Case study on the use of farm-made feeds and commercially formulated pellets for pangasiid catfish culture in the Mekong Delta, Viet Nam

Le Thanh Hung, Luu Thi Thanh Truc and Huynh Pham Viet Huy
Faculty of Fisheries
Nong Lam University, Ho Chi Minh City
Viet Nam

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SUMMARY

This survey was carried out during the period September to December 2005 and is based on data obtained from 107 fish farmers from three different locations in the Mekong Delta in Viet Nam. Feeding practices and culture facilities for pangasiid catfish varied widely, depending on location, culture tradition and feed types. In Viet Nam, cage culture of pangasiid catfish started in Chau Doc and then moved downstream to other locations along the river such as Long Xuyen and Can Tho/Vinh Long. It is expected that pond culture of pangasiids will soon be the predominant culture method for these species.

Traditional farm-made feeds consist mainly of trash fish and rice bran. However, recent changes in the availability of trash fish have resulted in significant increases in the price of farm-made feeds, which is affecting aquaculture throughout the country. The study revealed that about 39 percent of farmers now use soybean meal for the manufacture of farm-made feeds at inclusion levels ranging between 10 and 30 percent. The incorporation of other ingredients, such as fishmeal, is still a relatively rare occurrence and only 2 to 20 percent of farmers use such alternatives, depending on locality.

The production of pelleted feeds for catfish started in 1998. Since then it has expanded into all catfish growing areas in the Delta. Pelleted feeds appear to have several advantages, e.g. improved growth and food conversion. Despite the advantages farmers in the more traditional catfish growing areas still prefer farm-made feeds. It was also noted that even those farmers who regularly use pellets, revert to farm-made feeds during the final months of grow-out or when the price of fish decreases. The cost of production using pellets is higher than for farm-made feeds.

Although the use of commercial pelleted feed is expanding quickly, farm-made feeds still play an important role in pangasiid aquaculture in Viet Nam. A cost/benefit analysis revealed that the production cost in ponds, using farm-made feeds, is generally lower than in cages. Hence farmers adjust their feeding practices depending on the price of the fish at harvest.

To reduce the cost of farm-made feeds, farmers need to diversify and incorporate alternative ingredients into their feed formulations. To ensure the sustainability and future growth of pangasiid catfish aquaculture in the Mekong Delta there is a need for researchers and extension workers to focus on developing alternative and cost effective feed formulations and appropriate feeding strategies.

1. INTRODUCTION

In 2004, catfish production in Viet Nam amounted to some 260 000–300 000 tonnes, which comprised about 56 percent of freshwater aquaculture production in the Mekong River Delta, and constituted about 10 percent of national aquaculture export earnings (Phuong *et al*., 2005). It is widely recognized as one of the most important aquaculture sectors in Viet Nam. The Mekong Delta is the most important region for pangasiid aquaculture in Viet Nam. The most commonly farmed species are *Pangasius hypophthalmus*, *P. bocourti* and *P. conchophilus*. Cages, ponds and net pens are the most common farming practices in the region. Table 1 summarizes the trends in pangasiid aquaculture in the Mekong Delta.

Culture practices as well as the use of different types of feed vary widely, depending on location, available facilities and infrastructure. Farm-made feeds, in which trash fish forms the major protein component, are the most widely used in the Delta region. However, the use of trash fish in farm-made feeds currently poses several constraints on pangasiid aquaculture practices and development in the Delta. The most serious of these is the quality and availability of fish, which often arrives on site in a highly decomposed form. This is principally because fish is kept for 7–10 days at sea in unsuitable conditions and is not chilled during transportation to farming areas. This has led to the promotion of the use of formulated pellets under certain conditions. Pelleted feeds have several advantages over farm-made feeds. These include availability, lower feed conversion ratios and reduced environmental impact.

Previously, trash fish from the wetland areas of the Delta, especially during the flood season, was readily available and marine trash fish was only used as an alternative during the dry season. Over-fishing of the wetlands and the dependence on marine trash fish, even during the flood season, has increased the price of the commodity to a point at which the potential economic benefits may be negligible. It is mainly for this reason that farmers now seek alternative ingredients, such as soybean meal and other plant protein sources that are available in the Delta. Collectively, these issues have constrained the development of the catfish farming sector in the region.

Recent research has shown that pangasiid catfish can be reared on soybean meal based diets without any negative effects (Hung, 2003). Nevertheless, the use of trash fish is still a common practice in the catfish culture industry in the Delta. The present study was designed to obtain a better understanding of current feed use patterns and to assess the relative economic merits of farm-made and formulated feeds and to advise farmers accordingly. The objectives of the study were:

- to evaluate the use of farm-made feed versus formulated pellets in different locations where catfish culture is a common practice;
- to conduct a cost/benefit analysis of the two feed types to compare the production costs; and
- to identify the potential and future development of farm-made feeds for pangasiid catfish production in Viet Nam.

TABLE 1
Catfish culture area and production trends in the Mekong River Delta during 1997-2004

Category	1997	1999	2001	2003	2004 (estimated)	Growth rate (%/year)
Culture area (ha)	**1 290**	**2 253**	**2 305 5**	**2 717**	**3 200**	**24.6**
Ponds (area)	1 290	2 253	2 288	2 652	2 991	21.9
Cages (units)	1 300	1 621	2 539	2 271	1 872*	7.3
Production (tonnes)	**40 250**	**86 775**	**114 289**	**162 778**	**255 044**	**88.9**
Pond	22 550	50 330	66 660	109 105	178 624	115.3
Cage	700	19 005	37 418	48 068	45 748	-

*The lower number of cages in 2004 is a direct consequence of the higher unit production cost (see later).

Source: MOFI (2004)

2. METHODS

A structured questionnaire was developed and applied on 107 randomly selected farmers, such that the various catfish farming practices in the Mekong Delta were represented (Table 2). The survey was conducted in three locations during the period July to November 2005. The three survey areas were Chau Doc, Long Xuyen, and Can Tho/Vinh Long. Approximately 80–90 percent of catfish production in the Delta originates from these areas. Each location has its own farming traditions.

Historically, Chau Doc is the cradle of catfish cage culture in the Mekong Delta. Presently, cage culture is still the dominant form of pangasiid culture. For this reason 30 representative cage culture operators were selected from this region. The city of Long Xuyen, in An Giang province, is 30 km downstream from the town of Chau Doc. Just prior to the survey period the price of catfish dropped and many of the cage farmers in the region had switched to pond culture of other species. A total of 15 cage farmers were interviewed in this area. Pen culture is also practiced in this area and because of the similarities between pen and pond culture, the results for 14 pond and pen farmers were pooled.

Because of similar farming practices, traditions and physical conditions Can Tho and Vinh Long were grouped as the third study location. The locations are about 30–35 km downstream from Long Xuyen city. These two localities are the main representative areas for pond farming practices. Of the 48 interviewees in the area, 46 were pond farmers and two were cage farmers.

Based on the type of farming and feed use practices in each of the three areas a random selection of farmers was made so that the current status of the two feeding

FIGURE 1
Map of the Mekong Delta, showing the three study locations in Viet Nam

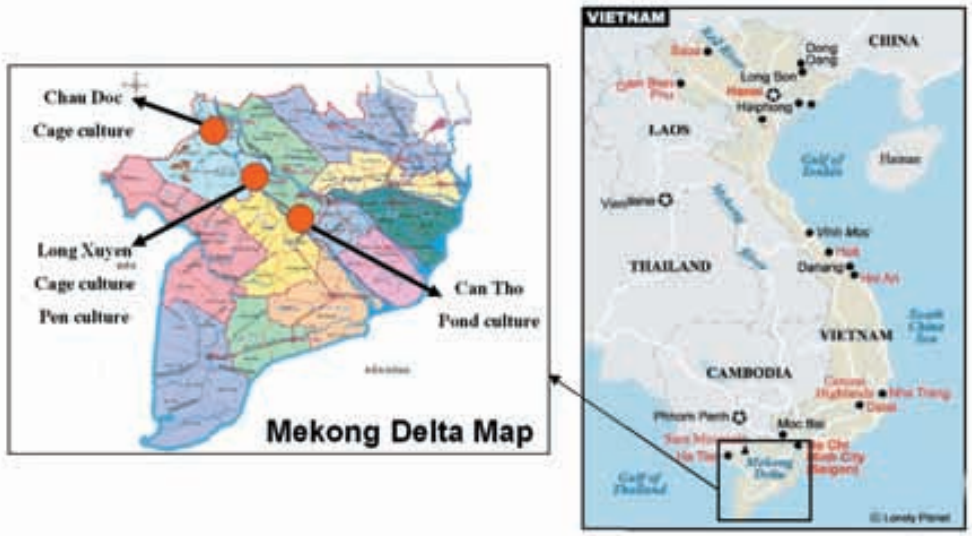


TABLE 2
Sample allocation in the three main catfish culture areas

Location	Culture facilities		Total
	Cage	Pond	
Chau Doc	30		30
Long Xuyen	15	14	29
Can Tho and Vinh Long	2	46	48
Total	**47**	**60**	**107**

practices in different culture facilities in respective study areas was well represented in the data.

Of 107 farmers selected for the survey, 48 households were further interviewed using an economic evaluation questionnaire to carry out cost/benefit analyses. The sample size for this exercise was smaller than the overall sample because only a small proportion of surveyed farmers were

able to provide detailed economic information (Table 3).

All data were coded and entered into Microsoft Excel spreadsheet for analysis.

TABLE 3
Sample size of farmers participating in the cost/benefit analysis

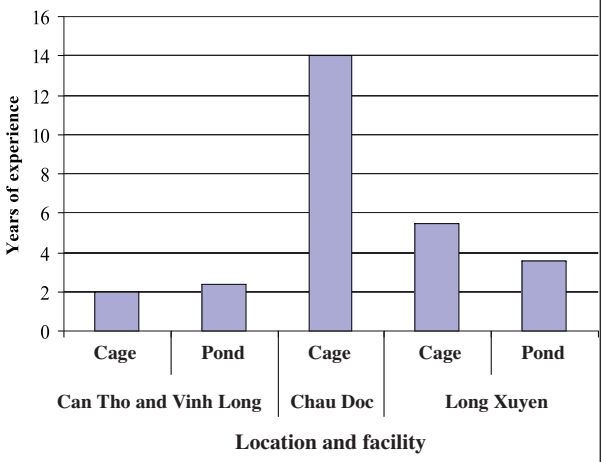
Location	Culture facility		Total
	Cage	Pond	
Can Tho and Vinh Long	0	27	27
Chau Doc	5	0	5
Long Xuyen	9	7	9
Total	**14**	**34**	**48**

3. RESULTS AND DISCUSSION

3.1 Experience of catfish farmers

Figure 2 shows the average years of experience of farmers in the three areas. In Chau Doc, where cage culture of catfish originated, farmers on average have over 14 years of experience, which is significantly more than in the other two areas, viz. 5.5 for Long Xuyen and two in Can Tho and Vinh Long. This has had a significant influence on culture practices. For example, Chau Doc farmers seem to be more conservative concerning the application of new techniques. In fact, many of the farmers started catfish culture before 1979 simply by following their parents' occupation (Action Aid, 2002).

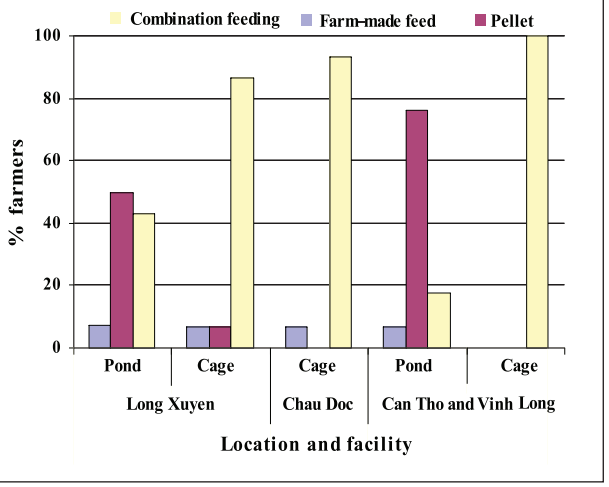
FIGURE 2
Average years of experience of farmers in the three sampling locations



The second most experienced farmers are in Long Xuyen where catfish farming developed soon after the evolution of catfish cage culture in Chau Doc. This location is also the second most important area for catfish culture along the Mekong River. On average, farmers in Long Xuyen have approproximately 5.5 years of experience in cage culture and approproximately 3.6 years experience in pond culture. Although many of the farming traditions have been passed on from Chau Doc, catfish culture in Long Xuyen has its own characteristics due to the difference in topography. In this region farmers make use of the tidal range for water exchange in ponds and as a result can practice both cage and pond culture.

Farmers in the Can Tho and Vinh Long area are the most recent practitioners of catfish farming in the Delta, and pond culture in this area is the dominant farming system. In this region, farmers have an average experience of about 2.4 years. Cage culture is not commonly practiced in Can Tho and Vinh Long due to the nature of the river system. The water borne river traffic in Can Tho and Vinh Long is intensive and this is a major constraint to cage culture.

FIGURE 3
Feed use patterns under different culture conditions in the three locations



3.2 Feeds and feeding practices

Feed use

The survey data suggests that type of feed depends on the farming system. A high percent of pond farmers in Can Tho and Vinh Long use commercially formulated pellets for the entire production cycle (Figure 3). The findings of the present study clearly show the evolution that has

taken place since the study undertaken by Phu and Hien (2003). Approproximately 76 percent of interviewed pond farmers in Can Tho and Vinh Long now use pellets for the entire grow-out cycle. This is in contrast to the 46 percent of farmers in Can Tho province and the 5 to 10 percent of farmers in other provinces that used pellets, as reported by Phu and Hien (2003). Around 17 percent of pond farmers use farm-made feed in combination with pellets, whilst only 6.5 percent of the farmers use exclusively farm-made feeds. In total only about 24 percent of farmers in this region now use farm-made feeds. Combination feeding is however used by 100 percent of cage farmers.

In the Long Xuyen area, approximately 50 percent of pond farmers use farm-made feeds, although most use these feeds in combination with pellets. The most widely used practice by cage farmers (87 percent) is to use pellets during the initial stages of rearing and farm-made feeds for the finishing stage (see later). Only a small proportion (7 percent) of farmers who practice cage culture use farm-made feeds exclusively for the duration of the production cycle. In general, combination feeding is the most prevalent feeding practice in the region.

In contrast to the feeding practices in Long Xuyen and Can Tho/Vinh Long, more than 93 percent of cage farmers in Chau Doc still use farm-made feeds as the principal feed and only use it in combination with pellets during the first month after stocking. The remainder use only farm-made feeds for the entire culture cycle. Therefore, nearly 100 percent of cage farmers in this area use farm-made feeds for the greater part of or the entire production cycle. This is very similar to the results reported by Phu and Hien (2003) and illustrates the tradition bound nature of the farmers in this area. The use of farm-made feeds here is principally related to the low price of the feed in comparison to pellets in the past, which is of course a decisive factor for any aquaculture business. Only a few farmers noted that the availability of ingredients influenced their decision to choose farm-made feeds over formulated pellets.

From the above it is evident that farm-made feeds are more generally used in Long Xuyen and Chau Doc, while commercially formulated feeds are more commonly used in pond culture systems in Long Xuyen and Can Tho/Vinh Long. It was interesting to note that even those farmers who use mainly farm-made feed, usually also use pellets during the first month of culture when the fish require high quality feed. Hence, it is difficult, if not impossible, to determine the proportion of fish produced using farm-made feeds and formulated feeds. However, based on the 300 000–350 000 tonnes of formulated feed produced in 2004 and a feed conversion ratio of 1.5–1.8 it is estimated that formulated feeds account for approximately 200 000 tonnes of fish. Total production of catfish in 2004 was 300 000 tonnes, suggesting that the remainder of the catfish (100 000 tonnes) were produced using farm-made feeds. The best estimate for the proportional contribution to total production attributed to farm-made feeds and pellets is around 1:1.9.

Feeding practices

The production cycle for pangasiid catfish is divided into three phases, viz., (1) the first month after stocking of the fingerlings, (2) the main growth period of around 4 to 5 months and (3) the final month before the fish are harvested. Feeding practices are closely related to these phases and as mentioned above also vary according to the location. The variation in feeding practices by farmers who mainly use farm-made feeds is illustrated in Figures 4, 5 and 6.

In Long Xuyen, pellets are commonly used in the first month in both cages and ponds. Some 93 and 86 percent of cage and pond farmers used pellets during the first month, respectively (Figure 4). The reasons for using pellets in the first month were diverse. However, the main reason was that farmers were of the opinion that small fish are better adapted to feed on pellets and that pellets also provide better nutrition.

Farmers were also of the opinion that the use of pellets reduced mortalities during the early rearing phase. During the middle months farmers use farm-made feeds, while during the final month some farmers keep on using farm-made feed. Others use a combination of farm-made feeds and pellets. Approproximately 28 percent of cage culture farmers in Long Xuyen combine pellets with farm-made feeds during the final month, while only 14 percent of pond farmers follow this practice. Farmers were of the opinion that feeding pellets in the final month improved the quality of the fish and resulted in a whiter meat at harvest. Farmers were also of the opinion that feeding fish with pellets accelerates the growth rate, such that the fish can be harvested earlier. The findings suggest that farmers recognize the benefits of pelleted feeds and would also use them for the entire cycle provided that the feed is affordable.

Feeding practices by cage farmers in Chau Doc is similar to those in Long Xuyen. About 83 percent of farmers use pellets during the first month and 90 percent use farm-made feeds during the middle months (Figure 5). However, in contrast to farmers in Long Xuyen, approximately 10 percent of farmers in Chau Doc use a combination of the feeds from the beginning to the end of the production cycle. Moreover, a higher percent of farmers (37 percent) in Chau Doc apply combination feeding in the final month than in Long Xuyen.

As previously mentioned, Can Tho and Vinh Long are relatively new catfish farming areas. The only real difference in these areas, in comparison with Chau Doc and Long Xuyen, is that a higher proportion of farmers (73 percent) use pellets during the first month.

FIGURE 4
Feed use practices in cages and in ponds during the three rearing phases in Long Xuyen

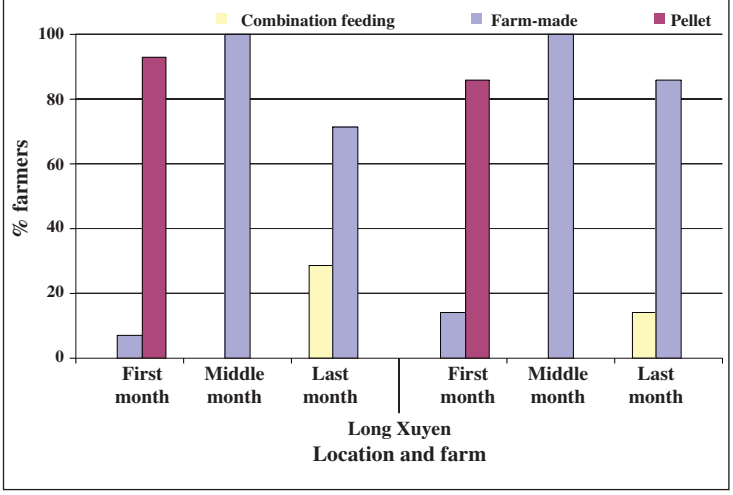


FIGURE 5
Feed use practices in cages during the three rearing phases in Chau Doc

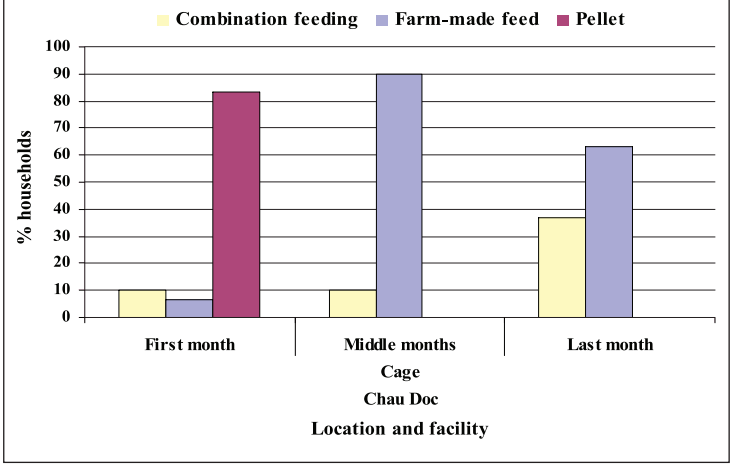


FIGURE 6
Feed use in ponds during the three rearing phases in Can Tho and Vinh Long

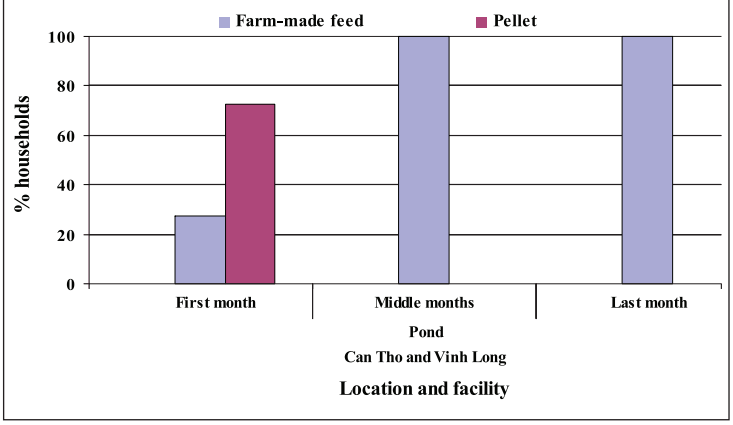


FIGURE 7
Farmer perception on the efficacy of farm-made feeds and pellets

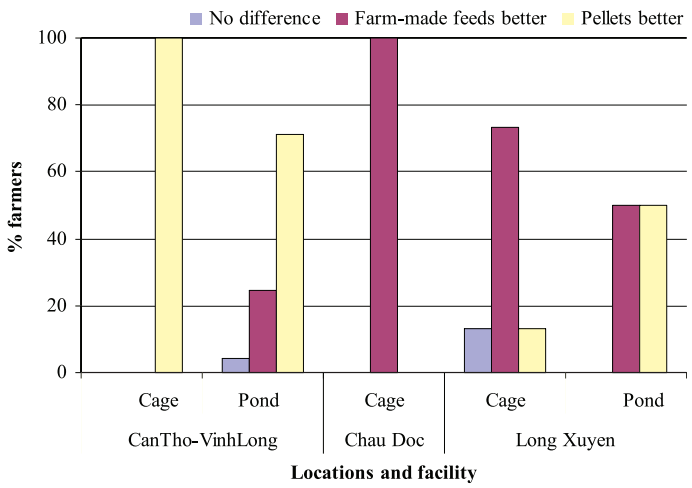
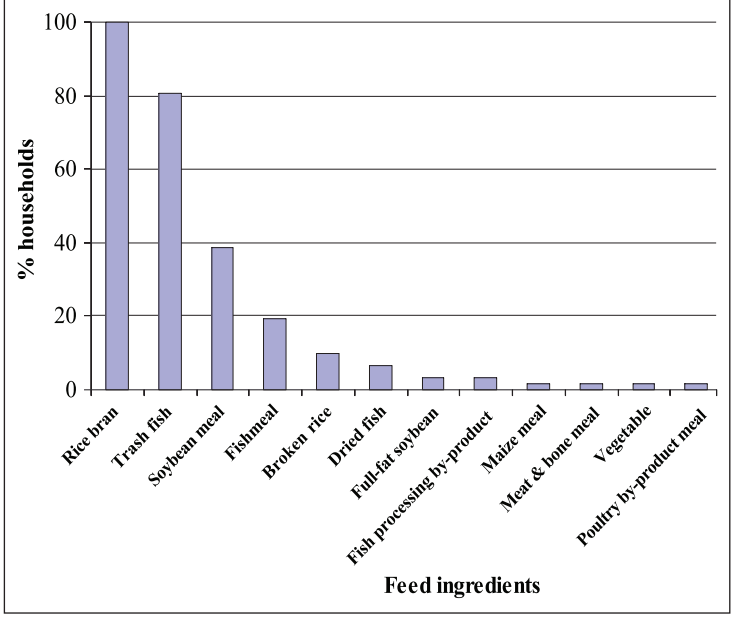


FIGURE 8
Feed ingredients used by fish farmer households for preparation of farm-made feeds



3.3 Farmer perceptions on the efficacy of different feed types

Commercial pellets are only used by farmers if there are known or perceived advantages over other feed types. Because of the high proportional use of pellets in Can Tho and Vinh Long it is clear that most farmers in these areas consider pellets to be more effective than farm-made feeds. On the contrary, 100 percent of cage farmers in Chau Doc and nearly 80 percent in Long Xuyen use farm-made feeds either exclusively or in combination with pellets. This suggests that they perceive farm-made feeds to be superior to pellets. However, this perception may be clouded as farmers in these areas are more conservative and averse to changes.

3.4 Preparation of farm-made feeds

Traditionally farm-made feeds were composed of rice bran and trash fish at a ratio of 1:1 or 2:1, depending on the production phase. Besides rice bran and trash fish farmers now also use other ingredients such as soybean meal, fishmeal, corn meal, dried fish, meat-bone meal and poultry by-product meal. Figure 8 shows the proportion of fish farmer households using different ingredients for the manufacture of farm-made feeds. The data show that all farmers who make their own feeds use rice bran as an energy source, whilst a very small proportion use broken rice or corn meal instead of rice bran. Several protein sources are used, though the majority of farmers (80 percent throughout the Delta) use trash fish. Soybean meal is the second most important protein source used by farmers (39 percent of farmers). It is either used as an alternative or as a supplement to trash fish. Farmers in the Mekong Delta have recognized the financial benefits of such substitutions in order to reduce production cost during the period when the supply of trash fish is low. Moreover, farmers also use soybean meal as an alterative protein source because of the reduced availability of trash fish and the increasing price of this commodity. Farmers appear to have a lower preference for other alternatives such as fishmeal, by-products of fish processing, meat-bone meal and poultry by-product meal. Furthermore, it was of interest to note that farmers in Chau Doc only used trash fish and rice bran for feed preparation, whilst

those from the other regions were more open to change and used alternative ingredients to reduce their dependency on trash fish.

The inclusion rates of ingredients in farm-made feeds varied between farmers, depending on perceptions, tradition of feed preparation and the availability of ingredients. In general, rice bran forms the bulk of their formulation and is included at over 50 percent by 66 percent of all farmers (Table 4). Broken rice is also commonly used but at inclusion levels of 10–30 percent (66 percent of farmers). The reason for the use of rice bran is its low price and high availability. Trash fish is the most important protein source. Inclusion rates vary from 10–30 percent (58 percent of farmers) and from 30 to 50 percent (36 percent of farmers). These differences can be attributed to traditional feed preparation practices. The second most commonly used protein ingredient is soybean meal and is used at inclusion rates of 10–30 percent (79 percent of farmers). The only other ingredient of consequence is the by-product of fish processing, which is included by some farmers at between 10 to 30 percent. The data suggest that pangasiid farmers in the Mekong Delta are actively beginning to seek alternative ingredients for their farm-made feed preparations.

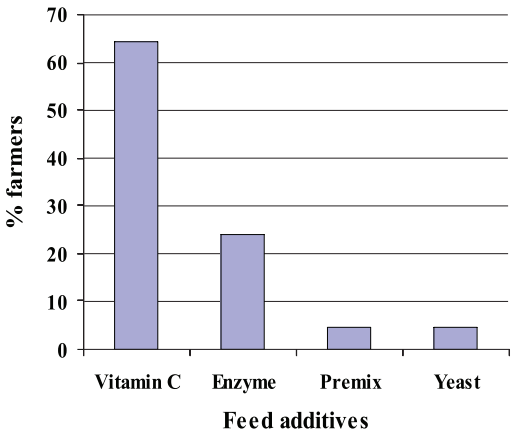
TABLE 4
Percent of farmers using different feed ingredients at various inclusion rates for farm-made feeds

	Inclusion rates of different ingredients (% as fed basis)			
Ingredient	**>50**	**31–50**	**10–30**	**<10**
Rice bran	66.1	32.2	1.7	0.0
Broken rice	0.0	33.3	66.4	0.0
Corn meal	-	-	100	-
Trash fish	4.0	36.0	58.0	2.0
Fishmeal	0.0	0.0	66.6	33.4
Dried fish	0.0	25.0	75.0	-
Soybean meal	0.0	4.2	79.2	16.6
Full fat soybean	0.0	0.0	100.0	0.0
Fish processing by-product	0.0	0.0	50.0	50.0
Meat and bone meal	-	-	-	100
Poultry by-product meal	-	-	-	100

In addition to the main ingredients, farmers often mix readily available feed additives into their preparations. Among others, these may include vitamin C, lysine, methionine, anti-oxidants, probiotics, brewer's yeast, enzymes, vitamin and mineral premixes. Figure 9 shows that about 65 percent of the interviewees use vitamin C to improve fish health and up to 24 percent of farmers use enzymes to increase feed digestibility.

Normally, ingredients are mixed, cooked and extruded into sticky long strings (see Figure 13) and are fed to the fish in a wet form. In some places in Can Tho and Vinh Long farmers only cook the broken rice to form a binding paste and then mix it with the other ingredients before extrusion. This method is called the partial cooking process in which premixes and feed additives are added at higher rates in comparison to the complete cooking process. The fuels to cook the ingredients include rice and cashew husks and rubber tyres, though most farmers use rice husks because it is cheap and available throughout the year.

FIGURE 9
Percent of farmers using feed additives in preparation of farm-made feeds

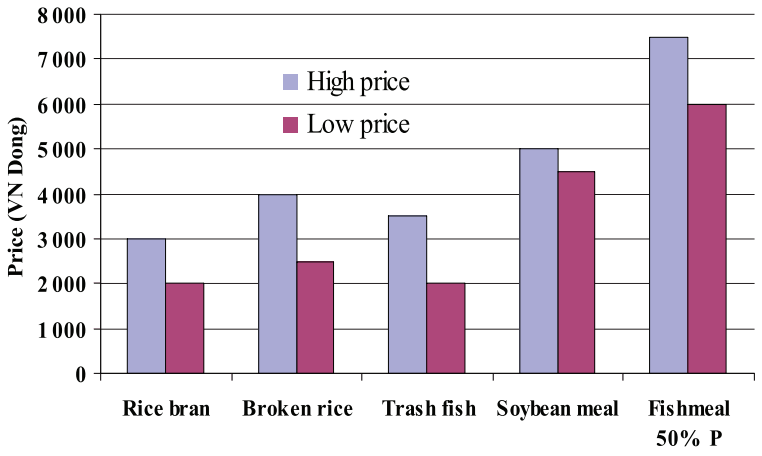


The survey identified nine major feed formulations (Table 5). These diets have relatively low protein levels for a carnivorous species and range from 13.6 to 31.5 percent, while lipid levels range from 6.7 to 12.2 percent. The estimated proximate composition of the diets is based on the nutrient composition of the ingredients. Farmers in Chau Doc traditionally use feed formulations 3 and 4 (Table 5) for the initial production phase and feeds 1 and 2 for the final stage of the production cycle. In contrast, farmers in Long

TABLE 5
Farm-made feed formulations for catfish farming in the Mekong Delta (% inclusion rate as fed basis)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9
Trash fish	20	20	30	35	25				
Rice bran	80	70	50	59	43	40	50	50	50
Broken rice		10	20						
Soybean meal					16	30		20	20
Soybean							30		
Fishmeal					16		20		
Corn								10	
Fish by-products						30		10	
Restaurant waste									30
Vegetable								10	
Brewer's grain				6					
Proximate nutrient composition of farm-made feeds (% dry matter)									
Crude protein	13.6	13.8	14.8	14.1	25.4	24.3	31.5	19.0	21.0
Crude lipid	12.2	11.5	9.9	10.0	9.0	9.8	6.7	9.3	8.0

FIGURE 10
Price fluctuations of the main farm-made feed ingredients in 2005 (US$1.00 = VND 15 800)



Xuyen and Can Tho/Vinh Long prefer to use diets 6 to 9 in which trash fish is completely replaced by soybean meal, fishmeal, by-products of fish processing or restaurant waste. Diets 6 to 9 are relatively high in protein when compared to the trash fish based diets due to the high protein content of soybean meal and fishmeal.

3.5 Price and availability of feed ingredients for farm-made feeds

Figure 10 illustrates the price of the five most important feed ingredients. Fishmeal (locally produced with 50 percent protein content) and soybean meal are more expensive than others, though protein content is approximately 3–4 times higher than for trash fish. Hence the use of soybean meal and fishmeal may be more profitable than trash fish in terms of cost per unit of protein. Seasonal price fluctuations are relatively high for trash fish and rice bran but not for soybean meal and fishmeal, which reflects seasonal and general availability. In comparison to other ingredients, trash fish has the highest price fluctuation and this is caused by the seasonal nature of the fishery.

3.6 Future trends in feed use and feeding practices

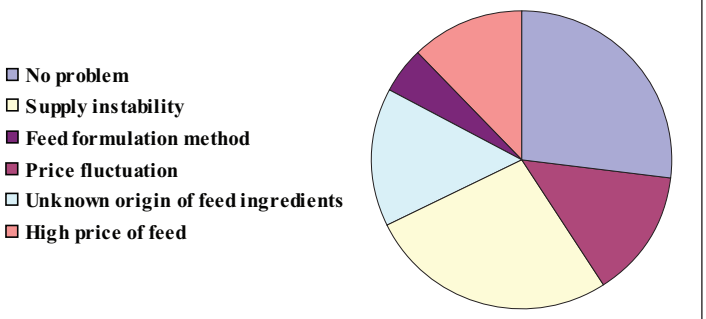
Constraints

Data in Figure 11 show that more than a quarter (27 percent) of interviewed farmers had no problem with the use of farm-made feeds, though the same proportion of farmers also identified supply instability of the main ingredient (trash fish) as the main constraint in the use of farm-made feeds. Some 26 percent of farmers regarded price and price fluctuation as a constraint. The third most common constraint (voiced by 15 percent of farmers) is the unknown origin and thus unknown quality of feed ingredients. In conclusion, almost all of the constraints revolve around the dependency on trash fish as the main source of protein for farm-made feed preparations.

Future trends in feed use patterns and manufacture

Although farmers face several constraints with respect to the use of farm-made feeds most of them (90 percent) reported that they would maintain their present feeding practices. However, some (10 percent) reported that they plan to change their feed preparations to deal with the scarcity of ingredients. These changes in feed preparation techniques are likely to include the choice of alternative protein sources such as fishmeal and soybean meal and the use of small-scale, on-farm extruders to produce floating pellets.

FIGURE 11
Constraints faced by farmers in the use of farm-made feeds



3.7 Economic evaluation of farm-made and pelleted feeds

Data collected from 48 catfish farmers were used for the economic evaluation of their activities. The analysis is based on a 6–7 month production cycle for both cage and pond farming systems. Farmers normally obtain a loan from a bank for cage or pond construction at an annual interest rate of 8–10 percent. Personal loans may also be obtained from relatives, friends and private lenders but this practice is less common due to their higher monthly interest rates, which may be 2–3 percent higher than bank rates. Other investment costs include capital for a cooker, feed mixer, compressor and a water pump, averaging around US$250–312[3], US$625–940, US$188–250 and US$312–625, respectively and totaling around US$1 750.

Cage culture system

Of the 15 cage farmers, 12 used farm-made feed and three used pellets. Fish stocking densities in cages range from 120–150 fish/m^3, and fingerlings range in size from 80–100 g/fish. Cages are depreciated over a span of 10 years, while other equipment such as feed mixers, extruders, cookers is depreciated over a span of 5 years. The cost per fingerling is in the range of VND 1 000–1 500 (US$0.06–0.09). Two permanent labour units are required if farm-made feeds are used and one unit for pellets. The average food conversions ration (FCR) for farm-made feed ranges from 2.0–3.7 and for pellets between 1.5 and 2. The cost/benefit analysis for cage culture was calculated for a unit of one cubic meter and the results are presented in Table 6.

The results show that the cost of feed accounts for the highest proportion of total production cost in cages (78.8 percent for farm-made feeds and 84.5 percent for pellets). Fingerlings account for the second highest proportional cost, though this is much lower than for feed, at around 8–9 percent. This finding suggests that catfish seed production is no longer a constraint for the catfish farming sector. Labour constituted a small proportion of the total production cost at around 0.9 percent and 1.6 percent for the pellet and farm-made feed systems, respectively.

The results show that the average production cost per kilogramme is higher in the pellet based systems (US$0.64 to US$0.65) than in the farm-made feed systems (US$0.51–0.73). However, because of the highly variable FCRs and the fluctuating price of trash fish it is not possible to conclude that higher profit margins are attained with the use of farm-made feeds.

[3] US$1.00 = 16 000 VND

TABLE 6
Average pangasiid catfish production costs (US$) in cage culture (per cubic meter) (US$1.00 = VND 16 000)

Item	Farm-made feed (n = 12)		Pellet feed (n = 2)	
	Amount	% total	Amount	% total
Fixed cost				
Depreciation (cage, boat, feed mixer and feeding machines)	1.61±1.13	2.41	1.19±0.46	2.44
Variable costs				
Fingerlings	6.58±2.85	9.84	3.58±2.75	7.38
Feed	52.51±0.47	78.55	41.15±0.11	84.69
Labour	1.06±0.99	1.59	0.42±0.03	0.86
Disease prevention and treatment	3.63±2.71	5.42	2.02±0.76	4.16
Fuel and electricity	1.16±0.83	1.74	0.19±0.04	0.39
Interest	0.0		0.0	0.00
Taxes and fees	0.19±0.18	0.29	0.04±0.02	0.08
Transport	1.10±0.01	0.15	0.0	0.00
Total cost				
Per cubic metre	**66.86±29.08**		**48.59±5.27**	
Per kilogramme	**0.62±0.11**		**0.64±0.01**	

Pond culture

The cost benefit analysis for pond based culture was based on data obtained from 34 farmers (Table 7). Stocking density in ponds ranges from 30–40 fingerlings/m^2. The fingerlings used in pond culture are smaller and hence cheaper (US$0.01–0.04) than those used in cages. Average FCRs using farm-made feeds and pellets in ponds are 2.0–3.5 and 1.5–1.7, respectively. Other production costs include fuel, electricity, labour, disease prevention and treatment, interest and transport.

The results show that feed cost accounts for 81 percent and 90 percent of the total production cost for farm-made feeds and pellets, respectively. Feed cost in pond culture is higher than in cage culture. As for cage culture, the cost of seed is the second highest contributor to total production cost.

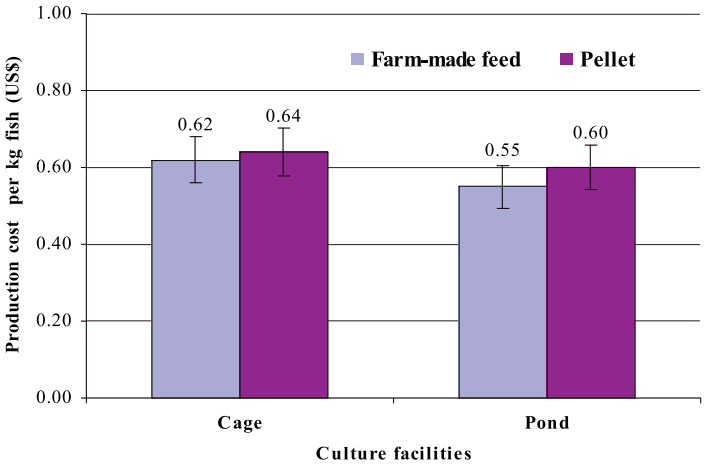
Though there is some variation in the overall production costs between farmers the data indicates that the average production cost is only marginally higher when the fish are fed on pellets (US$0.50–0.69 per kg) in comparison with farm-made feeds (US$0.43–0.64 per kg) (Tables 3 and 4; Figure 12). Overall, it would appear that the cost

TABLE 7
Average pangasiid catfish production costs (US$) in pond culture (per square meter)

Item	Farm-made feed (n = 11)		Pellet feed (n = 23)	
	Amount	% total	Amount	% total
Fixed cost				
Depreciation (pond, boat, feed mixer and feeding machines)	0.15±0.14	0.80	0.19±0.26	0.89
Pond rental	0.00	0.00	0.07±0.04	0.31
Variable costs				
Fingerlings	1.82±2.75	9.81	1.03±0.77	4.82
Feed	15.09±8.48	81.08	19.36±12.08	90.62
Labour	0.18±0.09	0.98	0.18±0.11	0.82
Disease prevention and treatment	1.00±0.61	5.37	0.06±0.85	2.38
Fuel and electricity	1.00±0.07	5.37	0.07±0.15	0.34
Interest	0.0	0.00	0.10±0.01	0.49
Taxes and fees	0.01±0.01	0.04	0.06±0.10	0.27
Transport	0.01±0.02	0.06	0.09±0.04	0.40
Total cost				
Per square metre	18.07±10.63		21.36±0.64	
Per kilogramme	0.55±0.115		0.60±0.10	

of production in ponds is lower than in cages, though this may not be significant. From these data we concluded that farm-made feeds might be a better choice for small-scale farmers. However, large-scale farmers would be advised to use pellets to ensure good stock management and to reduce the risk associated with the instability in trash fish supply.

FIGURE 12
Comparison of production cost in cages and in ponds with farm-made and pelleted feeds



4. CONCLUSIONS AND RECOMMENDATIONS

The survey of 107 fish farmers in the three different locations in the Mekong Delta revealed that feeding practices and culture facilities varied widely with respect to location, culture traditions and feed use practices. Cage culture of pangasiid catfish originated in Chau Doc. Pangasiid farming has now expanded to other locations along the Delta, where pond culture is generally favoured over cage culture. This is ascribed to the lower capital and production costs of pond culture; and perhaps also due to the greater competition for cage space with water borne traffic in Long Xuyen and Can Tho/Vinh Long. It is expected that the trend towards pond culture will soon become the dominant farming practice for pangasiid catfish farming in the Mekong Delta.

Commercially manufactured pellets first became available in 1998 and are now available in most parts of the Delta where catfish farming has developed. Pellets appear to have several advantages over farm-made feeds, though the average production cost per kg is higher than for farm-made feeds. Despite the advantages, farm-made feeds still remain the most popular type of catfish feed in the more traditional farming areas. Moreover, many pellet feeding farmers also use farm-made feeds during the final month(s) of grow-out period. The practice is particularly prevalent when the market price of fish declines. Figures 13 and 14 illustrate the preparation and use of farm-made feeds and pelleted feeds.

Farm-made feed traditionally consists of trash fish and rice bran. In recent years the supply of trash fish in Viet Nam has declined and the resultant higher price of the commodity has had a significant negative impact on aquaculture in the country. The instability in the supply of trash fish has led to the use of alternative protein sources such as fishmeal and soybean meal. Fortunately, recent studies have indicated that *Pangasius* species can be reared entirely on non-marine protein sources without retarding fish growth or survival rates (Hung, 2003).

There are numerous companies in the region that import and distribute ingredients suitable for catfish feed preparation and these are accessible to small-scale farmers. Trash fish throughout the SE Asia region, including Viet Nam, will become even scarcer in future. Hence, to ensure the growth of pangasiid aquaculture in the Mekong Delta there is a need to change the perception of the more traditional farmers, particularly in the Chau Doc area, with respect to the value of alternative ingredients. Farmers in the more recent catfish growing areas are more adaptable to change. Moreover, there is an urgent need for the state to promote and support appropriate on-farm research and extension programmes to assist farmers throughout the Delta to formulate new low-cost feeds and to determine the nutrient requirements of pangasiid catfish.

FIGURE 13
Cooked farm-made feed (top left), cooling of cooked farm-made feed (top right), extruding semi-moist catfish feed (bottom left) and feeding semi-moist, farm-made feed to pangasiid catfish in ponds

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FIGURE 14
Pelleted feed for pangasiid catfish (left) and feeding of *Pangasius hypophthalmus* in ponds (right)

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