On-farm feed management practices for striped catfish *(Pangasianodon hypophthalmus)* in Mekong River Delta, Viet Nam

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ABSTRACT

The Mekong delta is considered as the most important region for aquaculture production in Viet Nam and in 2008 accounted for approximately 73 percent of the total national aquaculture production (IFEP, 2009). The delta has a total freshwater area of 641 350 ha, of which 480 181 ha has the potential for further aquaculture development; and has the most diversified aquatic farming activities and greatest potential for increasing aquaculture production. There are several species that are commercially produced in the delta, of which striped (or tra) catfish is the most important. The production of striped catfish reached 1 147 000 tonnes in 2009 (Fisheries Directorate, 2010).

The rapid expansion of striped catfish farming has resulted from various factors, of which the improvement of feed and feeding practices has played a key role. The feed and feeding of striped catfish has changed overtime. In the early days of the striped catfish farming industry, farm-made feed (FMF) was mainly used. FMF was used across all the culture systems including cages, pens and ponds. Manufactured pelleted feed (MPF) was first introduced to striped catfish cultured in cages in 1995 and 1996. Since 2004, the use of MPF has gradually been accepted by striped catfish farmers. The survey indicated that 63.3 percent, 17.4 percent and 19.3 percent farms used MPF, FMF or a combination of MPF and FMF, respectively. Over the past five years, the striped catfish MPF industry has been developing rapidly in Viet Nam, with annual production increasing from 300 000 tonnes in 2004 (Tran, 2005) to 2 240 000 tonnes in 2008 (Annex 1).

The feeding practices used to culture striped catfish depends on the stock size and feed types. The feeding rates of MPF vary between 2 to 5 percent of body weight per day depending on the body weight of the fish, while the feeding rates for FMF are about 1–2 percent higher. Normally, three feedings are applied per day for the stock size of less than 100 g, one daily feeding is applied for the stock size of 800 g to harvest, and two daily feedings are used between these sizes. The feed conversion ratios vary according to feed type, and range from 1.6:1 for MPF to 2.9:1 for FMF. Feed cost accounts for the largest portion of

the total production cost. The feed cost of striped catfish fed full MPF, full FMF and combined MPF and FMF covers 82.9, 77.4 and 79.0 percent of the total production costs, respectively. The profit of striped catfish farming depends greatly on the feed cost and the farm-gate price. The survey showed that over the survey period 55 percent of farms lost money.

There are several issues related to the management of feed in striped catfish culture that require further research. These relate to the determination of the nutritional requirements of the larger stock sizes, on-farm feed digestibility studies, the development of feed management strategies, and the use of FMF.

1. INTRODUCTION

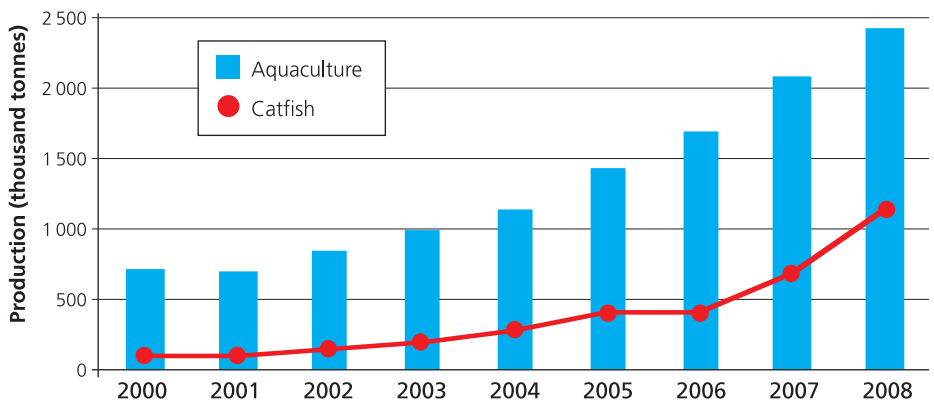
1.1 Rationale

Viet Nam has a high potential for aquaculture development due to its natural endowment of ponds, rice fields, rivers, lakes, estuaries and coastal areas. The Vietnamese Government estimates that the total area of water that may be used for aquaculture is 1.6 million hectares (Ministry of Fisheries, 2003). The aquaculture sector was initiated in the early 1960s with small-scale extensive culture systems, and during the past two decades there has been rapid growth in this sector. This expansion has been as a direct result of a diversification in farming practices, and the production of exportable species at increased levels of intensification (Nguyen and Dang, 2009).

In 2010, Viet Nam became the third largest aquaculture producers in the world (FAO, 2012). The Mekong Delta in the southern part of the country has a potential area for aquaculture development of nearly 1 370 000 ha, with 480 181 and 886 249 ha of freshwater and brackish and marine waters, respectively (IFEP, 2009). The delta has diversified aquatic farming activities and has the greatest potential of any area in the country for increasing aquaculture production.

There are several species that have been commercially produced in the delta, of which striped catfish (*Pangasianodon hypophthalmus*) predominates. In 2008, the total production of striped catfish represented 72.9 percent of the total aquaculture production in the delta (IFEP, 2009). In 2008, the production of striped catfish was 1 147 000 tonnes, and accounted for 47.1 percent of the total aquaculture production of Viet Nam (Figure 1). Catfish farming started at the beginning of the 1960s, and at that time included Mekong catfish (*Pangasius bocourti*), locally referred to *basa* and cultured in small cages, and striped catfish (*Pangasianodon hypophthalmus*), locally referred to *tra* and cultured mostly in small ponds. Striped catfish is a single species of

FIGURE 1
Striped catfish production in comparison with the total aquaculture production of Viet Nam

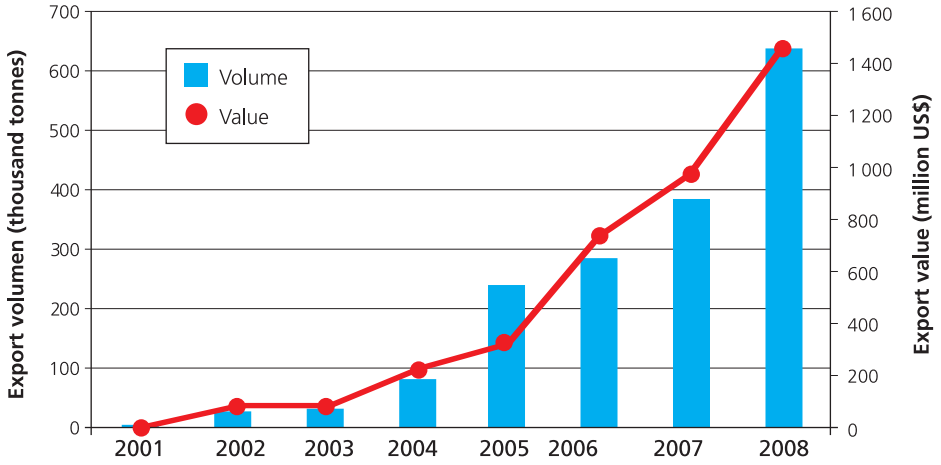


Source: IFEP (2009).

the genus *Pangasianodon* that occurs in the Lower Mekong Basin waters of Viet Nam, Cambodia, Lao People's Democratic Republic and Thailand. The fish has been farmed in the Mekong River Delta for decades as a home-based activity, primarily providing the fish needs of rural households. In recent years, commercial striped catfish farming has been based on cage, pen and pond based systems. However, since 2004, cage and pen culture have gradually reduced, and are now of no importance in the striped catfish production sector. Since 2006, catfish farming in the Mekong River Delta comprised of 95–97 percent striped catfish and 2–3 percent Mekong river catfish (Nguyen and Dang, 2009).

Over the past decade, striped catfish has become the biggest aquaculture export commodity in Viet Nam; recently export volume has increased significantly (Figure 2). The markets for striped catfish have expanded from the United State of America alone at the beginning of the 1990s to 125 countries and territories in 2008. In 2008, European markets accounted for 44.7 percent of Vietnamese production, the Russian market a further 12.6 percent, and the US market 3.7 percent (Nguyen, 2008).

FIGURE 2
Striped catfish export growth



Source: Nguyen (2008) and IFEP (2009).

1.2 Objectives of the study

The general objectives of this study were to assess the feed and feed management practices for striped catfish pond culture in the Mekong river delta. The specific objectives were to describe the changes in farming practices, the current feed use and feed management practices for broodstock, nursery and grow-out stages, the research needs, and the regulatory frameworks that apply to feed and feed management.

2. RESEARCH METHODOLOGY

2.1 Selection of study locations

The case study focused on striped catfish nursery and grow-out in ponds. Pond culture is the predominant production system in the Mekong river delta. Six representative locations (districts) of striped catfish farming in the Mekong river delta were selected for the study (Figure 3). Farmers from 112 grow-out and 30 nursery farms from the six selected districts were randomly interviewed (Table 1). Among the selected grow-out farms, 16 percent had total pond areas greater than 1.5 ha, and 84 percent of farms were less than 1.5 ha, which was considered as small scale. These farms were operated by individual farmers.

FIGURE 3
Map of the Mekong River Delta, with blue circles indicating the areas of striped catfish farming and yellow circles showing the survey locations

Source: Adapted from Nguyen *et al.* (2004).

2.2 Data collection and analysis

Semi-structural questionnaires were used to obtain technical and financial data from the farm owners or farm managers. The data on striped catfish growth in ponds were recorded from 14 grow-out ponds and based on 2009 and 2010 data.

Three types of grow-out feeding practices were categorized in this survey. These comprised the feeding of manufactured pelleted feed (MPF), the feeding of farm-made feed (FMF), and a combination of feeding MPF and FMF. Feeding of MPF refers to feeding striped catfish for the entire production cycle using industrially produced floating pellets, and using different sized pellets and feed formulations based on the size of the fish. The feeding of farm-made feed (FMF) refers to feeding striped catfish for the entire production cycle on feeds that are prepared at the farm site using locally available ingredients. A combination of manufactured and farm-made feeds refers to feeding striped catfish with MPF for the first two and the last 1.5 to 2 months of the production cycle, and feeding FMF for the intermediate 4 to 4.5 months during the middle of the culture cycle.

The collected data were collated and where appropriate mean, standard deviation and simple regression analyses were undertaken.

TABLE 1
Number and ratio of respondents by study locations

Study locations (district or town names)	Grow-out farms		Nursery farms
	Total of respondents	Ratio (%)	
Binh Thuy	6	5.36	
O Mon	20	17.9	12
Thot Not	36	32.1	10
Long Xuyen	20	17.9	8
Cu lao Dung	15	13.4	
Tieu Can	15	13.4	
Total	**112**	**100**	**30**
– Farms that used manufactured pelleted feed (MPF)	69	61.6	
– Farms that used farm-made feed (FMF)	19	17.0	
– Farms that used combined MPF and FMF	21	18.8	

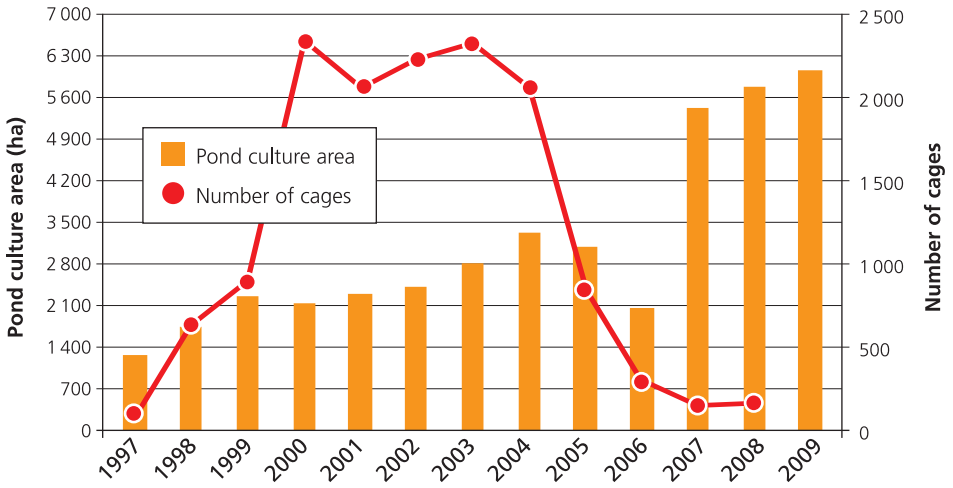
3. RESULTS AND DISCUSSION

3.1 Changes in striped catfish farming practices

The historical trends in the catfish farming sector in the Mekong Delta have been dealt with in detail by Nguyen and Dang (2009). Briefly, the intensive culture of striped catfish in ponds started in 1981–1982 by a famer in Can Tho city using wild caught fingerings and farm-made feeds. The success of striped catfish culture in ponds, together with the availability of hatchery-reared fingerlings, stimulated the development of striped catfish production in cages and pens. Since 2004, striped catfish farming has primarily become a pond culture activity (Figure 4), and the reasons for this change have been reviewed elsewhere (Nguyen and Dang, 2009; Phan *et al.*, 2009). The decline of cage and pen culture practices were primarily attributed to slower growth rates, higher mortality rates, and frequent disease outbreaks that led to reduced financial efficiencies compared to pond culture systems (Nguyen *et al.*, 2004; Nguyen and Dang, 2009). In recent years, the pond culture sector has increased in term of the area under culture, reaching over 5 700 ha of ponds in 2008 (Figure 4). While pond culture systems are operated at different scales, all are operated at a high level of intensification (Nguyen and Dang, 2009).

There were 1 174 striped catfish farms in operation in the six selected districts at the time of survey. The farms were categorized as <1.5 ha (82.7 percent), 1.5–5 ha (14.7 percent), 5–10 ha (1.87 percent) and >10 ha (0.77 percent). Most were operated as individual farming units, the exception being the 2.64 percent of farms that were operated by companies. According to Phan *et al.* (2009), the size of striped catfish farms in the Mekong delta was categorized as 72 percent <5 ha and only 9 percent being 10 ha; the average farm size was recorded at 4.09 ha.

FIGURE 4
Change in striped catfish production systems



Source: Nguyen (2008) and IFEP (2009).

3.2 General technical information of striped catfish farming

Technical information describing striped catfish culture in ponds is presented in Table 2. Pond sizes are generally small and vary between 0.30 and 0.33 ha; however, pond depths are high and vary between 4.28 to 4.61 m. The type of feed that was applied was not affected by the size of ponds that were used. These figures generally agree with the findings of Nguyen and Dang (2009), who reported catfish pond sizes between 0.4 to 0.42 ha, and Phan *et al.* (2009), who reported striped catfish pond depths ranging between 2.0 to 6.0 m with the great majority of farms (69 percent) using pond water depths of 3.5 to 4.5 m. These ponds are deeper than those that are used to farm other species in Asia.

TABLE 2
General technical information of striped/*tra* catfish farming in grow-out stage

Technical information	Categories			
	Overall (n=91)**	MPF (n=59)	FMF (n=15)	MPF+FMF (n=20)
Pond area (ha)	0.32±0.19	0.33±0.20	0.30±0.16	0.33±0.21
Pond depth (m)	4.39±0.88	4.28± 0.98	4.46± 0.7	4.61±0.57
Water depth (m)	3.64±0.75	3.46±0.80	3.83±0.54	3.94±0.55
Stocking density (fish/ha)	48.2±24.0	47.6±24.6a	50.3±28.9a	47.3±19.8a
Survival rate (%)	74.2±17.7	73.0±16.5a	77.3±23.8a	74.2±16.7a
Culture period (months)*	8.63±2.66	8.17±2.2	9.16±2.97	9.05±3.32
Productivity (tonnes/ha/crop)	360±162	325±153a	398±137ab	439±188b

Notes: Numbers represent mean ± standard deviation; * including nursery period; ** n: number of respondents; values in the same row with same superscript are not significantly different (p<0.05) (t-test).
Source: Field survey (2010).

Irrespective of feed type, the stocking density of striped catfish fingerlings in ponds was high and varied between to 476 000 to 503 000 fingerlings per ha per crop. The stocking densities depended on the size of seed stock. A high stocking density was considered as one of the key factors that contributed to the high productivity of striped catfish pond culture. However, the stocking density has gradually increased according to the developmental timeline. In the early days of pond culture, average stocking density was 205 000±100 000 fingerlings per ha (Nguyen *et al.,* 2004) but in recent years this has been increased to up to 480 000 fingerlings per ha (Phan *et al*., 2009). Despite the general increase in stocking densities, there have been no scientific studies to describe the effects of stocking densities on the productivity and growth of striped catfish under pond culture conditions. Although Phan *et al.* (2009) reported that there was no correlation between stocking densities and productivity, there is evidence to suggest that high stocking densities of small fingerlings results in low survival rates (P.N. Doan, Vinh Hoan Company, personal communication, 2009).

The average production cycle was between 8 to 9 months per crop. The production cycle of fish fed FMF and a combination of MPF and FMF was longer when compared to fish that were exclusively fed MPF (Table 2). The average productivity of striped catfish pond culture was 360 tonnes per ha per crop, which is high when compared with other culture species. According to Phan *et al.* (2009), the productivity of striped catfish varies from 70 to 850 tonnes per ha per crop (mean 406 tonnes per ha per crop), with 76 percent of the farms yielding 300 tonnes per ha per crop or more. Our survey showed that the productivity of fish fed FMF (398 tonnes per ha per crop) and a combined MPF and FMF (439 tonnes per ha per crop) was 22.4 and 25.9 percent higher respectively than the production from ponds fed MPF exclusively (325 tonnes per ha per crop).

Striped catfish nursery ponds averaged 0.44 ha (Table 3), which was similar in size to the grow-out ponds. However, the average water depth in the nursery ponds was 1.47 m which is lower than that recorded in the grow-out facilities. The nursery production cycle may be undertaken in either one or two stages. Seventy percent of nursery farms use a one-stage process, and the remaining 30 percent farms apply a two-stage process. The one-stage process takes an average of 2.7 months to complete (varying from 2.5 to 3 months) (Table 3), and the fish are nursed from larvae to a fingerling size of 1.5 to 1.7 cm (30–70 g). The two-stage nursery process takes approximately 3.5 months to complete (varying from 3 to 4 months), and the fish are nursed from larvae to fry in 1 to 1.5 months, and fry to fingerling in 2 to 2.5 months. The stocking densities and survival rates

for the first and second stage were 726±283 larvae per square meter and 33.3±7.4 percent; and 138±12.4 per square meter and 58.4±12.9 percent, respectively. Using the one-stage process, the average stocking density of larvae is relatively high (723±269 larvae per square meter); however, the average survival rate is correspondingly low (16.6 percent) (Table 3).

TABLE 3
General technical information of striped catfish farming in one stage nursery

Technical information	Values
Pond area (ha)	0.44±0.24
Pond depth (m)	2.15±0.62
Water depth (m)	1.47±0.39
Stocking density (fish/m^2)	723±269
Culture period (months)	2.70±0.36
Survival rate (%)	16.6±16.6

Notes: Numbers represent mean ± standard deviation; the stocking density, culture period and survival rate data of this table refer to one-stage nursery process.
Source: Field survey (2010).

3.3 Current feed use and feed management practices

There are two kinds of feed used in catfish farming in Viet Nam – manufactured pelleted feeds (MPF) and farm-made feeds (FMF). The MPF are produced as floating feeds with different sizes and formulations that are suited to the size of the fish. The FMF are sinking feeds that are prepared at the farm site using locally available ingredients. The feed usage in striped catfish production has changed overtime. In the early phase of sectoral development in the 1960s, the FMF was used for catfishes in cages, particularly for the Mekong catfish species (*Pangasius bocourti*) (Nguyen, 1998) but in recent years, MPF have replaced FMF.

3.3.1 Manufactured pelleted feeds

MPF were introduced to catfish cage culture systems in 1995–1996 by the Proconco Company. Initially, the feeds were poorly accepted by fish farmers as they were considered expensive and it was thought that their use would increase production costs. Moreover, catfish farmers have used farm-made feeds for several decades and traditionally were slow to change. In the late 1990s to early 2000s, many studies were conducted on the use of MPF for striped catfish, especially for pond culture. These studies investigated the potential to replace farm-made feeds, as farm-made feed use was becoming problematic in terms of ingredient availability. There was also a reduction in the availability of trash fish/low value fish. There were also needs to prevent the environmental pollution associated with their use, to improve the quality of the fish produced, and to ensure that a sustainable supply of feed was secured for the expansion of the sector. Since 2004, catfish farmers have gradually accepted the use of MPF; however, the level of acceptance depended on the location of the farms. For example, by 2004 in An Giang province, where striped catfish farming is most developed in the Mekong delta, 60 percent of catfish farm had shifted from FMF feed to a combined use of MPF and FMF (Tran, 2005); and by 2006, 50 percent of farms used MPF exclusively (Le and Pham, 2006).

The change from FMF to MPF has resulted in a significant increase in the number of aquafeed manufacturers in Viet Nam, and this has further exacerbated ingredient supply and cost issues for those farmers that still produce their own FMF, principally because the farmers could not buy ingredients at competitive prices. Tran (2005) reported that

there were 18 catfish feed manufacturers in operation in 2004 producing approximately 300 000 tonnes of MPF. However, by 2008 the number of registered catfish feed manufacturers had increased to 53 (various sizes). Currently, the total annual production capacity of these manufacturers is estimated to be 2 240 000 tonnes (Annex 1).

Depending on the manufacturer, MPF is produced in various size classes (Annex 2). There are 6 to 19 MPF size classes (Table 4). While some manufacturers are producing feed for both nursery and grow-out operations, many only produce grow-out feeds. The protein content of these feeds ranges between 18 percent and 40 percent, with small-sized (nursery) feeds containing a higher protein content (Table 5 and 6). The nutritional quality of the similar MPF size classes produced by different manufacturers is uniform (Table 5). The characteristics of a range of feeds from one randomly selected company are shown in Annex 3.

TABLE 4

Information of MPF from randomly selected feed companies

Feed company	Feed size (mm diameter)	Number of feed size classes offered	Crude protein content (%)*
UP	0.39–12.7	19	18–40
Cargill	1.8–10	11	22–28
Green Feed	2–12	18	20–28
Conco	powder–8	10	22–40
CP	2.5–12	8	20–30
Tongwei	powder–12	9	20–40
Ocialis	1.5–10	8	22–30
Dai Viet Hung	1–10	6	22–40

Note: *Data printed on feed bag and registered documents.

Source: Field survey (2010).

TABLE 5

The nutritional characteristics of MPF with similar feed size classes of four randomly selected companies (feeds for fish size of 100–400 g; as fed basis)

Composition	Tongwei Company	Proconco Company	CP Company	Viet Thang Company
Moisture (%)	10.4	11.3	8.6	9.84
Crude protein (%)	33.3	30.3	30.3	30.9
Crude lipid (%)	3.96	3.57	4.34	3.57
Ash (%)	10.1	9.99	14.1	10.8
Crude fibre (%)	7.65	4.19	9.03	5.74
Gross energy (kJ/g)	18	17.9	17.9	18
Pellet sizes				
- Length (mm)	3.54 ± 0.29	4.81 ± 0.27	4.56 ± 0.20	4.79 ± 0.35
- Diameter (mm)	3.21 ± 0.11	4.36 ± 0.18	4.44 ± 0.10	4.36 ± 0.23

Notes: Pellet sizes length and diameter are given in mean ± standard deviation; feed samples were analysed in the laboratory of College of Aquaculture and Fisheries, Can Tho University.
Source: Field survey (2010).

TABLE 6

The nutritional characteristics of MPF, feeding rate and feeding frequency of three randomly selected companies (feeds for nursery stage)

Items	Feed A	Feed B	Feed C
Crude protein (%)	≥40	≥40	≥42
Crude lipid (%)	≥5	≥6	≥5
Crude fibre (%)	≤3	≤6	≤6
Ash (%)	≤12	≤14	≤12
Moisture (%)	≤12	≤11	≤12
Phosphorus (%)	-	≥1	-
Feed type	powder/mash	particle	particle (<1 mm)
Fish size (g)	≤5	≤15	≤1
Recommended feeding frequency (% body biomass)	10–12	10–8	10
Recommended feeding rate (times per day)	6–8	5–6	5–15

Note: Data as specified on the feed bags.
Source: Field survey (2010).

The manufacturers use diversified ingredients to produce their feeds (Table 7), and these are dependent on seasonal supplies and prices. The most commonly used ingredients in MPF are fishmeal, soybean meal, rice bran, blood meal and meat and bone meal (MBM). The quantity of fishmeal used in MPF varies from 3 to 20 percent, depending on the feed sizes and protein level required. Fishmeal is expensive; therefore all manufacturers used other protein ingredients to partially replace fishmeal. These ingredients include soybean meal, blood meal and meat and bone meal. Studies have indicated that the protein digestibility of soybean meal, blood meal and meat and bone meal of striped catfish are 94.4 percent, 77.6 percent and 47.4 percent, respectively (Tran *et al.*, 2010). The energy supply for striped catfish feed is primarily derived from rice bran, and inclusion levels of this ingredient of up to 60 percent are used in the MPF formulations. While there are several kinds of rice bran available for striped catfish feeds, including dry full-fat rice bran, wet full-fat rice bran and de-fatted rice bran, the digestible levels of these ingredients are different. Moreover, inexpensive ingredients such as cassava and broken rice are also used in striped catfish diets as a source of carbohydrate. The dry matter digestibility of cassava and broken rice is 83.2 percent and 90.7 percent, respectively (Tran *et al.*, 2010).

TABLE 7

Nutritional values and digestibility of major feed ingredients used in the formulation of striped catfish MPF (percent dry matter)

Ingredient	Dry matter (%)	Crude protein (%)	Crude lipid (%)	Ash (%)	Nitrogen free extract (%)	Dry matter digestibility (%)	Protein digestibility (%)	Energy digestibility (%)
Fishmeal (65% protein)	91.9	65.3	6.19	19.1	-	87.7	96.1	93.9
Soybean meal	92.1	42.1	5.34	7.03	33.0	81.9	94.4	88
Blood meal	94.0	85	2	7	0	71.3	77.6	75.0
Meat and bone meal	-	50.0	16.1	23.0	8.59	74.1	74.4	70.9
Marine trash fish	24.4	17.8	1.42	4.00	1.14	89.1	94.5	96.4
Wet full-fat rice bran	88.0	11.8	13.6	5.90	54.7	81.5	67.6	84.2
Dry full-fat rice bran	90.7	12.8	18.9	9.07	43.9	62. 9	70.4	65.6
Defatted rice bran	90.4	14.9	1.72	9.49	5.82	56.7	66.4	54.5
Cassava	90.4	3.44	1.81	3.63	78.8	83.2	35.8	84.4
Broken rice	89.8	8.47	0.58	0.56	9.03	90.7	65.1	87.1

Sources: Compiled from Tran *et al.* (2010) and Nguyen and Tran (2008).

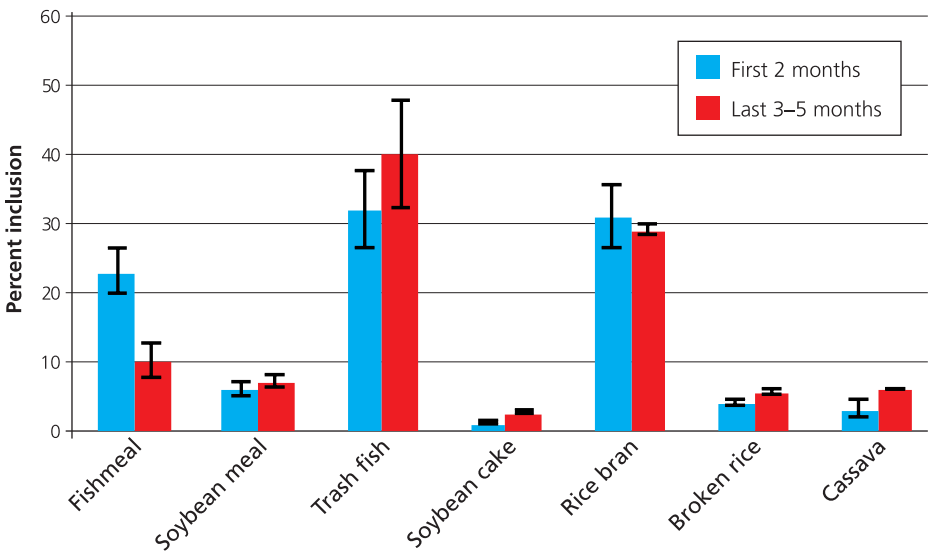
3.3.2 Farm-made feed

The FMF are formulated from inexpensive locally available feed ingredients including rice bran, broken rice, fresh trash fish and/or dried trash fish, soybean meal and fishmeal. The mixture of ingredients is cooked and extruded (Figure 5) to form a semi-moist pellet, which is fed directly to the fish within a day of manufacture. The quality of FMF is highly variable and is dependent on the quality of ingredients and the formulation of the diet. The crude protein level of the FMF during the first two months of the grow-out stage is usually higher than that which is used later in the grow-out cycle. Dietary crude protein levels vary from 19–25 percent, and are dependent on fish size. Nguyen (1998) found that the feed is normally formulated from 3 to 4 main ingredients such as trash fish, rice bran, broken rice and soybean meal. In recent years, the quality of FMF used for grow-out has improved significantly. This is a result of a diversification in feed ingredients, and formulations may now contain up to 6 or more primary ingredients (Figure 6). The FMF are either used for the full production cycle, or in combination with MPF. When used in combination, the MPF is used for the first two months of the production cycle or until the fish attain 100 g, and the last 1–2 months or until the fish reach approximately 800 g. The use of FMF throughout the production cycle is primarily limited to small scale farms.

FIGURE 5
Extrusion of farm-made feed (FMF) for grow-out striped catfish (*Pangasianodon hypophthalmus*)

COURTESY OF FAO/T.P. NGUYEN.

FIGURE 6
Formulations of farm-made feed for different grow-out stages of striped catfish



Source: Field survey (2010).

In addition, FMF are often used for broodstock as conditioning diets. In terms of broodstock feeds, 70 percent of the surveyed farms reported using FMF, and the remaining 30 percent used MPF. The feed formulations that are used for broodstock diets are relatively simple and are formulated from locally available ingredients (Table 8).

TABLE 8
Feed formulation for striped catfish broodstock

Ingredient	Dietary inclusion rate (%)
Dried trash fish	20.3±3.19
Fresh trash fish	40.8±5.98
Rice bran	30.2±4.11
Morning glory	10.8±5.34

Source: Field survey (2010).

3.3.3 The role of MPF and FMF in striped catfish farming

The use of MPF is very important for large and medium scale grow-out farms, where large amounts feed supplied on a regular basis are required. The use of MPF has been strongly recommended by government agencies due to their high quality and the associated levels of fish growth. Their use also results in a reduction in the potential for environmental pollution, improves the quality of the harvested product, and provides a mechanism for traceability. However, the disadvantage of using MPF is that they are expensive and the increased cost associated with their use can negatively affect the economics of the farming operation – particularly when the farm-gate price of the fish is low. The MPF industry is growing rapidly in Viet Nam, and in 2009, the total production capacity expanded to over 2 200 000 tonnes per annum. The MPF industry in Viet Nam is a highly competitive sector.

In contrast, government agencies have not recommended the use of FMF in striped catfish grow-out operations. Their use is discouraged due to concerns related to the formulations in use, potential nutritional imbalances, low water stability and concomitant concerns relating to the environmental impact of their use. However, the high price of MPF has forced a number of small-scale farmers to use FMF for at least some, or all of the grow-out cycle. Indeed – to reduce feed costs, some farmers that were previously using MPF reported that they reverted to using FMF when the farm-gate prices of fish were low. As a result of improved preparation techniques, the quality of FMF has been improved in terms of quality. The feed mixtures are cooked and extruded to form semi-moist pellets, which now have improved water stability (Figure 5).

3.3.4 Feed costs of striped catfish farming

The production costs during the grow-out stage are dependent on the type of feed that is used. The survey results confirm that feed costs, as a percentage of total production costs, are dependent on the type of feed used. MPF, FMF, or a combination of MPF and FMF accounts for 82.9 percent, 77.4 percent and 79.0 percent of total production costs, respectively (Table 9). However, calculated from this table, the average cost of feed was US$0.62 per kilogram of fish produced for the combined use of MPF and FMF; US$0.65 per kilogram for MPF, and US$0.68 per kilogram for FMF. Thus, the combined use of MPF and FMF increased the profits by US$0.03 per kilogram when compared to the use of MPF exclusively. This represents a significant cost saving, especially when the farm-gate price of the product is low. Generally, the price of MPF significantly affects both production costs and profits. Feed costs are high, and account for approximately 80 percent of total production costs (Nguyen and Dang, 2009). Nguyen *et al.* (2007) also stated that feed costs as a proportion of the total production costs were 92.4 percent when using MPF, 86.5 percent when a combination of MPF and FMF was

used, and 73.6 percent when FMF were used exclusively. Similarly, the survey found that feed cost accounts for 75.2 percent of the total nursery production costs (Table 10).

Improvement in feed utilization has been considered as the most effective way to reduce the production cost of striped catfish farming.

TABLE 9
Influence of different feed sources on production costs in striped catfish farming

Criteria	Overall (n=91)*	MPF (n=59)	FMF (n=15)	MPF+FMF (n=20)
Production cost (US$/kg fish)	0.800±0.125	0.789±0.149	0.877±0.247	0.790±0.231
Cost share (% total cost)				
Seed	5.4	4.5	7.5	7.1
Feed	81.3	82.9	77.4	79.0
Drugs and chemicals	4.0	3.8	4.6	4.2
Labour	2.3	2.3	2.1	2.4
Water pumping	1.4	0.9	2.1	2.0

*n= Number of respondents.
Source: Field survey (2010).

TABLE 10
Production costs of striped catfish farming in nursery phase

Criteria	Values (n=30)*
Production cost (US$/fingerling)	0.014±0.010
Selling prize (US$/fingerling)	0.022±0.009
Cost share (% total cost)	
Larvae (including transportation cost)	3.90±8.2
Feed	75.2±11.2
Drugs and chemicals	3.21±5.80
Labour	5.31±6.92
Gasoline and energy	2.56±2.94
Pond preparation	3.32±5.71
Other costs	4.71±6.72
Harvesting	2.24±3.21

*n= Number of respondents.
Source: Field survey (2010).

3.3.5 Feed prices and feed selection

Between 2008 and 2010 feed prices have reduced (Table 11). The price of MPF depends on the manufacturers, crude protein content, season and the prices of imported feed ingredients. The feed prices for FMF are difficult to estimate as they depend on the feed formulations and variations in ingredient prices (Table 12). However, the price of FMF feed is estimated at approximately US$0.237/kg to US$0.289/kg.

TABLE 11
The trend in feed prices according to crude protein level

Year	Crude protein (%) and feed costs (US$/kg)			
	30	26	20	18
2008	0.62±0.03	0.56±0.02	0.49±0	0.47±0.01
2009	-	0.50±0.04	0.48±0.01	0.41±0.03
Results of the survey (in 2010)	0.51±0.05	0.46±0.03	0.38±0.03	

Notes: Prices are given as mean ± standard deviation; the feed prices of 2008 and 2009 were recorded weekly from 4 selected companies.
Source: Field survey (2010).

TABLE 12
Feed ingredient prices

Feed ingredients	Price (VND/kg)	Price (US$/kg)
Fishmeal	16 875±3 216	0.888±0.169
Trash fish	3 670±1 244	0.189±0.065
Soybean meal	8 686±2 428	0.457±0.128
Soybean cake	1 300±1 240	0.068±0.065
Rice bran	3 607±821	0.161±0.043
Broken rice	4 453±1 355	0.234±0.071
Cassava meal	1 759±700	0.093±0.037

Note: Prices are given in mean ± standard deviation.
Source: Field survey (2010).

There are many criteria that farmers can use to select MPF. Of these, the reputation of the manufacturer and the feed price are the most important considerations. Other criteria such as payment schemes (credit schemes), feed conversion ratios and the availability of technical services from manufacturers are also taken into consideration. However, the large- and medium-scale farms usually select well-known brands. The MPF is distributed to the farm by various channels. These include direct distribution from the feed manufacturers, regional distributors, and retailers (Figure 7). Large-scale farms normally have contracts with feed manufacturers, and they benefit from lower prices when compared to those who buy the feed from distributors.

The cost of transportation of MPF or feed ingredients to the farm, either by the buyers or sellers, is dependent on the quantity or contract conditions. Feed sellers normally provide free transport of feed or feed ingredient to the farms. Vans and boats are main means of transport for feeds and ingredients (Figure 8). Feed storage is dependent on the facilities at individual farms. Large-scale farms have good storage facilities and can store large amounts of feed (Figure 9). However, small-scale farms normally have simple storage facilities that can only accommodate feeds that are bought on a weekly or bi-weekly basis. The feed ingredients that are used for FMF preparations such as rice bran, broken rice, soybean meal and cake and cassava meal are usually bought weekly or bi-weekly; trash fish are bought daily.

FIGURE 7
Distribution channels of manufactured pelleted feed (MPF)

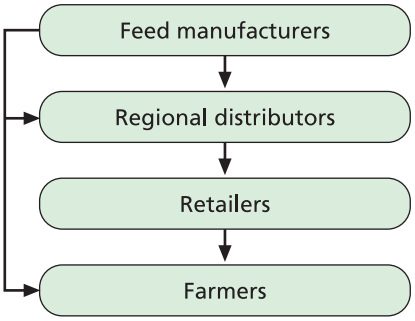


FIGURE 8
Feed transportation by boat

COURTESY OF FAO/T.P. NGUYEN.

FIGURE 9
Storage of manufactured pelleted feed (MPF) for grow-out striped catfish

COURTESY OF FAO/T.P. NGUYEN.

3.3.6 Feeding strategies

Feeding strategies depend on the types of feeds used and the size of the stock. The results of the survey revealed that the feeding rates using MPF vary from 2 to 5 percent body weight per day, and vary according to the size of the stock. The fish are fed at a rate of 5 percent when stock weighs less than 100 g, or the during the first two months of production; and at 2 percent when the stock weighs over 800 g or during the last 1.5 to 2 months of the culture cycle. The feeding rates between these sizes vary from 3 to 4 percent. At similar size classes, the feeding rates using FMF are approximately 1–2 percent higher than those rates that are used when feeding MPF (Table 13). Phan *et al.* (2009) reported that the average feeding rates of MPF for striped catfish were 5.6 percent, 3.2 percent and 2.0 percent body weight per day for months 1 and 2 of the production cycle, months 3 to 5, and months 6 and 7, respectively. Although the feeding rates are based on fish body mass, farmers usually feed to satiation.

The feeding frequencies that are used do not differ between the use of either MPF or FMF. Multiple-feeding frequencies are used when feeding small-sized fish. Fish are usually fed 3 times a day when small (<100 g), and 1–2 times for larger-sized fish (>100 g to harvest size) (Table 13). In addition to feed quality, feeding frequency is important in terms of improving feed conversion ratios. The feeding method differs according to feed type, i.e. either MPF or FMF. MPF are usually broadcast over the pond surface from boats, while FMF are fed at a specified feeding places or stations (Figure 10).

FIGURE 10
Feeding grow-out striped catfish with farm-made feed from a feeding station (top left), feeding with manufactured pelleted feed from a floating raft (top right) and fish coming in the surface during feeding (bottom centre)

COURTESY OF FAO/T.P. NGUYEN.

TABLE 13
Feeding rates and frequencies used in striped catfish in grow-out phase

Culture months and fish sizes	Feeding rate (% BW)	Feeding frequency (time/day)
Month 1st and 2nd (<100 g)		
Manufactured pelleted feed (MPF)	5–6	3 (08.00 hours, 10.00 hours and
Farm-made feed (FMF)	6–7	17.00 hours)
Month 3rd to 5th (>100 to 800 g)		
Manufactured pelleted feed (MPF)	2–3	2 (09.00 hours and 15.00 hours)
Farm-made feed (FMF)	4–5	
Month 6th and 7th (800 g to harvest)		1 (14.00 hours)
Manufactured pelleted feed (MPF)	1.5–2	
Farm-made feed (FMF)	3.5–4	

Source: Field survey (2010).

The survey showed that all catfish nursery farmers used MPF. For the past 3–4 years, MPF for larval, fry and fingerling diets have been commercially available. The feeding rates and frequencies applied to nursery production are provided in Table 14. Fish are fed an average of 10.7 percent of body weight per day for the first 25 days and the rate is eventually reduced to an average of 6.05 percent of body weight per day in the final 45-day phase before harvesting (Figure 11). These feeding rates are much higher than those used in grow-out production. The feeding frequency is also dependent on the production cycle, and fish are fed 3 times per day for the first 25 days of the production cycle and twice per day thereafter.

FIGURE 11
Harvest of striped catfish (*Pangasianodon hypophthalmus*), Mekong Delta, Viet Nam

COURTESY OF FAO/T.P. NGUYEN.

The feeding rate for broodstock varies according to the culture period. Fish are fed 4 to 5 percent of body weight per day during the preparatory conditioning period, and 1.5 to 2 percent for the maturation and spawning periods.

TABLE 14
Feeding rates and frequencies used in striped catfish in nursery phase

	Feeding rates (% BW)	Feeding frequencies (time/day)
Day 1st to 25th	10.7±3.19	3 (73.9% surveyed farms applied)
Day 26th to 45th (~0.5 g/fish)	8.14±5.98	2 (78.5% surveyed farms applied)
Day 46th to 90th (30 g/fish)	6.05±4.11	2 (96.3% surveyed farms applied)

Source: Field survey (2010).

The feed conversion ratios (FCR) recorded during the grow-out cycle differed according to the feed types that were used. The FCR derived from the MPF and FMF averaged 1.6:1 and 2.9:1 respectively (Table 15). There have been a number of reports relating to the FCR derived from MPF and FMF in striped catfish farming. In 2009, 27 grow-out farms using MPF reported an average FCR of 1.63, and maximum and minimum FCR at 1.71 and 1.52, respectively (P.N. Doan, Vinh Hoan Company, personal communication, 2009). Phan *et al.* (2009) reported that the FCR of MPF varied from 1.0:1 and 3.0:1 (average of 1.69:1), while for FMF, FCR ranged between 1.3:1 and 3.0:1 (average 2.25:1). The variation in the FCR is mainly a result of the survival rates of the fish attained; and of the quality of feeds and the feeding strategies that are applied. These reported data indicate that the FCR of MPF in striped catfish farming have not changed significantly over the past few years.

TABLE 15
Feed conversion ratios of striped catfish fed different feed types

Feeding categories	Number of respondents	FCR
Manufactured pelleted feed (MPF)	69	1.6±0.16
Farm-made feed (FMF)	19	2.9±0.62
A combination of manufactured pelleted feed and farm-made feed (FMF)	21	2.9±0.65

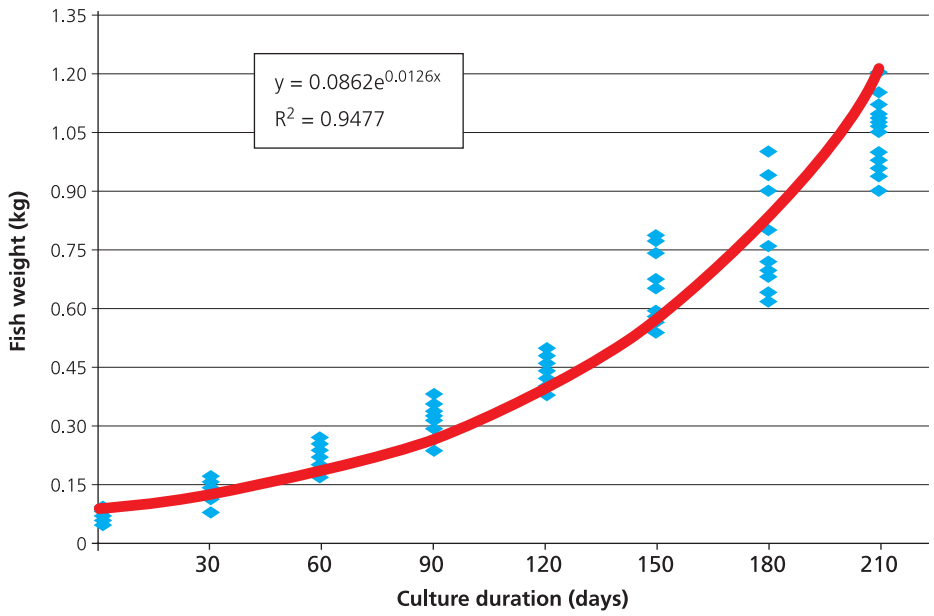
Note: FCR are given in mean ± standard deviation.

Source: Field survey (2010).

3.4 Growth performance of striped catfish

The growth performance of striped catfish varies according to the feeding practices employed. The production cycle of the fish fed MPF is about one month shorter than those fed other feeds or feed combinations (Table 2). Figure 12 illustrates a growth curve of striped catfish fed MPF that was collected from fourteen ponds (monthly sampling). Using these diets, and at an initial stocking size of around 50 g, the fish reach a marketable size after six to seven months.

FIGURE 12
Growth of striped catfish fed manufactured pelleted feed



Source: Computed from data collected during field survey (2010).

3.5 Cost benefit analysis

Catfish production requires a high level of investment. A cost/benefit analysis of striped catfish farming is presented in Table 16. The total production cost per ha depends on the stocking density. Currently, average net income is negative for farmers that use FMF or a combination of MPF and FMF, and is very low for the farms that use MPF exclusively. The average production cost per kg fish for all types of feeding categories was just over US$0.8/kg. Average production costs were lowest for those systems that used MPF exclusively (US$0.789/kg), and highest for those systems that used FMF exclusively (US$0.877/kg).

Between 49.2 to 73.3 percent of farms that were surveyed were losing money, especially those that exclusively used FMF (73.3 percent). The low profitability was attributed to a significant drop in the farm-gate price for the fish in 2009. The farm-gate price of marketable sized fish fell from around US$0.053 to 0.063 per kilogram of fish at the time of survey. Le (2008) reported that only 11.6 percent of farms encountered financial losses in 2008.

TABLE 16
Cost benefit analysis of striped catfish farming

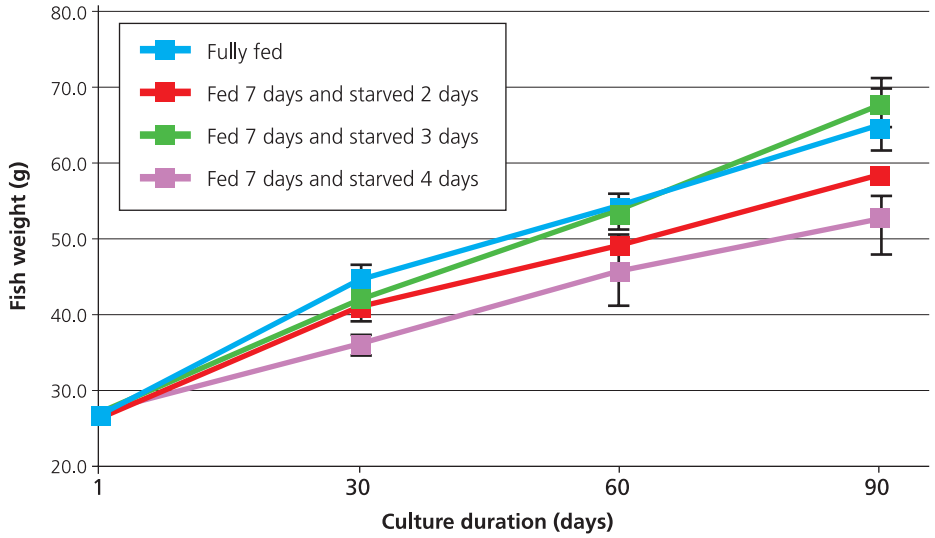
Criteria	Overall (n=91)*	MPF (n=59)	FMF (n=15)	MPF+FMF (n=20)
Productivity (tonnes/ha/crop)	360±162	325±153	398±137	439±188
Gross income (US$/ha)	281263±128 789	255 947±129 053	312 368±103 632	327 684±133 211
Total cost (US$/ha)	288 368±140579	253 789±124 842	351 632±124 158	335 842±169 158
Net income (US$/ha)	-7.05±51.2	2.11±37.16	-39.2±60 789	-8.10±69 789
Selling price (US$/kg)	0.789±0.05	0.791±0.052	0.786±0.055	0.777±0.043
Production cost (US$/kg)	0.804±0.125	0.789±0.149	0.877±0.247	0.795±0.231
Farms experiencing losses (%)	55	49.2	73.3	55
Farms in profit (%)	45	50.8	26.7	45

Notes: Values are given in mean ± standard deviation; *n: number of respondents.
Source: Field survey (2010).

3.6 New innovations in feeding strategies

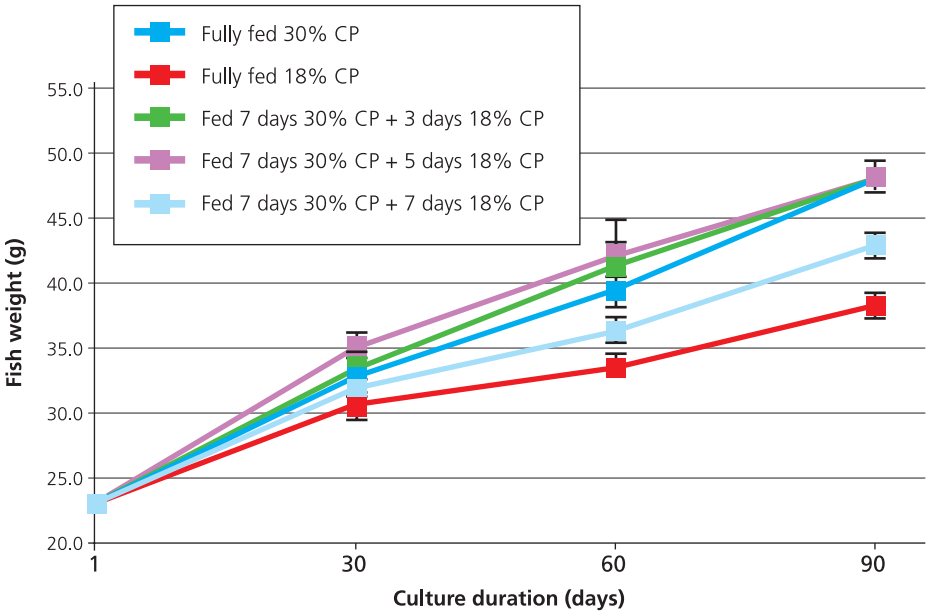
Over time, feeding strategies that are used in striped catfish production have changed as a result of the experience of farmers and of research. The FCR of striped catfish fed MPF improves when the feeding frequency is reduced from twice to once per day (H.D. Nguyen, Vemedim Company, personal communication, 2009). Similar findings have established that the feed cost per unit of fish production can be reduced by 3.33 percent if one feeding of MPF is applied throughout the production cycle.

FIGURE 13
Growth of striped catfish fed different restricted feeding regimes



Note: Error bars represent standard error of the means
Source: Duong, Ly and Nguyen (2011).

FIGURE 14
Growth of striped catfish fed different alternate feeding regimes of high and low protein manufactured pelleted feeds



Note: Error bars represent standard error of the means; CP = crude protein
Source: Duong, Ly and Nguyen (2011).

In such cases, the production cycle is prolonged by approximately four weeks (H.N. Nguyen, Thoi An catfish culture cooperative, personal communication, 2010). Duong, Ly and Nguyen (2011) reported that fish growth and feed conversion ratios can also be improved by applying novel feeding strategies such as restricting feeding regimes and using alternate regimes. The growth of fish fed a restricted feeding regime in which the fish were fed for 7 days and subsequently starved for 3 days was not significantly different to the growth rates derived from fish that has been fed on a continuous basis ($p>0.05$) (Figure 13). Furthermore, the FCR of the fish that had been placed under a restricted feeding regime was reduced by 18 percent. In addition, the growth rate of striped catfish fed alternate feeding regimes of 30 percent protein MPF for 7 days and 18 percent protein MPF for 3 or 5 days were not significantly different to fish that were fed 30 percent protein MPF all of the time ($p>0.05$) (Figure 14).

4. RESEARCH NEEDS

Currently, MPF are the majority type of feeds that are used for striped catfish production, with FMF still being used by small-scale farmers. Feed cost is a key factor affecting the profitability of striped catfish farming, and there are still a number of issues related to feeds that warrant attention in terms of improving feed utilization, and reducing pollution and nutrient loads into the environment.

The rapid growth of the feed industry during the past few years has seen the availability of different feeds on the market increase. The feed quality information that manufacturers are required to publicize includes basic proximate composition but other important factors, such as the digestibility of dry matter, crude protein and energy, are not reported. In this regard, research to determine the digestibility of feed ingredients used in feed formulations in MPF and FMF needs to be prioritized. Moreover, the development of proper methodologies to assess the digestibility of MPF and FMF under production conditions would be useful and highly valuable.

The FCR derived from the diets used in striped catfish culture in the surveyed farms varied from 1.6:1 for MPF to 2.9:1 for FMF. The protein content of feeds fed to larger sized fish is lower than the nutritional requirements of small striped catfish; fish that are <10 g have a protein requirement that is between 29.5 and 38 percent (Hung *et al.*, 2002; Tran *et al.*, 2004). A current study at Can Tho University, Viet Nam indicates that the protein requirement for striped catfish is reduced from 39 percent to 24 percent for stock sizes from 10 g to 1 000 g (unpublished data). Additional research on the nutritional requirements of the larger sizes of striped catfish is required to optimize formulations.

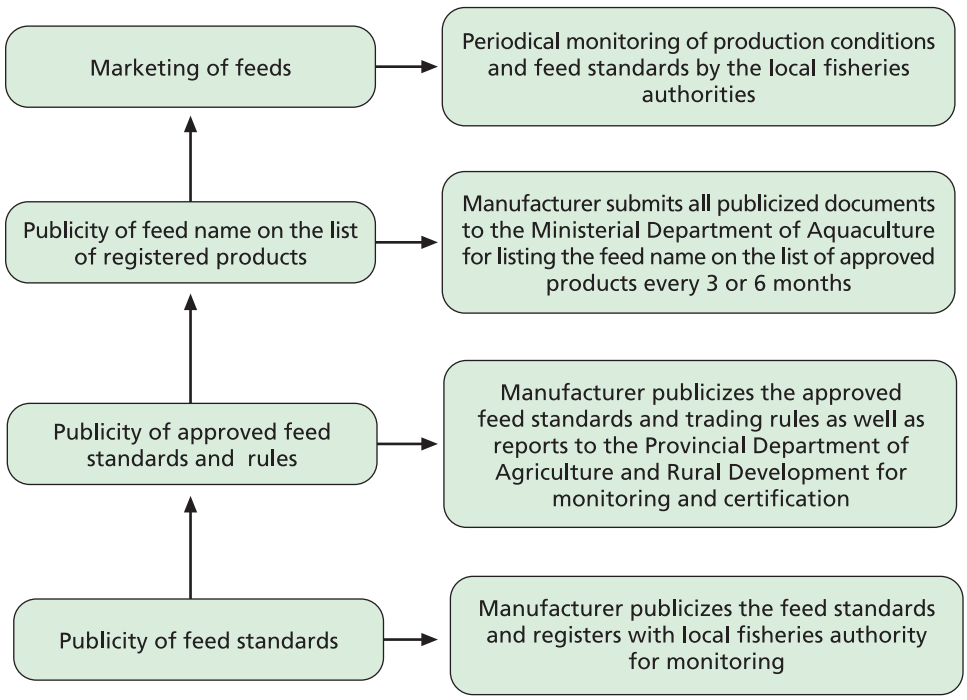
Feeding frequency is also an important factor contributing to the improvement of feed utilization and FCR reduction. In this regard, the feeding frequencies that are currently employed are not supported by scientific research. Research into feed use including feeding frequencies and the quality of FMF is required. In addition, the complete or partial use of FMF could prove to be an effective way to reduce feed costs. This is particularly important to small-scale farmers who have limited access to capital.

5. REGULATORY FRAMEWORK

The recent decree of the central government of Viet Nam (Decree No. 08/2010/NĐ-CP) provides a new detailed regulatory framework for manufacturing and trading in aquafeeds. Principally, the manufacturers are required to publicize the quality of feeds before the feeds are produced and commercialized. There are several steps that are required before the feeds can be traded (Figure 15). The local fisheries authorities are responsible for the approval and monitoring of feed quality and the production conditions of each manufacturer. This new regulatory

framework offers the manufacturers many advantages in that it simplifies the feed registration process and enables them to develop and improve their aquafeeds. The previous regulatory framework was complicated and included laboratory and pilot-scale tests of the feed quality before the feeds could be registered. At present, there is no regulatory framework to control feed prices. The manufacturers are only required to publicize the prices of their commercialized feeds. In practice, feed price is regulated by competition between the manufacturers/companies. There could be a need to regulate aquafeed prices in the future in order to support the sustainable development of the striped catfish industry.

FIGURE 15
Regulatory framework of feed manufacturing and quality control



Source: Adapted from Government of Viet Nam (Decree No. 08/2010/NĐ-CP).

6. CONCLUSIONS

Feed management of striped catfish farming in Viet Nam has changed markedly over the past ten years. The greatest change has been the shift from farm-made feeds to manufactured pelleted feeds. In recent years, the manufactured pelleted feed industry has expanded rapidly, and the production capacity of the existing manufacturers currently meets the demand of the striped catfish farming sector. However, feed costs represent the highest proportion of the total production costs, and they therefore constitute a major factor affecting the profitability of farming operations. Research to improve feed management for striped catfish is urgently required to improve the profitability and sustainability of the striped catfish farming sector in Viet Nam.

ACKNOWLEDGEMENTS

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ANNEX 1
List of manufacturers in Viet Nam

No.	Company	Estimated production in 2009 (tonnes)
1	CP	120 000
2	Viet Thang	100 000
3	Cargill	80 000
4	Novafeed	50 000
5	Tay Nam	150 000
6	Proconco	120 000
7	Greenfeed	60 000
8	Viet Long	30 000
9	Kien Thanh	30 000
10	Master	40 000
11	Co May	40 000
12	ViNa	50 000
13	UP	70 000
14	Ando Group	40 000
15	Tomboy	30 000
16	Vinh Hoan	75 000
17	Bluestar (ABS)	50 000
18	Cataco	50 000
19	Hiep Thanh	50 000
20	TongWei	50 000
21	Minh Quan	30 000
22	Dai Hung	35 000
23	Ocialis	30 000
24	Nutrifarm	30 000
25	Anco	30 000
26	CCP	30 000
27	Song Tien	50 000
28	Kim Anh	50 000
29	Cuu Long	50 000
30	Woosung	40 000
31	Forca – Biofeed	30 000
32	Growbest	40 000
33	Thanh Loi	30 000
34	Truong Son	30 000
35	Viet Anh	30 000
36	Nam Tien	30 000
37	A Chau	30 000
38	AFIEX	30 000
39	Bình An	30 000
40	Kim Xuan	30 000
41	Viet Bi	30 000
42	Viet Thai	30 000
43	Ha Lan	30 000
44	Con Heo Vang	30 000
45	Harvest	30 000
46	Nafatsco	30 000
47	Hanco	25 000
48	Viet Duc	25 000
49	Do Loc	20 000
50	My Tuong	20 000
51	Viet Dan	60 000
52	Domyfeed	30 000
53	FBT	30 000
54	Hoàng Long	30 000
	Total	**2 240 000**

ANNEX 2
Details of MPF of four selected large-scale manufacturers (in 2009)

Viet Thang Company

No.	Fish sizes (g/fish)	Feed size classes	Protein (%)	Feed sizes (mm)	Price (US$/kg)
1	<10	VT1	40	1	0.614
2	<14	VT1	40	1.5	0.593
3	<10	VT2	35	1	0.536
4	<14	VT2	35	1.5	0.508
5	<10	VT3	32	1	0.505
6	<14	VT3	32	1.5	0.475
7	<10	VT4	30	1	0.475
8	<14	VT4	30	1.5	0.454
9	<14	VT5	28	1.5	0.428
10	14–300	VT5	28	2.2–4	0.405
11	80–300	VT6	26	3–4	0.382
12	300–600	VT6	26	5–8	0.377
13	300–600	VT7	24	5	0.366
14	150–300	VT8	22	4	0.356
15	300–1 000	VT8	22	5–8	0.351
16	>1 000	VT9	18	8	0.334

Notes: Prices are at the manufacturing gate; data are specified on the bags and registered documents.

Concon company

No.	Fish sizes (g/fish)	Feed size classes	Protein (%)	Feed sizes (mm)	Price (US$/kg)
1	3–15 day-old	5001	40	Powder	0.701
2	16–30 day-old	5002	35	Powder	0.694
3	16–30 day-old	5002	35	Granules	0.580
4	16–30 day-old	5002	35	1–1.5	0.711
5	4–14 g	5004	32	1.5	0.554
6	14–150 g	5005	28	1.5	0.495
7	14–150 g	5005	28	2.2	0.449
8	14–150 g	5005	28	3–4	0.447
9	150–300 g	5006	26	5–8	0.391
10	300–600 g	5007	22	5–8	0.365

Notes: Prices are at the manufacturing gate; data are specified on the bags and registered documents.

Uni-President – UP company

No.	Feed size classes	Feed sizes (mm)	Protein (%)	Price (US$/kg)
1	T501S	<40 mesh	40	0.662
2	T501	18–40 mesh	40	0.662
3	T502S	14–18 mesh	40	0.662
4	T502	1.5–1.7	40	0.662
5	T503	2–2.2	40	0.609
6	T503SL	2–2.2	30	0.501
7	T503S	3–3.2	30	0.496
8	T504	4.3–4.7	30	0.488
9	T50426-3	3–3.2	26	0.416
10	T50426-4	4.3–4.7	26	0.405
11	T504S	5.3–5.7	26	0.405
12	T50426-6D	6.3–6.7	26	0.403
13	T50426-9D	9.3–9.7	26	0.403
14	T50426-12D	12.3–12.7	26	0.403
15	T505SL	3–3.2	22	0.395
16	T505S	4.3–4.7	22	0.389
17	T505	6.3–6.7	22	0.384
18	T50522-9D	9.3–9.7	22	0.382
19	T50522-12D	12.3–12.7	22	0.382

Notes: Prices are at the manufacturing gate; data are specified on the bags and registered documents.

Cargill Company

No.	Fish sizes (individual weights)	Feed size classes	Protein (%)	Price (US$/kg)
1	20–200 g	3	26	0.512
2	200–500	4.3	26	0.506
3	500 g – harvest	10	20	0.441
4	500 g – harvest	6–10	22	0.483
5	500 g – harvest	6–10	22	0.475
6	500 g – harvest	6–10	24	0.488
7	500 g – harvest	6–10	20	0.462
8	20–200 g	1.8	28	0.596
9	20–200 g	3	26	0.531
10	200–500 g	4.5	25	0.530
11	500g – harvest	6	22	0.504

Notes: Prices are at the manufacturing gate; data are specified on the bags and registered documents.

ANNEX 3
Details of quality of MPF from a randomly selected company

Feed size classes	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)	Fibre (%)	Feed sizes (mm diameter)
T501	10	40	4	12	5	<0.39
T501S	10	40	4	12	5	0.39–1.06
T502	10	40	4	12	5	1.06–1.41
T502S	10	40	4	12	5	1.5–1.7
T503	10	40	4	12	6	2.0–2.2
T503S	10	40	5	12	6	3.0–3.2
T504	10	30	5	12	6	4.3–4.7
T504S	10	26	5	12	6	5.3–5.7
T505	10	22	5	12	6	6.3–6.7
T506(S)	10	20 (18)	5	12	6	9.3–9.7
T507(S)	10	20 (18)	5	12	6	12.3–12.7

Notes: Data are as specified on the bags.