Temperature in the morning ranged from 28.0 – 29.5 ^oC while temperature in the afternoon was higher (29.5 – 32^oC) (Table 2.2.7). There was a small fluctuation in pH between the morning (6.8-7.5) and the afternoon (7.4 – 7.9). Dissolved oxygen was low in the morning (2.8 – 4.1 ppm) and higher in the afternoon (4.0 – 5.2 ppm).

Table 2.2.7. Temperature (^oC), pH and dissolved oxygen (ppm) of experiment 3 in An Giang province

Diets		Temperature (^oC)	pH	Oxy (ppm)
Trash fish	Morning	28.0 - 29.5	6.9 - 7.2	2.90 – 4.00
	Afternoon	30.0 - 32.0	7.4 - 7.8	4.00 - 5.20
Formulated feed	Morning	28.5 - 29.5	6.8 - 7.5	2.8 – 4.10
	Afternoon	29.5 - 32.0	7.4 - 7.9	4.2 - 5.0

Results

Survival and growth

Fingerlings that were fed only trash fish had significant greater daily weight gain compared to fish weaned from trash fish to formulated feed ($p<0.05$). However, there was no significant difference between treatments in the survival rate ($p>0.05$). Giant snakehead fingerlings can be weaned by formulated feed in replacing trash fish in the rate 10%.day^{-1} which reduce the dependence on trash fish supply, although farmers should expect that the growth rate of the fish will be reduced, at least temporarily.

Table 2.2.8. Survival rate (%), body weight (g.fish^{-1}) and daily weight gain (g.day^{-1}) of *Channa micropeltes* fed either trash fish for 30 days or weaned from trash fish to formulated feed over 10 days and then grown an additional 20 days. Data are means of three replicates per treatment ± SE. Means in the same column followed by the same superscript are not significantly different.

Diets	Initial weight	Final weight	WG	DWG	SR
Trash fish	$1.51±0.87^{a}$	$15.3±8.84^{b}$	$13.8±7.97^{b}$	$0.34±0.19^{b}$	$89.1±51.4^{a}$
Formulated feed	$1.51±0.87^{a}$	$9.97±5.76^{a}$	$8.46±4.89^{a}$	$0.21±0.12^{a}$	$91.1±52.6^{a}$

2.3 Study 3: Farm trials on grow-out of *Channa striata* fed with trash fish vs formulated feed

Introduction

In phase 1 of this project, we developed formulated feeds for *Channa striata* in which a significant amount of the fish meal was replaced by soybean meal and local ingredients like cassava meal and rice bran. This diet development was based on laboratory feeding trials in tanks followed by larger scale feeding trials in hapas in ponds at CTU. In the current phase of the project, we wanted to demonstrate the effectiveness of these diets on actual snakehead farms.

Methodology

The experiment was carried out in An Giang and Dong Thap provinces simultaneously. The test was set up with 6 hapas (50m^2/hapa) with a stocking density of 100 fingerlings/m^2. Hapas were placed in 2 ponds, each500 m^2. In pond 1, snakehead fingerlings (12-13g/fish) in the three hapas (5x10 m in size) were fed marine trash fish (control treatment) for 6 months. In pond 2, snakehead fingerlings (12-13g/fish) in the three 3 hapas (5x10 m in size) were fed formulated feed. In the two first months, snakehead fingerlings were fed by diet named CTU- CRSP 1 (44%CP). In the third month, fish were fed by diet CTU- CRSP 2 (41%CP) and CTU- CRSP 3 (38%CP) was used for the two last months. The formulation of three formulated diets is given in Table 2.3.1.

Formulated feed was made from main ingredients such as Kien Giang fish meal, defatted soybean meal, cassava meal, dried rice-bran. All diets were made in an extruding pellet mill at CTU. Trash fish was marine trash fish bought from markets andwas chopped up before feeding.

Table 2.3.1. The formulation of three formulated feed diets (% of dry matter basis) used in the farm trials with *Channa striata*. Note: 1 USD = 20,600 VND

Ingredients	44 % CP	41% CP	38 % CP
Fish meal	32.76	30.21	27.66
Soybean meal	31.87	29.39	26.91
Dried rice-bran	20.00	20.00	20.00
Cassava meal	7.12	11.99	16.86
Premix Vitamin	1.00	1.00	1.00
Premix mineral	1.00	1.00	1.00
Fish oil	3.32	3.48	3.64
Binder	1.90	1.90	1.90
Lysine	0.40	0.44	0.46
Methionine	0.28	0.28	0.28
Threonine	0.41	0.40	0.39
Phytase	0.02	0.02	0.02
Total	100	100	100
Price (USD)	0.94	0.92	0.90

Sampling

The amount of feed used daily was recorded. . The following water quality parameters were measured monthly: Transparency (Secchi disk), pH, dissolved oxygen, NH_3, NO_2^-. Growth was recorded monthly by weighing 30 fish/hapa. At the end of the experiment, a sensory evaluation was conducted to compare the fillet quality of experimental fish and wild fish.

Data calculations

(1) Chemical composition of the experimental feeds (see below)

(2) Survival rate (%) = (Number of fish end of experiment/number of initial fish) x 100

(3) Weight gain (WG) (g) = Final body weight – Initial body weight

(4) Daily weight gain (DWG) (g.day^{-1}) = [(Final body weight – Initial body weight)/ duration of the experiment]

(5) Feed Conversion Ratio (FCR)

FCR (wet) = Feed intake (wet) / Weight gain

FCR (dry) = Feed intake (dry) / Weight gain

(6) PER = (Final body weight – Initial body weight) / Protein intake

(7) Abnormal (humpback) rate (%)= 100%*(Number of abnormal fish/total fish)

(8) Profit (USD)= Total income – total cost

(9) Profit ratio (%) = 100*(profit/total cost)

(10) Sensory test of fillets (see below)

Chemical analysis

Feed was analyzed for chemical composition: moisture, crude protein (CP), crude lipid (CL), crude fiber (CF), nitrogen free extracts (NFE) and gross energy, according to AOAC (2000) methods. Loss on drying was used to determine moisture content; protein (N x 6.25) was determined by Kjeldahl method; lipid was determined by Soxhlet method; crude fiber was determined by acid and base hydrolysis; and gross energy was determined by bomb calorimeter. Carbohydrate-NFE = 100 - (CP + CL + CF). Fish samples collected at the beginning and end of the experiment were also analyzed for moisture, crude protein, crude lipid, crude ash and nitrogen free extracts.

Sensory evaluation

At the end of the experiment, all fish were killed, filleted and washed, then they were steamed for 3 minutes. First, these fish were used to determine the difference in the quality of fish fillet between the control and experimental groups by triangle test (2 controls and 1 sample) with three replacements per test. And the control sample was the snakehead which were bought at the local market. There were two samples named trash-fish and formulated feed.

If less than 6 out of 9 detected the odd sample correctly, we determined that there was no significant difference and therefore no need to conduct a sensory test. A pair test was run if there was any difference in any sensory attributes for texture or taste even if they were minor – called a 'descriptive pair test'. On the other hand, if 7 out of 9 people detected the odd sample correctly, there was a significant difference at $P<0.01$ or 6 out of 9 $P<0.05$. In this case, it was necessary to do a comprehensive pair test on appearance, texture and taste. A pair test is hedonic and scored on an intensity scale (1-9 points) on appearance such as liking (1, least like – 5, o.k. – 9, like very much), whiteness (1, dark – 5,medium – 9, very white), and structural integrity (uniformity: 1, very irregular – 5, medium – 9, very uniform); taste, for example liking (1, least like – 5, o.k. – 9, like very much); snakehead-like taste (1, very little – 5, o.k. – 9, very much)' presence of objectionable taste (yes or no) and presence of objectionable odor (yes or no); texture, for instance, liking (1, least like – 5, o.k. – 9, like very much); firmness (1, very soft – 5, medium – 9, very firm); moistness (1, very dry – 5, medium – 9, very moist); chewiness (1, mushy – 5, medium – 9, very chewy); and flakiness(1, least or rubbery – 5, medium – 9, very flaky). Mean values of results in different treatments were compared by paired sample t-test using SPSS 13.0 software. Treatment effects were considered with the significance level at $P< 0.05$.

Results

Experimental diets

Proximate analyses of the experimental diets are given in Table 2.3.2.

Table 2.3.2. Proximate analysis of experimental diets (% dry matter basis) used in the farm trial with *Channa striata*. MTF refers to the marine trash fish diet used against which the formulated feeds were tested.

Composition (%)	44 % CP	41% CP	38 % CP	MTF*
Dry matter	90.0	90.5	90.3	26.4
Crude protein	44.1	41.1	38.1	59.1
Crude lipid	9.5	9.7	9.6	9.85
Nitrogen free extract	28.3	32.6	35.9	-
Crude ash	11.6	10.2	10.0	27.8
Crude Fibre	6.50	6.40	6.40	-

Proximate compositions of the formulated feeds were similar to the theoretical levels in the diet formulations diet while trash fish had higher protein level (59.1%) in dry basic matter.

Water quality parameters

Water quality parameters are presented in Table 2.3.3. There was some variation in water quality parameters between the two experimental ponds in each province. In particular, dissolved oxygen levels were lower in the ponds fed trash fish than they were in the ponds fed formulated feed. Trash fish is generally considered to pollute the water in which the fish to which it is fed are held and our observations may indicate that more oxygen is being used to break down the organic matter in the trash fish-fed ponds than in the formulated diet-fed ponds.

Table 2.3.3. Water quality parameters in An Giang and Dong Thap provinces

Provinces	Diets	Temperature (^oC)	pH	DO (ppm)	Transparency (cm)	NH_3 (mgL^{-1})	NO_2^- (mgL^{-1})
An Giang	Trash fish	29.0 - 31.8	7.1 - 7.8	2.5 – 3.0	22 – 30	0.01 – 0.08	0.01 – 0.05
	Formulated feed	29.0 - 31.8	7.0 - 7.5	3.0 - 4.5	20 - 25	0.01 – 0.02	0.01 – 0.03
Dong Thap	Trash fish	29 - 31.8	7 - 7.3	2.2 – 3.2	20 - 25	0.02 – 0.06	0.01 – 0.05
	Formulated feed	28.7 - 31.5	7 - 7.5	3.5 – 4.5	18 - 22	0.01 – 0.02	0.01 – 0.02

Survival and growth

After 6 months of culture in An Giang province, the average final weight of fish fed fed with formulated diet (403 ± 2.21g) was significantly higher than that of fish fed with trash fish (391 ± 3.32g) (Fig. 2.3.1), as was daily weight gain (2.75±0.02 $g.day^{-1}$ and 2.67±0.02 $g.day^{-1}$ respectively) (Table 2.3.4). After 4 months of culture in Dong Thap province, the average final weight of fish fed with trash fish (136 ± 10 g) was significantly lower than that of fish fed with formulated diet (199 ± 3 g)(Fig, 2.3.2), as was daily weight gain (1.15 ± 0.10 g/day and 1.74 ± 0.02 g/day, respectively) (Table 2.3.4).

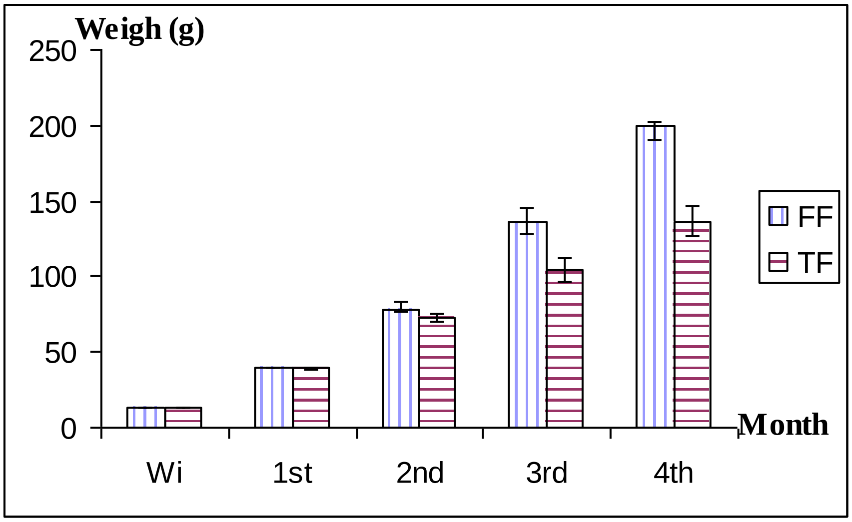


Figure 2.3.1. The growth performance of snakehead throughout the crop in An Giang province

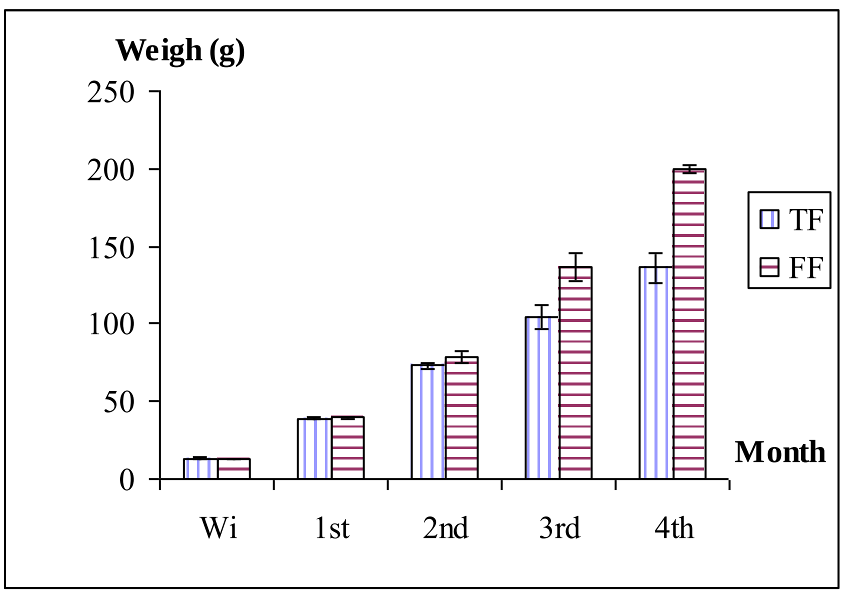


Figure 2.3.2. The growth performance of snakehead throughout the crop in Dong Thap province

The survival rate in the experiment showed no significance between fish fed formulated feed and trash fish in the two provinces ($p<0.05$) (74.8±0.55% and 73.3±0.32%, An Giang province; 79.7±2.67% and 78.5±3.44%, Dong Thap province) (Table 2.3.4).

Table 2.3.4. Survival rate (%), feed conversion ratio (wet and dry basic matter), protein efficiency ratio (protein. weight gain^{-1}) and abnormal rate (%) of *Channa striata* fed experimental diets of experiment 2 in An Giang and Dong Thap province.

Provinces	**Diets**	**SR**	**FCR (wet)**	**FCR (dry)**	**PER**	**Abnormal rate (%)**	**DWG**
AG	TF	74.8±0.55^{a}	4.45±0.07^{b}	1.12±0.02^{b}	1.78±0.03^{b}	1.26±0.16^{a}	2.67±0.02^{a}
	FF	73.3±0.32^{a}	1.44±0.03^{a}	1.29±0.03^{a}	1.56±0.03^{a}	20.1±1.83^{b}	2.75±0.02^{b}
DT	TF	78.5±3.44^{a}	3.72 ± 0.10^{b}	1.10 ± 0.04^{a}	1.56±0.06^{b}	00	1.15±0.10^{a}
	FF	79.7±2.67^{a}	1.59 ± 0.04^{a}	1.59 ± 0.04^{b}	1.34±0.04^{a}	00	1.74±0.02^{b}

Note: TF: trash fishFF: formulated feed

Abnormal rate from fish fed formulated diet (20.1 ± 1.83%) was significantly higher than that of fish fed the trash fish diet (1.26 ± 0.16%) ($p<0.05$) in the trial at An Giang province; however,. we did not observe any abnormal fish in the trial in Dong Thap province (Table 2.3.4).

FCR on a wet matter basis from treatment fed trash fish showed significantly higher values (4.45 ± 0.07 in An Giang province and 3.72 ± 0.10 in Dong Thap province) than did the treatments fed formulated feed (1.44 ± 0.03 in An Giang province and 1.59 ± 0.04 in Dong Thap province). However, calculating on a dry matter basis, FCR of trash fish diet was significantly lower (1.12 ± 0.02 in An Giang province and 1.10 ± 0.04 in Dong Thap province) than that of formulated feed (1.29 ± 0.03 in An Giang province and 1.59 ± 0.04 in Dong Thap province) in both provinces. (It should be noted, though, that trash fish is purchased on a wet matter basis, not on a dry matter basis.) In addition, PER from the treatment fed trash fish showed significantly higher values than did the treatment fed formulated feed ($p<0.05$) (1.78 ± 0.03 and 1.56 ± 0.03, An Giang province; 1.56 ± 0.06 and 1.34 ± 0.04, Dong Thap province). However, the daily weight gain of the fish fed formulated feed was significantly higher than that of fish fed trash fish (2.75 ± 0.02 and 2.67 ± 0.02, An Giang province; 1.74 ± 0.02 and 1.15 ± 0.10, Dong Thap province).

Table 2.3.5. Production and yield of *Channa striata* fed experimental diets in An Giang and Dong Thap provinces.

Provinces	Diets	Production (kg)	Yield (kg/m^2)
An Giang	TF	1462 ± 8.01^{a}	29.2 ± 0.16^{a}
	FF	1476 ± 12.6^{a}	29.5 ± 0.25^{a}
Dong Thap	TF	533 ± 30.7^{a}	10.7 ± 0.61^{a}
	FF	789 ± 13.7^{b}	15.8 ± 0.27^{b}

There was no significant difference in production or yield between ponds fed formulated feed or trash fish for snakehead culture in An Giang province ($p>0.05$) (Table 2.3.5). In Dong Thap province, production and yield in ponds given formulated feed were significantly higher than those in ponds fed trash fish (Table 2.3.5).

Economics

The feed cost made up the biggest variable cost for snakehead culture in these trials, whereas costs of labor, fingerlings and chemicals were relatively minor (Figs. 23.4 and 2.3.5)

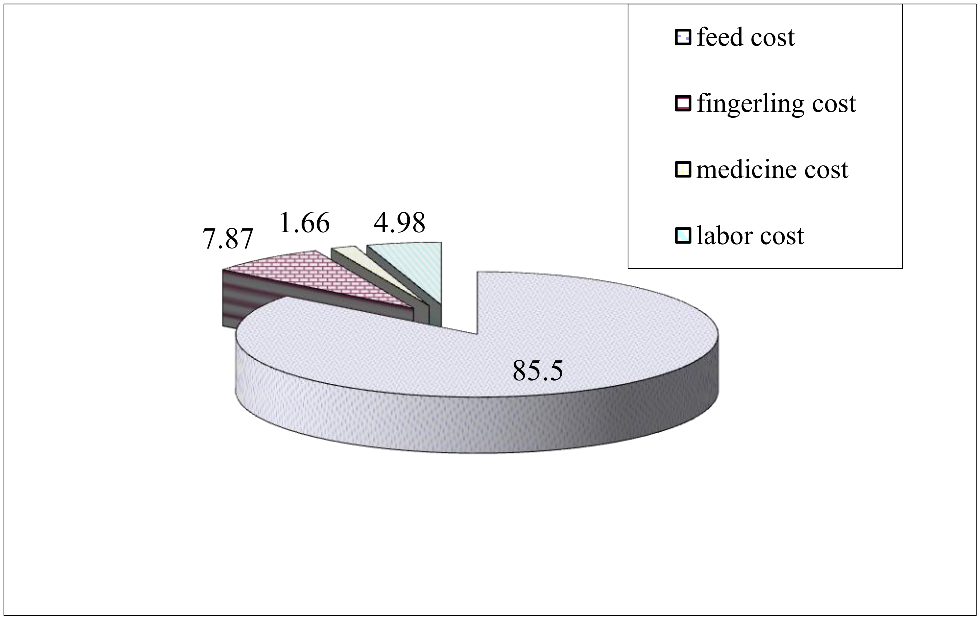


Figure 2.3.3. Breakdown of variable costs as percentages of total cost for the ponds fed formulated feed in the farm trials with *Channa striata*

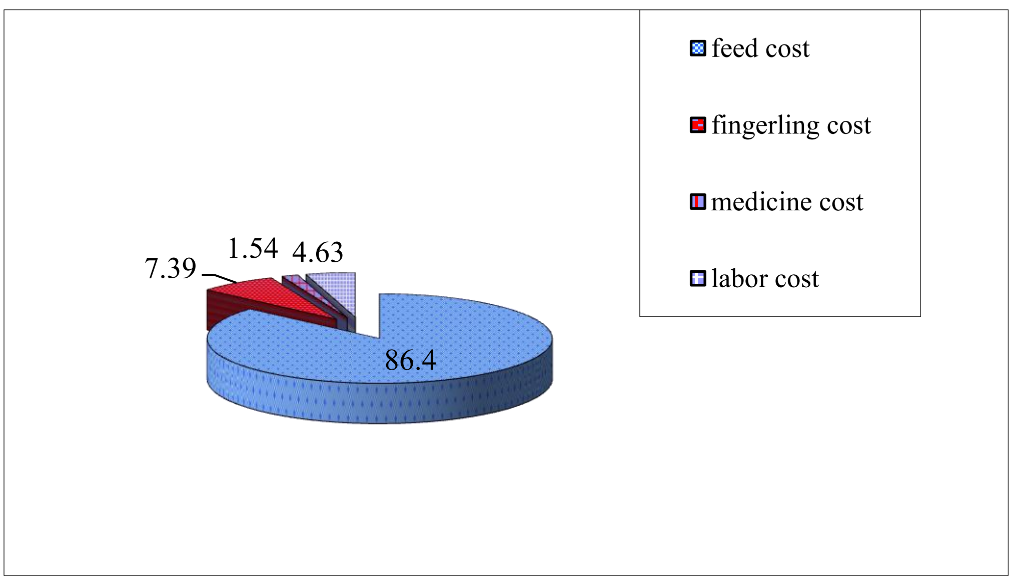


Figure 2.3.4. Breakdown of variable costs as percentages of total cost for the ponds fed trash fish in the farm trials with *Channa striata*

Profit from ponds fed trash fish were much lower than that from ponds fed formulated feed and there was a significant difference between treaments ($p<0.05$) in both provinces (Table 2.3.6). Profit in both treatments in An Giang province were much lower than those in Dong Thap province. This was primarily due to the lower income received for both types of fish in Dong Thap because they were smaller sized.

Table 2.3.6. Economics of experimental snakehead culture in An Giang and Dong Thap province on a per-hapa and per-meter-squared basis. Note: Crop duration was 6 months for An Giang province and 4 months for Dong Thap province.

Provinces	Diets	Total cost (million VND/hapa)	Total income (million VND/hapa)	Profit (million VND/hapa)
An Giang	TF	14.3 ± 0.13^{b}	20.6 ± 0.11^{a}	6.37 ± 0.21^{a}
	FF	13.4 ± 0.14^{a}	20.8 ± 0.18^{a}	7.43 ± 0.32^{b}
Dong Thap	TF	5.97 ± 0.16^{a}	11.5 ± 0.66^{a}	5.54 ± 0.51^{a}
	FF	9.04 ± 0.16^{b}	17.0 ± 0.30^{b}	8.01 ± 0.38^{b}

Provinces	Diets	Total cost (million VND/m^2)	Total income (million VND/m^2)	Profit (million VND/m^2)
An Giang	TF	0.95 ± 0.01^{b}	1.37 ± 0.01^{a}	0.42 ± 0.01^{a}
	FF	0.89 ± 0.01^{a}	1.39 ± 0.01^{a}	0.50 ± 0.02^{b}
Dong Thap	TF	0.25 ± 0.01^{a}	0.48 ± 0.03^{a}	0.23 ± 0.02^{a}
	FF	0.38 ± 0.01^{b}	0.71 ± 0.01^{b}	0.33 ± 0.02^{b}

Table 2.3.7. Economics of experimental snakehead culture in An Giang and Dong Thap province on a per kg fish basis. Note: Crop durationwas 6 months for An Giang province and 4 months for Dong Thap province

Provinces	**Diets**	**Total cost (thousand VND/kg fish)**	**Total income (thousand VND/kg fish)**	**Profit (thousand VND/kg fish)**
An Giang	TF	32.5 ± 0.41^{b}	47.0 ± 0.00	14.5 ± 0.41^{a}
	FF	30.5 ± 0.62^{a}	47.0 ± 0.00	16.5 ± 0.62^{b}
Dong Thap	TF	24.0 ± 0.62^{a}	45.0 ± 0.00	21.0 ± 0.62^{a}
	FF	23.5 ± 0.62^{a}	45.0 ± 0.00	21.5 ± 0.62^{a}

Fish quality

Sensory analysis

In appearance, both fish fed trashfish and formulated feed received scores of approximately 4 to 5, meaning that the fillets were passable or fairly likable for liking; medium or rather white for whiteness; except structural integrity, for which the scores were nearly 7- relatively uniform. In taste, the fish fillet had snakehead-like taste without the presence of objectionable taste and odor. In texture examination, for liking, the score was from 5 to 6, from rather not like – passable – fairly like.For firmness, the scores were 4-5, relatively soft – medium fish fillet. The fillet moistness was judged to be rather dry to medium (not dry and not moist). The fillet chewiness and flakiness was fairly mushy and relatively rubbery or medium (not mushy and not chewy; not rubbery and not flaky).

The result showed that there was no significant difference between paired samples in triangle tests (less than 6 out of 9 people detected the odd sample correctly). These samples were then subjected to "descriptive" pair tests, with the result that the quality of fish fillet samples from the two treatments did not significantly differ.

Table 2.3.8. Triangle test for difference (Number from a 9-person sample who detected the odd sample correctly

TF	FF
2.67 ± 0.33	4.33 ± 0.33

Table 2.3.9. *Channa striata* sensory analysis. Data are mean ± SE.

Content	Scores	
	TF	FF
Appearance		
Liking	4.70 ± 0.07	4.96 ± 0.13
Whiteness	4.59 ± 0.07	4.48 ± 0.04
Structural integrity	7.00 ± 0.00	6.93 ± 0.07
Taste		
Liking	4.30 ± 0.10	4.70 ± 0.10
Snakehead-like taste	4.56 ± 0.11	5.81 ± 0.23
Presence of objectionable taste	No	No
Presence of objectionable odor	No	No
Texture		
Liking	5.30 ± 0.10	5.89 ± 0.19
Firmness	5.41 ± 0.07	4.93 ± 0.10
Moistness	3.74 ± 0.07	5.04 ± 0.36
Chewiness	5.63 ± 0.04	5.67 ± 0.06
Flakiness	3.70 ± 0.07	4.04 ± 0.13

In summary, snakehead fillet quality was fairly like and did not significantly differ between samples in triangle tests. In desciptive pair tests, there was also no significant difference between samples. So, the diets did not affect on the quality of fish fillet for fish in these farm trials.The results confirmed that trash fish can be replaced by formulated feed for snakehead culture.

2.4 Study 4: Farm trials on grow-out of *Channa micropeltes* fed with with trash fish vs Formulated feed

Introduction

Just as for *Channa striata*, it is important to demonstrate the effectiveness in actual farm trials of the formulated diets developed in phase 1 of this project for *Channa micropeltes*.

Methodology

The experiment was carried out in An Giang province. The test was set up with 6 hapas ($50m^2$/hapa) placed in one pond (700 m^2)with a stocking density of 100 fingerlings/m^2. Giant snakehead fingerlings (12 - 13g/fish) in three hapas (5x10 m in size) were fed marine trash fish (control treatment) for 5 months. Fingerlings (12-13g/fish) in the other three hapas (5x10 m in size) were fed formulated feed. In the two first months, snakehead fingerlings were fed the diet named CTU- CRSP- 1 (44%CP). In the third month, fish were fed by diet CTU- CRSP- 2 (41%CP) and CTU- CRSP- 3 (38%CP) for the two last months. Experimental diets, sampling, data calculation and analysis were done the same way as experiments on snakehead experiments

Results
The experiment will be completed on 15 September

2.5 Study 5: Replacing trash fish by rice bran and rice bran + cassava meal in snakehead *Channa striata* feed

Introduction
Although hatchery-reared snakehead that have been weaned to pellets are available in Vietnam, such fish are not available in Cambodia and it will take some time before Cambodian hatcheries are fully functional and the snakehead have been domesticated there. In the short term in Cambodia, it will be necessary to use moist diets based on trash fish and other ingredients, such as rice bran and cassava meal. Rice bran is available and abundant in Mekong Delta. Using this ingredient will reduce feed cost for fish and animal production. Actually, it has often been used in formulated fish feed such as commercial feed (30-40% of rice bran has been used) and home-made feed (60-70%) for some species. Rice bran contains vitamins A, D, E, B1, and B2 at levels higher than those in corn, and rather high protein 8.34-16.3% (Hien et al., 2009).

Cassava meal is acheap source of carbohydrates and serves as a good binder in fish feed. According to Hien (2009), the dry matter digestibility of cassava is approximately 83.3%, high compared to other carbohydrate sources.

Methodology

Figure 2.5.1. Experimental hapas

Experimental fish
Before starting the experiments, all the fish were reared in 2000-L round tanks and were fed with trash fish combined with pellet diets for 2 weeks. Replacement of trash fish by pellet feed was applied gradually at a rate of 10% day-1 until 100% of trash fish was substituted by pellet feed.

Experimental design
There are two experiments in this study. The first is replacing marine trash-fish (MTF) by rice bran and cassava meal. The second is replacing freshwater trash-fish (FTF) by those ingredients. Both experiments were conducted with 11 diet treatments consisting of a control diet formulated pellet (FP) which concluded fish meal, soybean meal, rice bran and cassava meal in the optimal combination as determined

from experiments in phase 1; marine trash-fish (MTF); freshwater trash-fish (FTF); and others which were mixed with different ratios of MTF or FTF, rice bran (RB) and RB + cassava meal (CM) (Tables 2.5.1 and 2.5.2) Each treatment had three replicates.

The 33 hapas (1x1x2m/hapa) used in each experiment were fixed in a pond in CAF, Cantho University (Fig. 2.5.1). Fifty snakehead fingerlings (3.7 - 3.9 g in initial weight) were assigned randomly in each hapa. Experimental time was 6 weeks.

Table 2.5.1. Composition of 11 experimental diets (%)

Treat	Mixed ratios	FP	MTF	FTF	Replacing ratios of MTF (FTF)	RB	CM
1	Formulated Pellet (FP)	100	-	-		-	-
2	MTF	-	100	-		-	-
3	FTF	-	-	100		-	-
4	MTF (FTF)+RB+CM 80:10:10	-	-		80	10	10
5	MTF (FTF)+RB+CM 70:15:15	-	-		70	15	15
6	MTF (FTF)+RB+CM 60:20:20	-	-		60	20	20
7	MTF (FTF)+RB+CM 50:25:25	-	-		50	25	25
8	MTF (FTF)+RB 80:20	-	-		80	20	-
9	MTF (FTF)+RB 70:30	-			70	30	-
10	MTF (FTF)+RB 60:40	-	-		60	40	-
11	MTF (FTF)+RB 50:50	-	-		50	50	-

Fish were fed until satiation twice daily at 08:00am and 15:00pm. The amount of feed consumed was adjusted on a daily basis and recorded. All hapas were cleaned every two weeks. Total fish weight in each aquarium was determined at the beginning and at the end of experiments. Dead fish were recorded and weighed for calculating feed conversion ratio (FCR).

Water temperature was measured daily and ranged from 27.0–30.1^{o}C. pH and dissolved oxygen were measured weekly and determined to be 6.5–7.6 and 1.9–2.6 ppm in the early morning, and 4.8-6.8 in the afternoon, respectively. No aeration was provided in the ponds.

Methods for data calculation, chemical analysis and statistical analysis were identical to those used in the trial on farm experiments**.**

Results and Discussion

Experiment 1

Marine trash-fish (17.0%) had higher protein content than freshwater trash-fish (15.5%). The lipid content was 2.22% for freshwater and 6.20% for marine trash-fish. Crude protein decreased with increasing replacement of fish meals with rice bran and cassava meal, and diets replacing trash-fish by only rice bran (16.5 – 14.8%) had higher protein content than those replacing TF by both RB and CM (15.5 – 12.5%) (Table 2.1.2).

Table 2.5.2. Chemical compositions of treatment diets basing on wet matter (%)

Treatment diets	Moisture (%)	Crude ash (%)	Crude Protein (%)	Crude Lipid (%)
Formulated Pellet (44%CP)	10.2	10.21	38.80	8.36
MTF	73.6±1.50	6.93±0.24	17.0±0.19	2.22±0.21
FTF	71.1±0.41	5.50±0.31	15.5±0.27	6.20±0.48
MTF+RB+CM 80:10:10	56.8±0.38	6.58±0.21	15.5±0.16	2.97±0.18
MTF+RB+CM 70:15:15	52.8±0.98	6.42±0.09	14.7±0.11	3.22±0.10
MTF+RB+CM 60:20:20	46.0±0.48	6.24±0.07	13.3±0.10	3.41±0.15
MTF+RB+CM 50:25:25	46.1±0.36	6.14±0.07	12.5±0.44	3.79±0.23
MTF+RB 80:20	63.0±0.31	7.07±0.06	16.5±0.11	3.45±0.17
MTF+RB 70:30	54.6±0.03	7.10±0.38	15.8±0.2	4.26±0.08
MTF+RB 60:40	42.8±0.84	7.15±0.03	15.2±0.38	5.37±0.01
MTF+RB 50:50	39.4±0.71	7.19±0.13	14.8±0.17	5.89±0.15

Significantly higher growth rates were obtained with formulated pellet and freshwater trash-fish (0.56 and 0.57 g.day^{-1}, respectively) than with the other treatments (Table 2.5.3). Conversely, significantly lower growth was obtained with diets MTF+RB+CM 50:25:25 (0.21 g.day^{-1}) and MTF+RB 50:50 (0.23 g.day^{-1}). This means that the greater amount of marine trash-fish that is replaced, the lower fish growth will be. In addition, snakehead using FTF grew as fast as fish fed by formulated pellet and faster than fish fed by MTF.

Table 2.5.3. The growth of *Channa striata* fingerlings

Treatments	Wi	Wf	DWG	SGR	SR
FP (44%CP)	3.79±0.01^{a}	27.3±0.25^{e}	0.56±0.01^{e}	4.70±0.02^{c}	91.0±1.73^{d}
MTF	3.75±0.02^{a}	19.0±0.13^{c}	0.36±0.00^{c}	4.66±1.17^{c}	79.0±5.20^{cd}
FTF	3.75±0.01^{a}	27.9±1.09^{e}	0.57±0.03^{e}	4.78±0.10^{c}	68.0±3.06^{abc}
MTF+RB+CM 80:10:10	3.80±0.03^{a}	21.3±0.89^{d}	0.42±0.02^{d}	4.57±0.04^{bc}	70.0±1.15^{abc}
MTF+RB+CM 70:15:15	3.78±0.02^{a}	17.6±1.18b^{c}	0.33±0.03^{bc}	3.84±0.27^{abc}	63.3±6.77^{ab}
MTF+RB+CM 60:20:20	3.76±0.02^{a}	14.8±0.51^{ab}	0.26±0.01^{ab}	3.57±0.31^{abc}	77.0±1.73^{bc}
MTF+RB+CM 50:25:25	3.78±0.01^{a}	12.6±0.43^{a}	0.21±0.01^{a}	2.87±0.09^{a}	66.7±2.40^{abc}
MTF+RB 80:20	3.77±0.02^{a}	14.5±0.25^{ab}	0.26±0.01^{ab}	3.20±0.05^{a}	66.0±3.06^{abc}
MTF+RB 70:30	3.79±0.02^{a}	18.5±1.08^{c}	0.35±0.03^{c}	3.77±0.13^{abc}	62.9±8.86^{ab}
MTF+RB 60:40	3.77±0.00^{a}	16.0±0.26^{b}	0.29±0.01^{b}	3.34±0.15^{ab}	56.0±2.31^{a}
MTF+RB 50:50	3.78±0.02^{a}	13.2±0.93^{a}	0.23±0.02^{a}	2.70±0.32^{a}	58.0±5.29^{a}

Data are means of three observations ± SE. Means in the same column with the same superscript are not significantly different (P<0.05).

Initial mean weight – Wi (g), final mean weight – Wf (g), daily weight gain – DWG (g.day^{-1}), special gain rate – SGR (%.day^{-1}) and survival rate – SR (%) of snakehead fed experimental diets (Mean±S.E., n=3) in the experiment 1

Survival rate of *C. striata* was the highest with formulated pellet (91.0%) while the lowest values were with diets replacing MTF by RB 60:40 and 50:50 (56.0 and 58.0%, respectively). It may be that snakehead fed by formulated pellet had reduced risk of contact with pathogens in the trash fish. Compared to results of experiments in phase 1 on *C. striata*, the survival rate in this experiment was high in the formulated diet treatment and fairly high in the treatments MTF (79.0%), FTF (68.0%), and treatments in which MTF was replaced by ingredients (56.0-77.0%).

The lowest FCR was in the FP treatment (1.02) and the highest was in the treatment MTF (6.11) (Table 2.5.4). Otherwise, fish effectively used protein in pellet (2.52) better than that in MTF (0.97). Moreover, feed cost per kg weight gain of fish was lowest in the pellet treatment (18,900 VND/kg fish). This value decreased with increasing replacement ratios of MTF by RB or RB and CM. Furthermore, feed cost for FTF is higher than that for MTF (35,900 and 33,600 VND/kg fish, respectively) because of the high price of FTF.

Table 2.5.4. Feed conversion ratio, protein efficiency ratio, and feed costs for producing one kg weight gain of snakehead fed experimental diets (% of wet matter basis) in the experiment 1

Treatments	**FCR**	**PER**	**Feed cost/kg weight gain of fish (,000 VND/kg fish)**
FP (44%CP)	1.02 ± 0.00^{a}	2.52 ± 0.01^{d}	18.9
MTF	6.11 ± 0.35^{d}	0.97 ± 0.06^{a}	33.6
FTF	4.49 ± 0.34^{b}	1.45 ± 0.11^{bc}	35.9
MTF+RB+CM 80:10:10	4.89 ± 0.26^{bc}	1.33 ± 0.07^{b}	24.5
MTF+RB+CM 70:15:15	4.60 ± 0.30^{b}	1.49 ± 0.10^{bc}	21.8
MTF+RB+CM 60:20:20	4.53 ± 0.47^{b}	1.70 ± 0.17^{c}	20.4
MTF+RB+CM 50:25:25	5.77 ± 0.07^{cd}	1.39 ± 0.02^{bc}	24.5
MTF+RB 80:20	4.63 ± 0.22^{b}	1.32 ± 0.06^{b}	23.6
MTF+RB 70:30	4.33 ± 0.41^{b}	1.49 ± 0.15^{bc}	21.2
MTF+RB 60:40	4.40 ± 0.39^{b}	1.52 ± 0.12^{bc}	20.7
MTF+RB 50:50	4.53 ± 0.28^{b}	1.50 ± 0.09^{bc}	20.4

Data are means of three observations ± SE. Means in the same column with the same superscript are not significantly different (P<0.05).

Experiment 2

Table 2.5.5. Chemical composition of treatment diets based on wet matter (and dry matter in brackets)

Treatment diets	Moisture (%)	Crude ash (%)	Crude Protein (%)	Crude Lipid (%)
FP (44%CP)	(90.0)	(11.6)	(44.1)	(9.50)
MTF	73.1	70.3 (26.1)	16.2 (60.2)	2.5 (9.29)
FTF	70.5	5.78 (19.6)	15.1 (51.3)	6.9 (23.6)
FTF+RB+CM 80:10:10	60.1	4.36 (10.9)	14.9 (37.2)	7.77 (19.5)
FTF+RB+CM 70:15:15	55.1	5.25 (11.7)	14.3 (31.9)	7.83 (17.4)
FTF+RB+CM 60:20:20	51.1	5.45 (11.1)	13.9 (28.5)	8.06 (16.5)
FTF+RB+CM 50:25:25	42.2	5.46 (9.45)	13.0 (22.4)	8.35 (14.5)
FTF+RB 80:20	58.7	6.12 (14.8)	14.5 (35.1)	8.22 (19.0)
FTF+RB 70:30	50.9	6.62 (13.5)	13.3 (27.0)	8.51 (17.3)
FTF+RB 60:40	43.1	7.43 (13.1)	13.2 (23.1)	9.25 (16.3)
FTF+RB 50:50	39.7	7.72 (12.8)	12.9 (21.4)	9.50 (15.8)

The fish fed diets in which FTF was replaced by both rice bran and cassava meal grew faster than those of diets replaced by only rice bran (Table 2.5.6). The highest growth was in the treatment FTF+RB+CM 80:10:10 (1.58 g.day^{-1}) and there was no significant difference (P>0.05) between treatments FTF, FTF+RB+CM 80:10:10, and FTF+RB+CM 75:15:15 (1.50, 1.58, and 1.53 g.day^{-1}, respectively).

Table 2.5.6. The growth and survival rate of snakehead fed with different diets

Treatments	Wi	Wf	DWG	SGR	SR
FP	3.90±0.001	60.0±0.56^{e}	1.34±0.01^{e}	6.51±0.02^{f}	91.0±1.73
MTF	3.91±0.009	63.7±1.35^{ef}	1.42±0.03^{ef}	6.65±0.04^{fg}	86.0±3.46
FTF	3.91±0.006	67.0±0.66^{fg}	1.50±0.02^{fg}	6.76±0.02^{g}	92.0±2.00
FTF+RB+CM 80:10:10	3.91±0.001	70.3±3.55^{g}	1.58±0.08^{g}	6.88±0.12^{g}	92.0±8.00
FTF+RB+CM 70:15:15	3.90±0.002	68.0±1.18^{fg}	1.53±0.03^{fg}	6.80±0.04^{g}	89.3±5.21
FTF+RB+CM 60:20:20	3.91±0.007	46.6±2.64^{c}	1.02±0.06^{c}	5.89±0.13^{d}	82.7±10.4
FTF+RB+CM 50:25:25	3.90±0.004	38.2±1.73^{b}	0.82±0.04^{b}	5.42±0.11^{c}	90.0±5.77
FTF+RB 80:20	3.90±0.004	54.3±0.41^{d}	1.20±0.01^{d}	6.27±0.02^{e}	91.0±1.73
FTF+RB 70:30	3.90±0.003	34.1±1.39^{b}	0.72±0.03^{b}	5.16±0.10^{b}	97.0±0.58
FTF+RB 60:40	3.91±0.008	20.4±0.22^{a}	0.39±0.01^{a}	3.94±0.02^{a}	93.0±2.89
FTF+RB 50:50	3.91±0.007	19.0±0.04^{a}	0.36±0.00^{a}	3.77±0.00^{a}	90.0±3.46

Data are means of three observations ± SE. Means in the same column with the same superscript are not significantly different (P<0.05).

Initial mean weight - Wi (g), final mean weight - Wf (g), daily weight gain – DWG (g.day^{-1}), special gain rate - SGR (%.day^{-1}) and survival rate - SR (%) of snakehead fed experimental diets (Mean±S.E., n=3) in the experiment 2

The lowest FCR was in the FP treatment (1.04) and the highest was in the MTF treatment (7.31). There were no significant differences (P>0.05) between treatments FTF, FTF+RB+CM 80:10:10, FTF+RB+CM 75:15:15, FTF+RB 80:20, and FTF+RB 70:30 (4.33, 4.40, 4.62, 4.23 and 4.21, respectively). Protein in formulated pellet was the most effectively used (PER = 2.22) while PER was only 0.85 in MTF. In addition, the lowest feed cost per kg weight gain of fish was in the FP treatment (19,700 VND/kg fish), the highest was in the MTF treatment (47,500 VND/kg fish) and the second lowest feed cost was in the treatment FTF+RB 70:30 (28,000 VND/kg fish). Compared to results of the experiment 1, feed cost per kg weight gain of fish fede diets containing FTF (28,000 – 35,300 VND/kg fish) was higher than those containing MTF (20,400 – 24,500 VND/kg fish) because FTF is had problems of seasonal availability, so its price was high and fluctuated.

Table 2.5.7. Feed conversion ratio, PER and feed costs for producing one kg weight gain of snakehead fed experimental diets (% of wet matter basis) in the experiment 2.

Treatments	FCR	PER	Feed cost/kg weight gain of fish (,000 VND/kg fish)
FP	1.04 ± 0.00^{a}	2.22 ± 0.01^{d}	19.7
MTF	7.31 ± 0.20^{e}	0.85 ± 0.02^{a}	47.5
FTF	4.33 ± 0.38^{b}	1.55 ± 0.15^{bc}	34.7
FTF+RB+CM 80:10:10	4.40 ± 0.30^{b}	1.54 ± 0.11^{bc}	31.1
FTF+RB+CM 70:15:15	4.62 ± 0.19^{bc}	1.52 ± 0.06^{bc}	30.5
FTF+RB+CM 60:20:20	5.38 ± 0.52^{cd}	1.36 ± 0.12^{bc}	33.0
FTF+RB+CM 50:25:25	5.51 ± 0.10^{cd}	1.40 ± 0.03^{bc}	31.2
FTF+RB 80:20	4.23 ± 0.13^{b}	1.64 ± 0.05^{bc}	30.0
FTF+RB 70:30	4.21 ± 0.54^{b}	1.84 ± 0.21^{cd}	28.0
FTF+RB 60:40	5.79 ± 0.41^{d}	1.32 ± 0.09^{b}	35.9
FTF+RB 50:50	6.14 ± 0.07^{d}	1.64 ± 0.38^{bc}	35.3

Data are means of three observations ± SE. Means in the same column with the same superscript are not significantly different ($P<0.05$).

To sum up, the snakehead *Channa striata* more effectively used trash fish from freshwater compared to trash fish from marine sources. The results from quality analysisshowed that fresh-water trash fish exhibited low TVB-N values on the day after they were caught. After three days of storage, the fresh-water trash fish was still fresh, whereas marine trash fish were in stale condition. The formulated pellet which was studied from the phase 1 experiments was also effectively used by this kind of fish. Formulated pellet contributed to reduce the feed cost in snakehead culturing. Moreover, farmers could utilize available local rice bran and freshwater trash-fish through the diet which is 70% freshwater trash-fish and 30% rice bran. In addition, farmers could also use diets MTF+RB+CM 60:20:20 or MTF+RB 50:50 for snakehead culturing.

2.6. Study 6. Grow-out of *Channa striata* on demonstration farms

Introduction

In addition to the experiments that were carried out on farms comparing formulated feed to trash fish, two additional demonstrations of use of formulated feed for snakehead culture were carried out in Dong Thap province.

Methodology

Fingerlings were fed with floating commercial pellets. Pellets fed to snakehead in the 1st, 2nd, and 3rd months contained 44% crude protein and the remain months were 40% CP. Pellets were given to satiation. During the first three months, water was changed at 50% volume every three days and daily in the last months. Methods for data calculation, chemical analysis and statistical analysis were identical to those used in the trial on farm experiments**.**

Results

Observation and sampling for two practical farms

Data for the two ponds used in this demonstration are given in Table 2.6.1 and Figure 2.6.1

Table 2.5.1. Data of two ponds used for demonstration in Dong Thap province

Parameters	**Pond**
Area (m^2)	1300±71
Density (fish.m^2)	100±0.0
Initial weight (g.fish)	2.44±0.05
Final weight (g.fish)	562±135
Abnormal rate (%)	5.82±3.99
WG (g)	560±135
DWG (g/day)	3.05±0.84
SR (%)	54.6±1.59
FCR	1.30±0.02
Production (ton)	30.6±6.5
Yield (kg/m^2)	22.6±3.63

The result was displayed by mean ± STD

Average of two investigated ponds was 1300 ± 71m2, socking density was 100 fish.m^2. After 6 months of stocking, fish weight was 560 ± 135 (g.fish), survival rate was 54.6 ± 1.59 %, abnormal rate was 5.82 ± 3.99 %. FCR was low, 1.30 ± 0.02. Average production was 30.6 ± 6.5 ton and average yield was 22.6 ± 3.63 kg/m^2.

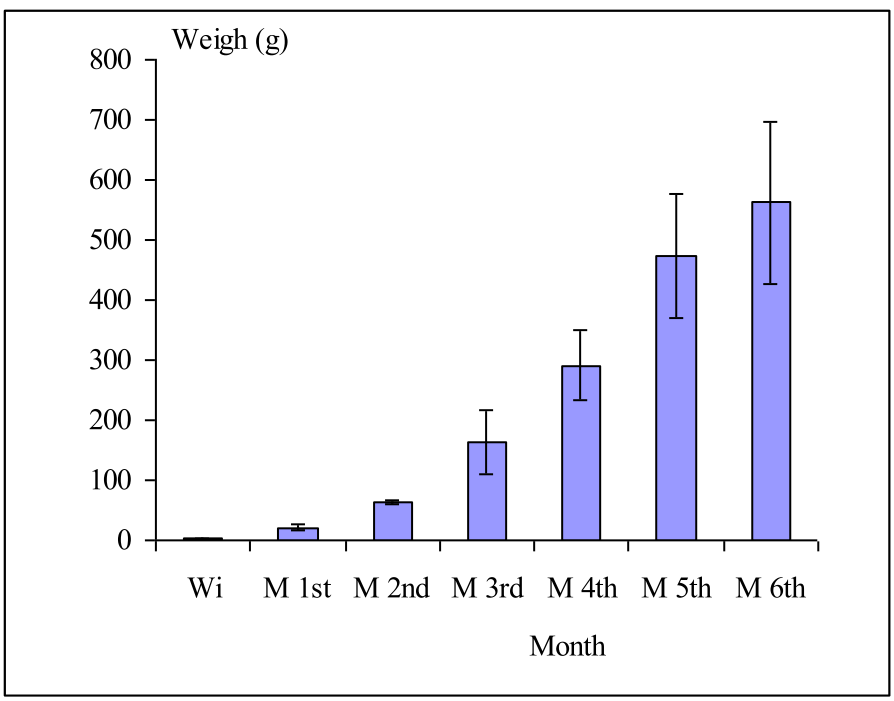


Figure 2.6.1. Growth rate of fish on practical farm demonstrations.

Total cost was 1.61 ± 0.01 USD/kg fish and total income 2.28 ± 0.03 USD/kg fish, farm gate price. Profit was 0.67 ± 0.02 USD/kg fish and profit ratio was 41.7 ± 0.80%.

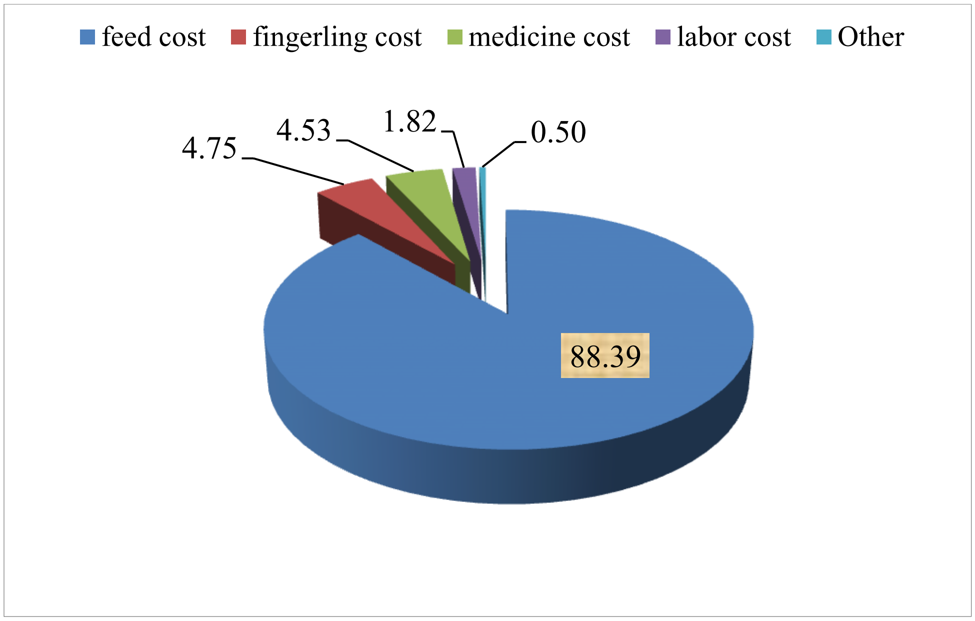


Figure 2.5.2. Division of costs as a percentage of total cost

As in the previous on-farm experiment, the feed cost made up the biggest cost for snakehead culture.

2.7 Study 7: Investigation on the status of commercial pellet usage for cultured snakehead fish (*Channa striata*) in An Giang and Dong Thap provinces

Introduction

In the Mekong Delta, snakehead fish is an economically important culture species which was and is cultured popularly (Nguyen Van Thuong, 2004). There are many snakehead cultured systems commonly in Mekong Delta, including pond culture, hapa culture, cage culture and nylon tank (Le Xuan Sinh and Do Minh Chung, 2010). *Channa striata* and *Channa micropeltes* are the main culture species in Mekong Delta at present. Previous studies were performed (Le Xuan Sinh and Do Minh Chung, 2010; Nguyen Thi Diep Thuy, 2010; Sarowar *et al.,* 2010). These study results illustrated data on the status of culturing snakehead, comprising of household information, culture skills, economic effectiveness and managing on feeding, water quality and disease problems as well. Feeding and feed cost were evaluated as a crucial elements during the culture period. In a study on feed cost, Hien *et al.* (2009) estimated that feed cost play a major role in the total cost of culture systems, contributing 50-80% of total expenditures. Snakehead in the Mekong Delta have been cultured in small scale sytems and "spontaneous systems" (meaning that the farmer did not follow the provincial plan for aquaculture) (Le Xuan Sinh and Do Minh Chung, 2010) using trash fish from both freshwater and marine sources as an important source feed However, rapid development of aquaculture activities resulted in considerable reduction in the availability of trash fish from the wild. Therefore, commercial pellet feed was developed for feeding cultured snakehead. This was considered to be an ideal feed because it reduced culture risks by improving feed and water quality and decreasing the feed cost as well. An investigation on the status of usage of pelleted commercial feed in the culture of snakehead is necessary.

Methodology

Data collecting

Methods of secondary data collecting: secondary data were collected from the reports of local agencies and sectors consisting of Fisheries Stations of An Giang and Dong Thap provinces, Department of Fisheries Resources Management of An Giang and Dong Thap provinces, newspapers and magazines for aquaculture, websites for aquaculture and relating documentations to aquaculture.

Methods of primary data collecting: primary data were collected by directly interviewing 29 farmers in An Giang (An Phu, Long Xuyen and Chau Thanh District) and 12 farmers in Dong Thap (Tam Nong, Tan Hong and Hong Ngu District) by a questionnaireon the farmer's information, culture skills, custody and fish health management and status of disease outbreaks as well as economic effectiveness.

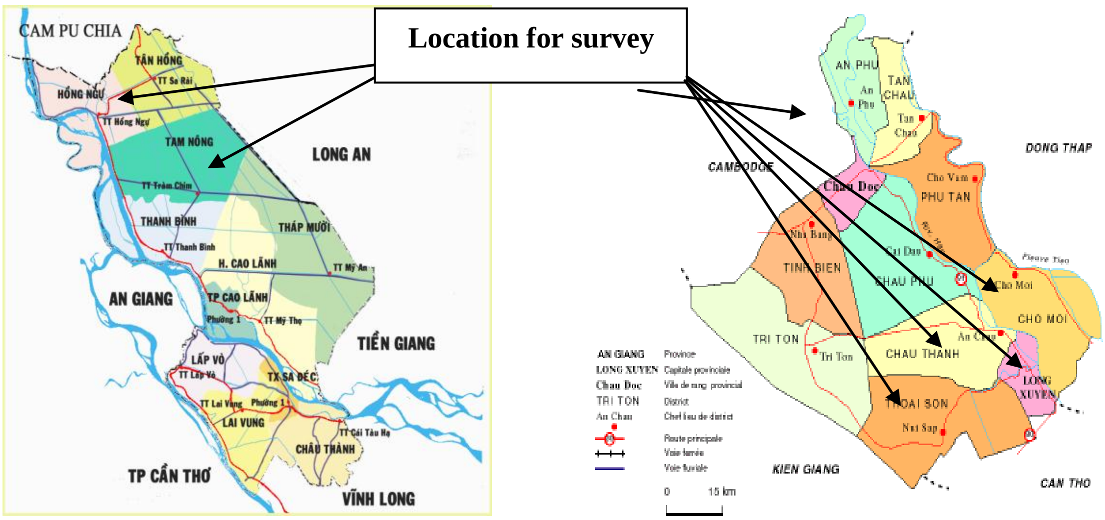


Figure 2.6.1: Location for survey
Figure 2.7.1: Map of study site in An Giang and Dong Thap Province

Statistical analysis

Statistical analysis of collected data was done by SPSS for Windows version 13.0 in descriptive statistic (mean, maximum, minimum, standard deviation) and comparison of means.

Laboratory analysis

The pelleted commercial feeds used in feeding cultured snakehead fish were collected from interviewed farmers to evaluate the chemical composition of feeds which are used for snakehead culture.

The nutrient compositions in the feed such as moisture, crude protein, crude lipid, crude ash were carried out using AOAC (2000) methods. Crude protein (Nx6.25) of feed was determined on total nitrogen determination (Kjeldahl). Crude lipid was defined by Soxhlet method. Crude ash was estimated by burning samples in a furnace overnight at 560^{o}C.

Results

Status of cultured snakehead systems

The investigation results showed that there were 3 systems for culturing snakehead being applied by the households. The highest proportion (85.4%) of farmers culture snakehead inearthen ponds. The plastic covering tank system, which constituted 12.2%, was much less and the lowest percentage (2.4%) of snakehead culture system applied by farmers was hapas in ponds,. In the earthen pond culture system, commercial pellets have been applied because the amount of trash fish is declining. Moreover, snakehead fish farmers are moving away from using trash fish to commercial pellets to practice more intensive culture. However, hapa and plastic-covering snakehead fish culture systems are small scale and farmers can catch trash fish to feed totheir snakehead. The conclusion is that commercial pellets are applied only to the snakehead fish earthen pond culture system.

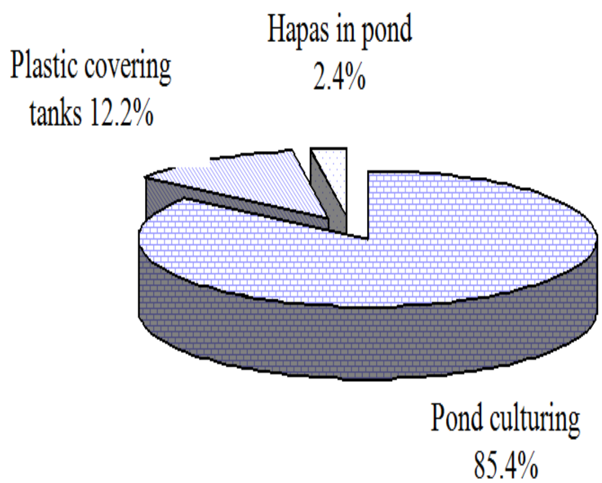


Figure 2.7.2: The types of snakehead fish culture systems in An Giang and Dong Thap Provinces

Snakehead fish culture in earthen pond in An Giang and Dong Thap Provinces

The general information of snakehead fish culture pond in An Giang and Dong Thap Provinces is illustrated in Table 2.7.1. The information of average area of culture pond in this survey illustrated that culturing ponds in Dong Thap Province were larger than in An Giang Province, 1314±741 m^2 in comparison to 941±692 m^2, respectively. Also, the water depth of culture ponds in Dong Thap Province is deeper than in An Giang Province, 3.1±1.1 m and 2.8±0.7 m, respectively. Moreover, stocking density is lower in Dong Thap Province (65.0±43.8 indi/m^2) than in An Giang Province (80.7±85.2 indi/m^2). Overall, there is higher survival rate and total production in Dong Thap Province in comparison to An Giang Province by 6.9% and 21.1 ton, respectively.

Table 2.7.1. Parameters of snakehead fish culture in An Giang and Dong Thap Provinces

Parameters	An Giang province	Dong Thap province
Area (m^2)	940.8±692.2*	1314.2±740.5
Depth (m)	2.8±0.7	3.1±1.1
Stocking density (fish/m^2)	80.7±85.2	65.0±43.8
Price (VND)	265.2±80.3	280.8±50.2
Survival rate (%)	71.0±24.9	77.9±13.0
Total production (ton)	21.8±30.4	42.9±32.6

**average±std*

Information on commercial pelleted feeds used for snakehead fish culture in An Giang and Dong Thap Provinces is shown in Table 2.7.2. The four kinds of feed fed to cultured snakehead fish in pond culture in An Giang and Dong Thap provinces are AquaFeed, Ca Vang, Cargill and UP. However, Cargill was not fed in Dong Thap and the lowest percentage (6.9%) of Cargill was fed in An Giang province. Moreover, feed UP was not fed in An Giang, but this feed was fed commonly in Dong Thap province (75%). The feed for snakehead was a mixture of pellets and trash fish in both provinces (100% of farmers in Dong Thap Province and 93.1% in An Giang Province used a mixture in the first month). In the period of the investigation, a problem, humpback, in the fish was noted, showing the incidence of 4.5 ± 7.0% in An Giang Province and 3.5 ± 5.8% in Dong Thap Province.

Table 2.7.2. Commercial pelleted using for snakehead fish earthen pond culture in An Giang and Dong Thap Provinces

Parameters	**An Giang Province**	**Dong Thap Province**
Name of feed		
AquaFeed (%)	20.7	8.3
Ca Vang (%)	72.4	16.7
Cargill (%)	6.9	
UP (%)		75.0
Combined trash-fish & pellet		
No (%)	6.9	
Yes (%)	93.1	100.0
Reasons	**29**	**12**
Fast growth (%)	13.8	16.7
Reducing cost (%)	58.6	50.0
Unavailable of trash-fish (%)	20.7	16.7
Decrease humpback fish (%)	6.9	16.7
Feeding rate (times/day)		
2 (%)	10.3	41.7
3 (%)	86.2	58.3
5 (%)	3.4	
Feeding method		
Direct (%)	96.6	100
Wet form (%)	3.4*	

**Some farmers added water to feed 15 minutes before feeding, because they think the commercial feed is too hard to be palatable to the fish.*

Economic analysis of this investigation on snakehead culture was carried out and demonstrated in Table 2.7.4. The total cost and profit were different in different Provinces. The total cost of culture pond in Dong Thap Province (commercial pellet feed) was lower than in An Giang Province (trash fish feed) by 4,375.8 MVND/ha/crop. Moreover, the result showed higher fixed cost and variable cost in An Giang Province than in Dong Thap Province, which were 44.5 ± 72.5 and 27.0 ± 36.1 and 14,706.6 ± 8,994.1 and 10,348.3 ± 12,792.4 VND/ha/crop, respectively.

Table 2.7.4. Cost and structure of cost of snakehead culture in An Giang and Dong Thap provinces

Parameters	Trash fish feed (N=29)	Commercial pellet feed (N=42)
Total cost (MVND/ha/crop)	14,751.1±9,020.5*	10,375.3±12,803.3
Fix cost (MVND/ha/crop)	44.5±72.5	27.0±36.1
Variable cost (MVND/ha/crop)	14,706.6±8,994.1	10,348.3±12,792.4
Feed (%)	87.8	89.9
Interest (%)	7.1	5.0
Seed (%)	2.5	2.6
Energy (%)	1.5	1.3
Labour (%)	0.7	0.8
Soil sludge out (%)	0.4	0.4

**average±std*

Nutrient composition of feeds fed to cultured snakehead

Seven commercial sources of feed fed to cultured snakehead were investigated. Feed samples were collected from the culture ponds in both survey provinces and were analyzed in the College of Aquaculture and Fisheries, Can Tho University. The results are given in Table 2.7.5. As might be expected, composition of the diets varied markedly. Levels of crude protein ranged from 26.7-44.5% and crude lipid ranged from 1.90-7.49%.

Table 2.7.5. Chemical compositions of feeds

Feed	Moisture (%)	Crude ash (%)	Crude Protein (%)	Crude Lipid (%)	Crude Fibre (%)	NFE
1	6.82	13.8	44.5	2.10	2.95	29.8
2	7.16	12.7	35.7	2.34	3.10	39.0
3	7.56	12.8	43.6	7.49	2.75	25.8
4	9.38	11.9	40.5	6.58	2.84	28.8
5	8.78	14.0	39.0	1.90	4.82	31.5
6	8.97	27.3	42.0	6.50	2.70	12.5
7	10.7	12.8	26.7	6.15	7.02	36.7

Comparison in cultured snakehead fed by commercial pellet feed (CF) and trash fish feed (TF)

We conducted a comparison of operations using trash fish as feed and those using commercial pellet feed. The results of this study are given in Table 2.7.6. The stocking density at farms using CF for feeding cultured snakehead was lower than that at farms using TF (93±94 compared to 110±105 fish/m^2). Survival was 74.8±16.2% for CF, higher than the 59.1±24.9% observed for TF. FCR value in CF (1.4±0.3) was lower than in TF (3.9±0.8). As a result, the return on equity of CF was higher than of TF, showing 0.4±0.7 compared to 0.3±0.3. Therefore, CF system demonstrated an effectiveness in culture snakehead in pond condition.

Table 2.7.6. Comparison between trash fish feed and commercial pellet feed fed cultured snakehead

Parameters	Trash fish feed (N=29)	Commercial pellet feed (N=42)
Area (m^2)	1,345±605*	1,366±1153
Depth (m)	2.9±0.6	3.0±0.8
Stocking density (fish/m^2)	110±105	93±94
Survival rate (%)	59.1±24.9	74.8±16.2
Havested size (g/fish)	743±200	729±215
Total production (ton)	50.7±24.0	39.5±65.1
Yeild (ton/ha/crop)	451±274	293±321
Total of feed (ton/ha/crop)	1,719.8±1,001.5	401.8±498.9
Trash fish (ton/ha/crop)	1,710.8±1,001.5	26.6±32.3
Freshwater trash fish	652.6±981.4	12.2±13.2
Marine trash fish	1,067.1±1,125.6	14.4±19.8
FCR	3.9±0.8	1.4±0.3
Total cost (MVND/ha/crop)	14,751.1±9,020.5*	10,375.3±12,803.3
Fixed cost (MVND/ha/crop)	44.5±72.5	27.0±36.1
Variable cost (MVND/ha/crop)	14,706.6±8,994.1	10,348.3±12,792.4
Income (MVND/ha/crop)	19,250.1±12,907.6	15,762.9±29,250.5
Production cost (1000d/kg)	32.6±6.7	33.8±7.8
Average size (g/fish)	743.1±200.7	728.6±207.6
Price of Selling (1000d/kg)	41.7±5.9	41.2±5.0
Profit (1000d/kg)	7.9±8.2	7.3±
Return on equity	0.3±0.3	0.4±0.7
Loss (%)	20.7	16.7
Profit (%)	79.3	83.3

**average±std*

Pond culture for snakehead iss popular in theMekong Delta, showing the highest proportion (85.4%) of farmers. The lowest percentage was the hapas sytem with 2.4%. The total cost and profit were different in different provinces, being higher in Dong Thap province than in An Giang province. The nutrient composition in feeds fed to cultured snakehead was high in protein and lipid proportion, but very variable. Commercial pellet feed used for feeding cultured snakehead is probably a more sustainable system than using trash fish, based on results for survival, FCR value and return on equity.

CONCLUSION

1. The results from quality analysis showed that fresh-water trash fish exhibited low TVB-N values on the day of capture. Three days later, the fresh-water trash fish was still fresh, whereas the marine trash fish was in stale condition, even though they were still at the distribution site.
2. Giant snakehead start to weaning at 30- 40 day old, replacement rate is 10%/days in 3 days
3. Trial on farm: snakehead fingerlings can be weaned by formulated feed in replacing trash fish in the rate 10%.day^{-1}; the growth of fish and survival rate were not significantly different compared to 100% trash fish use. For giant snakehead, feeding fingerlings with trash fish yielded significantly higher daily weight gain compared to formulated feed ($p<0.05$). However, there was no significant difference between treatments fed different diets in the survival rate ($p>0.05$).
4. The results confirmed that trash fish can be replaced by formulated feed for snakehead culture. Using formulated feed for snakehead culture provided significantly higher profit in AnGiang province than did using trash fish.

5. The snakehead *Channa striata* more effectively used trash-fish from freshwater sources compared to trash-fish from marine sources. Formulated pellet contributed to reduction in the feed cost in snakehead culturing. Moreover, farmers could utilize available local rice bran and freshwater trash-fish through the diet which is 70% freshwater trash-fish and 30% rice bran. In addition, farmers could also use diets MTF+RB+CM 60:20:20 or MTF+RB 50:50 for snakehead culturing. These results will probably be more applicable to farmers in Cambodia than to those in Vietnam.
6. Pond culture in culture snakehead was popular in Mekong Delta, showing the highest proportion (85.4%) of farmers. The lowest percentage was hapas sytem with 2.4%. Pellet feed using for feeding cultured snakehead was probably a more sustainable system than using trash fish based on survival, FCR value and return on equity.

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