On-farm feeding and feed management in whiteleg shrimp *(Litopenaeus vannamei)* farming in Viet Nam

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ABSTRACT

The study surveyed 97 whiteleg shrimp (WLS) farmers in Central and Southern Viet Nam in 2009. Farmers stocked at very high densities (100–200 shrimp per ha) and harvested in 80 to 100 days. Culture periods of less than 80 days were reported when shrimp were reared only to small sizes (12–15 g). Farmers used manufactured feed and rarely applied supplemental feeds. The feeds contain high protein levels, ranging from 36 to 44 percent. Dietary protein levels varied according to shrimp size. The feed conversion ratio varied from 1.1:1 to 1.2:1 and the shrimp yields were in the range of 10 to 20 tonnes/ha/crop. Shrimp farmers in Central Viet Nam had smaller ponds and often stocked at higher densities than the farmers in the Mekong delta (Southern Viet Nam). As a result, the shrimp yields in Central Viet Nam were often higher.

The production cost and benefits of WLS farming were analysed. The analysis showed that feed costs comprised 66 to 68 percent of total production costs. Costs for seed and fuel (electricity) were the second and third highest production costs, varying from 8 to 10 percent. Labour costs contributed only 2 percent of total production costs. The total production cost/ha/crop was US$32 000 and US$16 500 in Central and Southern Viet Nam, respectively. The cost-benefit ratios were 0.69 and 0.75 in Central and Southern Viet Nam, respectively. The results demonstrated that whiteleg farming in Central Viet Nam is more intensive but less profitable than farming in Southern Viet Nam.

While there is potential to further develop WLS farming in Southern Viet Nam, development has peaked in Central Viet Nam. Shrimp farmers often report disease outbreaks, especially in Central Viet Nam.

1. INTRODUCTION

Historically, shrimp farming in Viet Nam has been based on extensive production systems. More recently, intensive farming systems that require different feed and feed management strategies have been introduced.

1.1 Overview of shrimp farming in Viet Nam

1.1.1 Extensive production systems

Extensive shrimp farming is a traditional farming practice that has developed in the Mekong delta and other coastal provinces in Central and Northern Viet Nam. Extensive culture systems require water to be exchanged under tidal influences with the inflow bringing natural seed and feed to the culture ponds. Harvesting is undertaken on a bi-monthly basis during low spring tide events, when the ponds can be completely drained. Supplemental feeding is not used in extensive culture systems, and the shrimp rely completely on natural feed. Until 10 to 15 years ago, natural seed abundance of banana prawn (*Penaeus merguiensis*) and Indian white prawn (*P. indicus*) was sufficiently high to supply the ponds with juveniles. However, in recent years, and due to a decline in naturally produced postlarvae (PL), farmers have had to stock black tiger shrimp (*Penaeus monodon*) PL to improve their yields. The practice of stocking PL in this manner is known as the 'improved extensive system'. These two systems occupy a large proportion of the shrimp culture area in Viet Nam, particularly in the Mekong delta (Hung and Huy, 2007). In 2004, extensive and improved extensive systems accounted for 68 percent and 27 percent of the shrimp farming surface area in the Mekong delta, respectively (Phuong, Minh and Tuan, 2004).

1.1.2 Semi-intensive and intensive production systems

In semi-intensive production systems culturing black tiger shrimp (*P. monodon*), the natural food is supplemented with trash fish, small shrimp, Jawla paste shrimp (*Acetes indicus*) and cheap shrimp pellets (approximately US$0.8/kg) Stocking density ranges from 5 to 10 shrimp/m^2. Aeration is not used. The farms may either be operated as rotational shrimp/rice farms, or integrated into the mangrove areas. In 2003, there were 20 500 ha of semi-intensive shrimp farms in the Mekong delta (MoFI, 2003).

In the intensive production systems, black tiger shrimp are stocked at 20 to 50 shrimp/m^2. Ponds are usually constructed in areas at the top of the tidal prism, and have a surface area of 2 000 to 3 000 m^2. The system requires a high level of maintenance and management with respect to feeding, water quality control, and aeration. Though most farmers use commercially formulated shrimp feeds in these systems, some still follow traditional methods of improving yields by using fertilizers to stimulate natural productivity and by adding trash fish. The total surface area under intensive culture in 2003 was 15 534 ha (MoFI, 2004). The main culture species in the Mekong delta is tiger shrimp. Formulated feeds are mostly used in intensive systems, though some farmers combine formulated and farm-made feeds during the final days of the production cycle. Farm-made feeds include cooked trash fish, small shrimp and molluscs. Nhan (2005) demonstrated that in Quang Ngai province of Central Viet Nam, 30 percent of farmers still use farm-made feeds when intensively culturing tiger

FIGURE 1
A feeding tray used to monitor feed consumption and to adjust the amount of feed provided

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shrimp. Farmers use feeding trays (2 to 4 trays per 4 000 to 5 000 m² pond) to monitor consumption and to adjust the ration (Figure 1).

Pellets are fed using by broadcasting them over the pond surface. Feeding is restricted to two to three times per day, using a boat or floating raft. All feed producers provide feeding tables to calculate feeding rates and minimize over- or under-feeding. Table 1 provides an example of a recommended feeding strategy. Daily feed is adjusted according to shrimp size, and the portion of feed remaining on the feeding tray from the previous feed. Farmers normally distribute 3–4 percent of the daily feed ration onto feeding trays (2.8, 3.0 and 3.3 percent for 5–10 g, 10–20 g and >20 g shrimp, respectively). The feeding trays are checked after two hours of feeding. If the unfed feed left in the feeding tray is higher than 10 percent, the farmers reduce the feed ration at the next feeding. The ration size is increased when the feeding tray has been emptied. When well-managed, the feed conversion ratios (FCR) attained using commercially formulated feeds range from 1.3:1 to 1.5:1. In poorly managed systems, FCR can be as high as 2.5:1. Under intensive culture conditions, yields of up to 7 tonnes/ha/crop can be attained (Hung and Huy, 2007).

TABLE 1
Example of a feeding schedule for intensive culture using formulated feeds for black tiger shrimp

Stage	Shrimp size (g)	Feeding rate (kg/day)	Feed distributed in feeding tray (% of daily feed)	Feeding tray monitoring intervals (hours)
PL20-PL27	<0.2	1.0–1.5 kg/90 000 PL/day	NA	NA
PL28-PL35	0.2–0.6	1.5–2.0 kg/90 000 PL/day	NA	NA
PL36-PL45	0.6–1.5	6.0–6.5	2	3
PL46-PL55	1.5–5.0	5.5	2.4	2.5
PL56-PL75	5.0–10.0	4.5	2.8	2.5
PL76-PL95	10.0–20.0	3.8	3.0	2
>PL95	>20 g	3.5	3.3	2

Notes: PL = Postlarvae; NA = not applicable.
Source: Hung and Huy (2007).

Intensive shrimp farming based on whiteleg shrimp (*Litopenaeus vannamei*), hereinafter referred to as WLS, has been introduced to Viet Nam over the past ten years. WLS are native to the Western Pacific Coast of Latin America, and were introduced into Tahiti in the early 1970s to establish their potential for aquaculture. The successful production of this shrimp species in South America led to its introduction into Asia. The timing of these introductions (some illegal) was: Mainland China, 1988; Taiwan Province of China, 1995; Philippines, 1997; Thailand, 1998; Viet Nam, 2000; Indonesia, 2001; Malaysia, 2001; India, 2001 (Briggs *et al.*, 2004).

During 2002 to 2009, Thailand, Indonesia and China changed from tiger shrimp farming to WLA farming; WLS production now dominates the shrimp farming industries in these countries. In 2003 the Ministry of Fisheries, Viet Nam (MoFI) banned the production of WLS in the country for fear of the transmission of viral diseases between the introduced WLS and indigenous species such as tiger shrimp, and the potential impact that the introduction could have on biodiversity. Until 2006, and under pressure from producers, the Ministry restricted the production of WLS in Central and Northern Viet Nam, and prohibited its production in the Mekong delta (Southern Viet Nam). Since 2008, the Ministry has allowed the farming of WLS in the

Mekong delta. As a result of these restrictions, while WLS farming has been practiced in Viet Nam since 2000, its production remains small in comparison with that of the tiger shrimp. In 2009, 84 320 tonnes of WLS and 236 492 tonnes of tiger shrimp were produced (Table 2).

TABLE 2
Shrimp production and the area under cultivation in Viet Nam (2009)

Area/production	Tiger shrimp	WLS	Other shrimp	Total production
Surface area (ha)	598 679	18 628	12 136	629 443
Production (tonnes)	236 492	84 320	66 729	387 541

Source: MAR (2009).

During the initial period in which WLS was introduced to Viet Nam, PL were illegally imported from China. During this period, tiger shrimp production was severely impacted by white spot disease, especially in Northern and Central Viet Nam where farmers lost multiple crops, and in many cases had to abandon their ponds. In response, WLS farming was embraced by farmers as an alternative culture species – this despite the species being banned until 2006 for fear of the introduction of the Taura viral disease, and the potential impact on biodiversity.

Artificial breeding protocols are available for the production of both tiger shrimp and WLS (Khang, 2008). Over the past ten years, the number of shrimp hatcheries has increased rapidly from 2 086 units in 1998, producing approximately 6.6 million PL15 shrimp to 5 094 units in 2004, producing approximately 26 billion PL15 (MoFI, 2005). These hatcheries, supply seed to the entire country, and are primarily located in Central Viet Nam, but can now also be found in the Mekong delta (Khang, 2008). As there are no significant differences in breeding techniques between the two shrimp species, the hatcheries can produce either tiger shrimp or WLS. As WLS are not indigenous, the broodstock used in Viet Nam is imported. While large-scale hatcheries import SPF (Specific Pathogen Free) broodstock from Hawaii or Thailand, their smaller counterparts often import uncontrolled broodstock from China. Eyestalk ablation techniques are used to induce female maturation. The feeding strategies developed for WLS larvae are similar to those applied to tiger shrimp, with feeding strategies being dependent on developmental stage. At the zoeal stage, larval feeds mainly comprise live algae or algal powders (*Spirulina*) and microencapsulated feeds (e.g. Frippak, Lansy, V8-Zoae, V8-larval 1, 2, 3, 4). At the mysis stage, larvae are fed microencapsulated feed and live, newly hatched *Artemia* nauplii. At the postlarval stage, shrimp are fed both formulated feeds and live hatched *Artemia* nauplii (ECAA, 2009).

In 2004, the Ministry of Fisheries published quality standards for tiger shrimp feeds to regulate and control the quality of feed production. The standards obligate feed mills to comply with certain minimum standards: crude protein content should be 35 percent for grow-out shrimp (>20 g); and up to 42 percent for starter feeds (0.01 to 0.20 g). Gross energy should be at least 3 000 cal/kg for grow-out and 3 400 cal/kg for starter feeds. Other nutrients in formulated feed such as crude lipid, calcium, phosphorus, fibre, minerals, lysine and methionine and the allowable levels of aflatoxin are also standardized. There are about five to six types of feed that are produced for the different developmental stages of tiger shrimp. The nutrient composition of the various products does not differ much among producers. Table 3 provides an example of the general nutrient composition of tiger shrimp feeds. Feed is distributed through an elaborate network of dealers and sub-dealers throughout the country. Each company sets up its own distribution channels to cover markets in coastal provinces throughout Viet Nam (Hung and Huy, 2007).

TABLE 3
Examples of nutrient composition of commercial tiger shrimp feeds (percentage dry matter)

Feed type	Moisture (%)	Crude protein (%)	Crude lipid (%)	Crude fibre (%)	Ash (%)	Calcium (%)	Phosphorus (%)
Postlarvae	<11	>43	>5	<3	<16	>2.5	>1.5
Starter	<11	>41	>6	<3	<16	>2.5	>1.5
Grower	<11	>38	>6	<3	<16	>2.5	>1.5
Finisher	<11	>36	>6	<3	<16	>2.5	>1.5

Source: Hung and Huy (2007).

Government agents, working for the National Fisheries Quality Assurance and Veterinary Directorate (NAFIQUAVED) in central government, monitor the feed mills for compliance with the quality standards. In the past, shrimp farmers in Viet Nam experienced serious disease outbreaks, which at the time were attributed to environmental factors (Nhuong, 2006). Notably, the increased volumes of shrimp feed, therapeutants and other products that are associated with higher-intensity shrimp farming, creates serious problems. These occur when redundant shrimp feed and wastes that have not been treated are disposed of directly into the environment, polluting rivers and coastal areas, and impacting biodiversity. In addition, the risk of disease contamination continues to threaten the economic efficiency of the production systems (Khang, 2008). In 2001 and 2002, shrimp diseases caused significant damage to farmers in Central Viet Nam, and for this reason, many farmers switched from culturing tiger shrimp to WLS.

According to government regulations (Good Aquaculture Practices approved by the Government of Viet Nam), prior to discharging effluent shrimp farms should treat their pond water to eliminate diseases and reduce emissions. Only large-scale farms can afford to apply these regulations – small-scale farms, generally comprising 1 to 2 ponds, have insufficient land to the construct the necessary water-treatment ponds needed. In the past, attempts have been made to close these small-scale farms. However, as the government has a policy to alleviate rural poverty, a dilemma arose as to whether to apply the effluent control regulations, or promote small scale farming as a mechanism with which to reduce rural poverty. As a result, some farms currently do not treat their effluent waters.

At present, WLS farming has expanded to the whole country (North, Central and Southern Viet Nam). The WLS farming production system is intensive, using high stocking densities - extensive production techniques are not applied to WLS farming. In comparison with tiger shrimp farming, WLS production dominates in Central and Northern Viet Nam (Table 4).

TABLE 4
Production of tiger and whiteleg shrimps in three areas of Viet Nam in 2009 (tonnes)

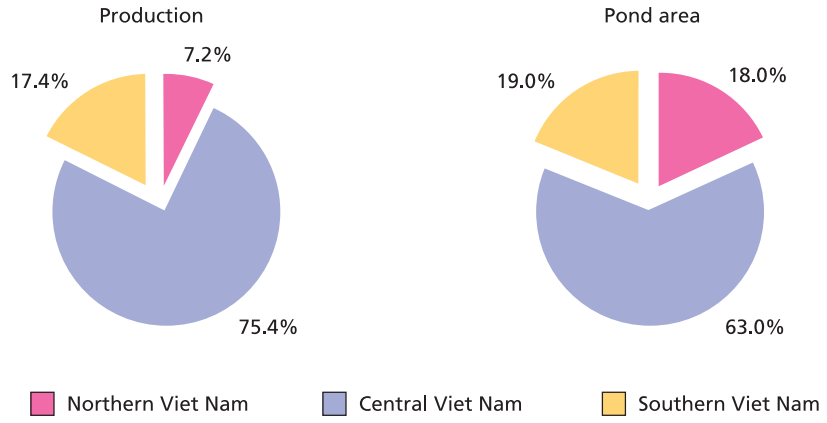
Locations	WLS	Tiger shrimp	Total
Northern Viet Nam	6 058	3 427	9 485
Central Viet Nam	63 554	9 321	72 875
Southern Viet Nam	14 708	223 745	238 453
Total	84 320	236 493	320 813

Source: MAR (2009).

In Southern Viet Nam tiger shrimp is the dominant culture species, accounting for 74.9 percent of the total shrimp production in the region; while WLS farming started only a couple of years ago, production has rapidly increased and now stands at 4.93 percent of the total shrimp production.

Central Viet Nam is the leading area for WLS farming, accounting for 75.4 percent of the country's total production, and 63.0 percent of the production area (Figure 2). Southern Viet Nam accounts for 17.4 percent of production, occupying 19 percent of the production area. In contrast Northern Viet Nam accounts of 7.2 percent of the country's production, occupying 18 percent of the surface area available for production.

FIGURE 2
Production and surface areas associated with whiteleg shrimp farming in Viet Nam in 2009



Source: MAR (2009).

As discussed, WLS farming represents a relatively novel farming practice in Viet Nam, and there is currently a paucity of published information pertaining to the feed and feed management practices that are in use in the country. The present study was undertaken to obtain a better understanding of these details, and to evaluate the production costs and production efficiencies.

The objectives of the study were to:

- Provide a review of the current status of WLS farming in Viet Nam.
- Provide a synthesis of current feed use and feeding practices, including the choice of feed, availability, feed transportation and on-farm storage systems.
- Study the existing feeding strategies used in WLS farming, with specific focus on feeding frequency, feeding rate and methods.

2. METHODOLOGY

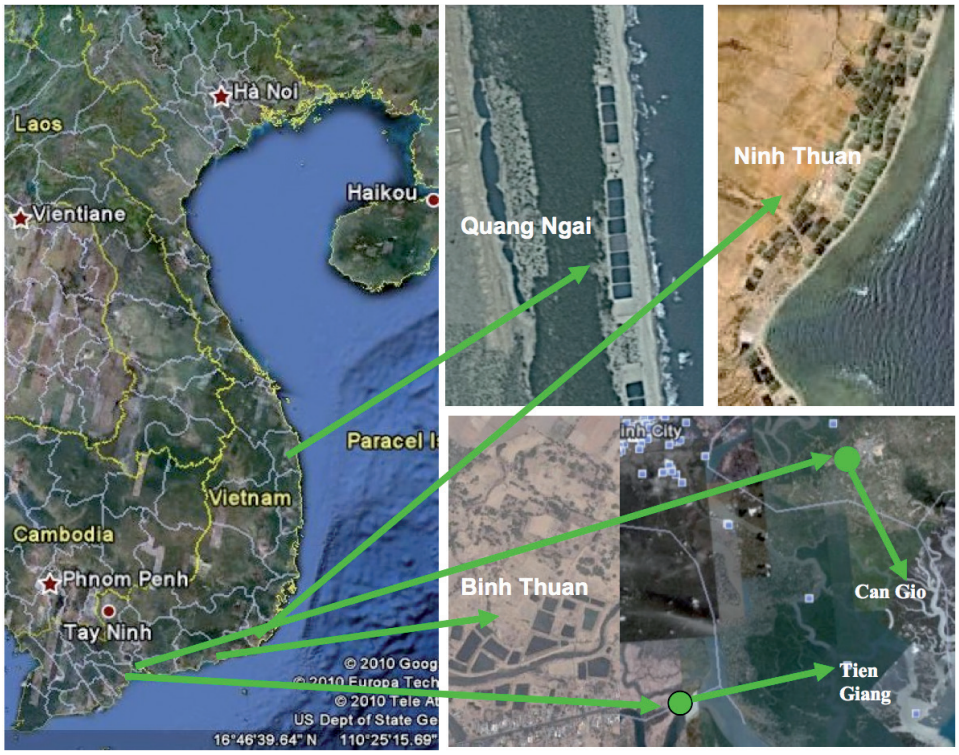
The study was conducted between January and mid-February 2010.

2.1 Site selection for the survey

While WLS is cultivated from N orth to Southern Viet Nam, the survey was restricted to Central and Southern Viet Nam (Figure 3), which is the major area where WLS farming occurs.

A total of 97 shrimp farmers were interviewed during the survey period. In Central Viet Nam 57 shrimp farmers were interviewed in Binh Thuan, Ninh Thuan and Quang Ngai provinces. In Southern Viet Nam 40 shrimp farmers were interviewed in Ho Chi Minh and Tien Giang provinces. All farmers were interviewed using structured questionnaires. Sample numbers for each province were determined according to the regional distribution of the farms, and to ensure a representative sample of all farming practices (Table 5). The farmers that were selected to participate in the survey were selected at random.

FIGURE 3
Map of five different studied locations along the coast of Viet Nam



Source: http://maps.google.com/maps (accessed 15 August 2010).

TABLE 5
Survey questionnaire – regional distribution

Locations		Sample size	Total
Central Viet Nam	Quang Ngai Ninh Thuan Binh thuan	5 27 25	57
Southern Viet Nam	Can Gio-HCM city Tien Giang	20 20	40

Source: Field survey (2010).

A total of 43 farmers agreed to participate in an economic analysis of their farming activities. Those that failed to participate in this section of the survey did so because they either lacked the necessary information, or viewed their information as proprietary knowledge. Survey data was coded and entered into an MS Excel spreadsheet for analysis.

2.2 Questionnaire limitations

The survey was only carried out on 97 shrimp farmers in Central and Southern Viet Nam and did not include farmers in Northern Viet Nam – this omission was due to time limitations and restricted human resources to undertake the survey. In addition, the study did not interrogate farmers about hatchery feeds and larval feeding.

3. RESULTS AND DISCUSSION

3.1 Experience of shrimp farming

The survey revealed that tiger shrimp farmers in Central and Southern Viet Nam had more experience than WLS farmers. More than 50 percent of the total number of WLS farmers interviewed had less than two years of experience, and very few farmers (4.8 percent) had more than four years of experience (Table 6). Farmers in Southern Viet Nam had fewer years of experience than farmers in Central Viet Nam.

TABLE 6
Experience profile of the shrimp farmers in Central and Southern Viet Nam

Experience (years)	Central Viet Nam		Southern Viet Nam	
	WLS (%)	Tiger shrimp (%)	WLS (%)	Tiger shrimp (%)
0–2	47.37	-	65.00	-
2–4	43.86	59.65	32.50	52.50
4–8	8.77	22.81	2.50	40.00
>8	-	17.54	-	7.50

Source: Field survey (2010).

3.2 Farm size and shrimp ponds

In general, prawn farms are relatively small (Table 7). Across the two survey regions, 71 percent of the farms were less than 1 ha in size, 18.3 percent were between 1 and 2 ha, and only 10.7 percent were over 2 ha. Fewer large (>2 ha) farms were found in the South Viet Nam areas surveyed. With respect to the pond sizes that were in use, 66.7 percent of farms in Central Viet Nam used ponds that were less than 0.3 ha. In contrast, only 22.5 percent of the pond sizes in Southern Viet Nam were 0.3 ha, with the majority (70 percent) being 0.3–0.6 ha. Only an average of 4.6 percent of the farmers reported using ponds larger than 0.6 ha.

TABLE 7
Characterisation of farm and pond sizes used across Central and Southern Viet Nam

Farm/pond size	Central Viet Nam (%)	South Viet Nam (%)	Mean (%)
Farm size (ha)			
<1 ha	71.9	70.0	71.0
1–2 ha	14.1	22.5	18.3
>2 ha	14.0	7.5	10.7
Pond surface area (ha)			
<0.3 ha	66.7	22.5	44.6
0.3–0.6 ha	31.5	70.0	50.8
>0.6 ha	1.8	7.5	4.6

Note: data presented as regional percentages and the mean for both regions.
Source: Field survey (2010).

3.3 Feed and feeding management

As WLS farming is practiced under intensive culture conditions, farmers use compound aquafeeds and do not use supplemental feeds such as trash fish, small shrimp, or other low-grade feedstuffs. Prior to 2006, compound aquafeeds specifically formulated for

WLS were unavailable in the country. In their absence, farmers used formulated feeds that were designed for tiger shrimp. In 2006, the government formally allowed farmers to culture WLS, and thus the commercial feed companies started to produce feeds that were specifically formulated for use with this species. In September 2009, the government issued a feed standard for WLS in which the gross nutrient composition, feed size and form (crumble, pellet) was specified (Table 8).

Currently, there are more than ten feed mills producing compound aquafeeds for WLS in Viet Nam. The feed producers are required to follow the manufacturing standards for the various feed types (Table 8). To ensure compliance with the standards, Government agencies randomly inspect feed quality by testing samples of the feeds that are being distributed in the market. Most of the feed mills are run by foreign companies: these have invested in Viet Nam primarily to produce feed for the local market, but may also export small amounts to neighbouring countries. The arrival of multi-national aquafeed companies such as the CP group, Uni-President, and Grobest Company, have overwhelmed the local shrimp feed producers; often local feed manufacturers are no longer able to compete with multinational aquafeed producers. These companies manufacture between 6 and 8 feed types (Annexes 1 and 2). The feeds produced are classified as starter, grower and finisher feeds (Table 9). The starter feeds typically have dietary protein levels of 40–42 percent protein, with the finisher feed having lower protein contents at around 36–38 percent. The feed price varies according to its protein levels.

TABLE 8

Quality norms and feed standards for whiteleg shrimp

Stage	Feed form	Feed size	Digestible protein not less than (%)	Crude lipid not less than (%)	Fibre not higher than (%)	Moisture (%)	Lysine (% feed)	Methionine (% feed)	Ca:P ratio
Zoea to mysis	Powder	250 µm	40	6–8	3	10	2.0	0.9	1.0–1.5
PL1 to PL15	Powder/ Crumble	250 µm–0.5 mm	40	6–8	3	10	1.9	0.8	
Juvenile (1.2–2.5 cm)	Crumble	0.4–0.8 mm	38	5–7	3	11	1.8	0.8	
Juvenile 2 (2.5–3.5 cm)	Crumble	0.7–1.68 mm	38	5–7	4	11	1.8	0.8	
Shrimp 1 (1–3 g)	Crumble/ pellet	1.4–2.2 mm	38	5–7	4	11	1.7	0.7	
Shrimp 2 (3–12 g)	Pellet	1.5–2.3 mm	36	4–6	4	11	1.6	0.7	
Shrimp 3 (12–25 g)	Pellet	1.8–2.4 mm	34	4–6	4	11	1.5	0.7	
Shrimp 4 (> 25 g)	Pellet	2.2–2.6 mm	32	4–6	4	11	1.5	0.7	

Source: MAR (2009).

TABLE 9

Summary of commercial feed used for whiteleg shrimp in Viet Nam

	Starter	Grower	Finisher
Protein content (%)	40–42	38–40	36–38
Feed form	Crumble/powder	Pellet	Pellet
Feed size (cm)	Ø 1; L:2–4	Ø 1.4; L:2–4	Ø 2.0; L:3–5
Shrimp stage	PL to 1.0 g	1.0–10 g	10–15 g
Price (US$/kg)	1.07–1.08	1.05–1.07	1.03–1.05

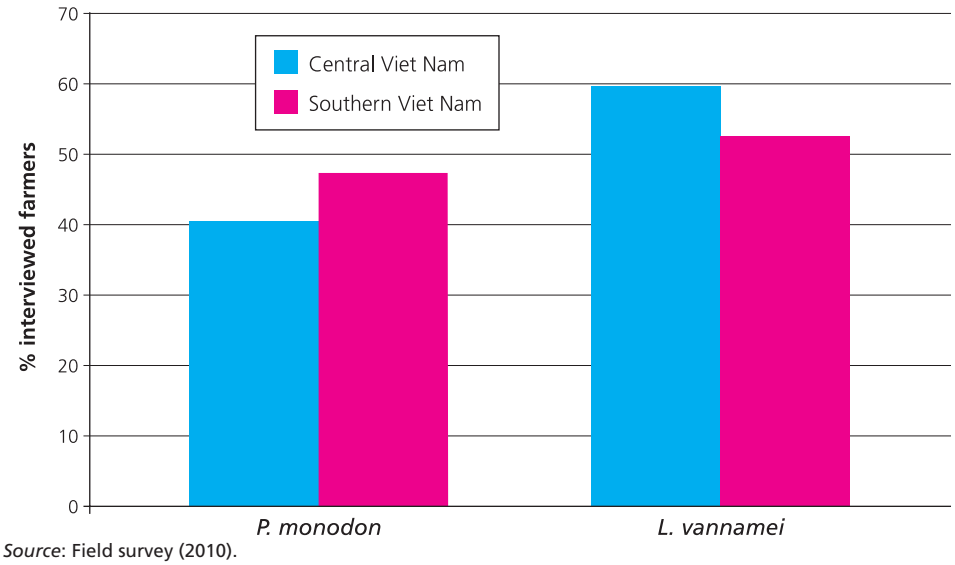
Notes: Ø: diameter; L: feed length.

Source: Synthesis from data of various feed mills.

The survey found that farmers stocking WLS used formulations containing protein levels between 36 to 42 percent (Table 9). These dietary protein levels should be considered greater than the optimal for the species. Hertrampf and Piedad-Pascual (2000) reported that WLS have a dietary protein requirement in the range of 32 to 35 percent protein. Hu *et al.* (2008) undertook a study to determine the effect of the growth and body composition of WLS juveniles fed different ratios of dietary protein to energy. These authors demonstrated that a diet containing 34 percent protein and 7.5 percent lipid with a protein:energy ratio of 21.1 mg protein/kJ was optimum for the WLS, and that increases in dietary lipid levels did not elicit a significant protein sparing effect.

This contrasts to the dietary protein requirement for tiger shrimp, which is reportedly in the range of 36 to 42 percent (Shiau, 1998). These findings suggest that some WLS farmers are using feeds that are designed for use with tiger shrimp. Indeed, approximately 40 to 50 percent of the farmers interviewed in the study reported using tiger shrimp feeds when culturing WLS (Figure 4). As WLS feeds with the correct protein levels are readily available on the market, this finding suggests that despite their unsuitability, farmers have become used to using tiger shrimp feeds for WLS culture, and select these feeds in preference to the WLS feeds.

FIGURE 4
The percentage of whiteleg shrimp farmers that reported using feed designed for either tiger or whiteleg shrimp



Source: Field survey (2010).

Despite using feeds that have already been formulated to contain sufficient vitamins and minerals, farmers often 'top dress' their feeds with additional vitamins and minerals. The practice of 'top dressing' is believed by many farmers to prevent diseases, promote growth and enhance digestibility. In this regard, Vitamin C is often applied as a health prophylactic at a dose of 2–3 g/kg feed (Table 10). Moreover, Moss, Forster and Tacon, (2006) studied WLS growth using different water sources (groundwater, pond water) with and without vitamin supplements and found that the increased natural productivity in pond production systems provided sufficient vitamins to the shrimp, and thus the quantity of vitamins in the formulation could be reduced. It seems that algae and microbes probably contributed significantly to this effect. By exploiting endogenously produced microbes and associated detritus, shrimp farmers and feed manufacturers can substantially reduce vitamin levels in shrimp feeds (Moss, Forster and Tacon, 2006). In addition, farmers regularly supplement their feeds with digestive enzymes (e.g. proteases, amylases, cellulases and lipases) in an attempt to enhance feed digestibility (Table 10).

TABLE 10
Summary of feed supplementation in whiteleg shrimp feed in Viet Nam

Supplemented Nutrients	Composition	First month	Second month	Third Month
Vitamin C	Ascorbic acid 10%	3–5 g/kg feed 1–2 times/day	2–3 kg/feed 1 time/day	2–3 kg/feed 1 time/day
Nutrients/additives	Sorbitol, lysine, methionine, vitamin B	3–5 ml/kg feed 1–2 times/day	2–3 ml/kg feed 1 time/day	NA
Premixes	Minerals and vitamins	2–3 g/kg feed 1–2 times/day	2–3 g/kg feed 1–2 times/day	2–3 g/kg feed 1–2 times/day
Enzyme mixtures	Proteases, amylases, cellulases, lipases	2–3 g/kg feed 1–2 times/day	2–3 g/kg feed 1–2 times/day	2–3 g/kg feed 1–2 times/day

Source: Field survey (2010).

3.4 Disease management

If a disease should occur within 60 days of stocking, farmers often use chlorine to eradicate the disease and kill the shrimp. This is a preventative measure that is designed to restrict the spread of the disease. If the disease outbreak occurs on the farm after 60 days from stocking, farmers undertake an emergency harvest. In an attempt to resolve disease issues, some farmers reported supplementing their feeds with antibiotics (Norfloxacine or Cyproxacin). The success rate of this strategy was reported to be very low.

3.5 Pond fertilization protocols

The practice of using fertilisers in the preparation of the culture ponds and to stimulate natural productivity is not commonly applied to WLS culture. Only 17.5 percent of farmers reported using fertilizers to prepare ponds, and only 3 percent reported applying fertilizers during the grow-out period. There was no appreciable difference in the use of fertilizers between the farmers in Central and South Viet Nam (Table 11).

TABLE 11
The use of fertilizers during pond preparation and during the grow-out phase

	Central Viet Nam (% use)	Southern Viet Nam (% use)	Average (% use)
Pond preparation			
No fertilizer use	82.46	82.50	82.48
Fertilizer use	17.54	17.50	17.52
Grow-out			
No fertilizer use	96.49	97.50	97.00
Fertilizer use	3.51	2.50	3.00

Source: Field survey (2010).

Of those farmers that do apply fertilizers during the pond preparation phase of production, poultry litter (organic fertilizer) and urea or NPK (Nitrogen, Phosphorus and Potassium) are applied (Table 12). Fertilizers are not applied during the grow-out phase; however, chemicals are applied at different dosages during both production phases (Table 12). The combination of high protein feeds and the intensification of the production systems cause large amounts of nutrients to be released into the water during the grow-out phase. The accumulation of these nutrients can cause the shrimp pond waters to become eutrophic. In order to limit nutrient concentrations in the production ponds during grow-out, pond fertilization is not undertaken. In contrast, farmers use large amounts of lime during both pond preparation and grow-out. The farmers in Southern Viet Nam use lime at a higher dosage than the farmers in Central

Viet Nam. This is due to soil acidity in Southern Viet Nam, and the need to increase the pH of the production ponds. Dolomite is often applied during grow-out and pond preparation, with Zeolite being used to reduce ammonia levels in the grow-out stage.

TABLE 12
Fertilizers and chemical usage in whiteleg shrimp farming in Central and Southern Viet Nam

Duration	Fertilization		Chemicals		
	Poultry litter (kg/1 000 m²)	Urea, NPK (kg/1 000 m²)	Lime (kg/1 000 m²)	Zeolite (kg/1 000 m²)	Dolomite (kg/1 000 m²)
Central Viet Nam					
Pond preparation	13–36	2–4	20–150	-	6–40
Grow-out	-	-	300–400	20–50	150–200
Southern Viet Nam					
Pond preparation	10–20	5–15	150–200	-	6–40
Grow-out	-	-	500–600	20–30	100–150

Source: Field survey (2010).

3.6 Stocking densities and feeding practices

In comparison with tiger shrimp farming, the stocking densities applied to WLS farming are usually higher. Seventy five percent of farmers in Central Viet Nam stocked at densities between 100 to 200 PL/m², with 12 percent stocking at rates above 200 PL/m². In contrast, farmers in Southern Viet Nam usually stocked at lower densities, with 80 percent of farmers reporting stocking rates of less than 100 PL/m² and none stocking at densities higher than 200 PL/m² (Table 13). The lower stocking rates recorded in Southern Viet Nam are probably attributable to the soil structure and muddy pond bottoms associated with this region, which reduce the suitability for higher density culture.

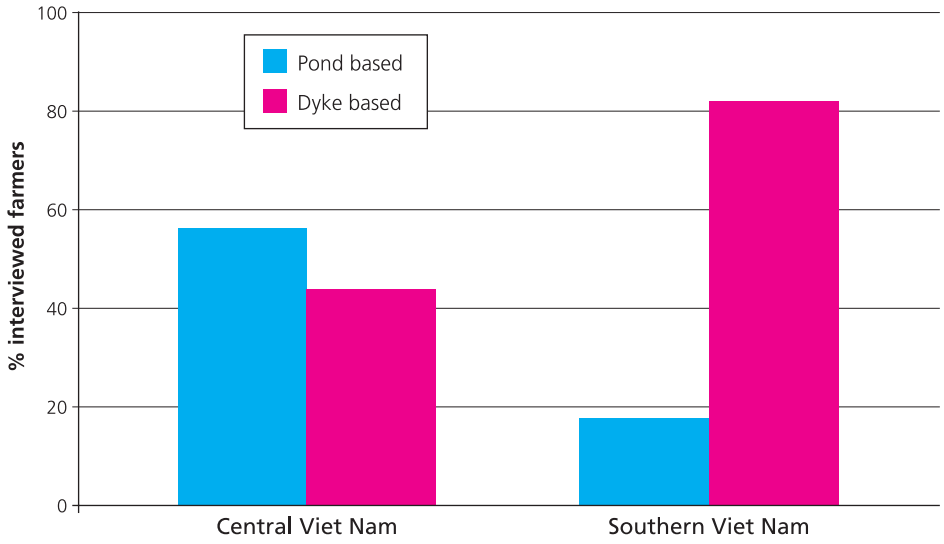
The practice of stocking at higher densities in Central Viet Nam was associated with a longer production cycle. Indeed, 60 percent of farmers in Central Viet Nam reported a grow-out period in excess of 80 days. In contrast, 62.5 percent of farmers in Southern Viet Nam reported grow-out periods of less than 80 days, and no farmers reported grow-out periods in excess of 100 days (Table 13). With respect to the size of the shrimp at harvest, there were few appreciable regional differences between the harvest sizes. The exceptions were that in Central Viet Nam, 21 percent and 43.9 percent of the crop was below 10 g and between 10-12 g respectively, while in the South, these figures were 7.5 percent and 60 percent respectively.

TABLE 13
Regional differences between stocking densities, culture duration and sizes at harvest

Stocking density (shrimp per m²)	Central Viet Nam (%)	Southern Viet Nam (%)
<100	12.3	80.0
100–200	75.4	20.0
>200	12.3	0.0
Culture duration		
<80 days	40.3	62.5
80–100 days	50.9	37.5
>100 days	8.8	0.0
Shrimp size (g)		
>12 g	35.1	32.5
10–12 g	43.9	60.0
<10 g	21.0	7.5

Source: Field survey (2010).

FIGURE 5
Feed management – feed distribution patterns (feed *in situ* in ponds vs. feeding from dykes)



Source: Field survey (2010).

Farm feeding practices are presented in Figure 5. Broadcast feeding is either undertaken from a boat or raft or *in situ* in the pond (Figure 6). To ensure a uniform distribution of the feed, wires are placed parallel to the pond dykes and feeding is undertaken along these lines (Figures 7 and 8). Alternatively, feeding is undertaken from the pond dykes. In Central Viet Nam, 56 percent of farmers employ pond based feeding practices as compared to just 18 percent in Southern Viet Nam where the majority of farmers distributed feed from the dikes. The reasons for this were the small surface area of the shrimp ponds as well as the higher stocking densities.

Feeding frequency is presented in Table 14. The majority of farmers (±60 percent) feed four times a day for the first 30 days post stocking. After thirty days post stocking, the majority of the farmers (89.5 percent) in Central Viet Nam reduced their

FIGURE 6
Feeding in situ

COURTESY OF FAO/L.T. HUNG.

FIGURE 7
A shrimp pond with feeding lines to ensure uniform distribution of the feed

COURTESY OF FAO/L.T. HUNG.

FIGURE 8
Distribution of feed along a feed line using a boat

COURTESY OF FAO/L.T. HUNG.

feeding schedules to three times per day. In contrast in the South, the majority of farmers (72.5 percent) maintained feeding at 4 times a day during this period. The pellet size, feeding frequency and feeding rate data is summarised in Table 15 and provides an indication of the pellet sizes used, feeding frequency and feeding rates that are applied.

TABLE 14
Feed management: feeding schedules

Feeding schedules (feeds/day)	Central Viet Nam (% of farmers)		Southern Viet Nam (% of farmers)	
	30 days	After 30 days	Before 30 days	After 30 days
2	5.2	-	-	-
3	31.6	89.5	40.0	27.5
4	63.2	8.8	60.0	72.5
5	-	1.7	-	-

Source: Field survey (2010).

TABLE 15
Feed management – pellet size, feeding frequency and feeding rates.

Duration (months)	Shrimp size (g)	Feed type (cm)	Feeding (frequency/day)	Feeding rate (% body weight)
1	1–4	Ø 1.2 L: 2–4	4	7–8
2	5–8	Ø 1.4 L: 2–4	3–4	5–6
3	9–102	Ø 1.7 L: 2–4	3	3–4

Ø = feed diameter; L: feed length.
Source: Data summarized from survey.

On the establishment of a new cluster of shrimp farms, a feed shop would normally be built in the vicinity to supply the farmers with feeds, chemicals, fertilizers and any other supplies that may be required. The survey showed that most farms (88–98 percent) in both Central and Southern Viet Nam usually bought feed within a radius of 10 km of their farms (Table 16). The distance from the farm to the feed shop

and the topography of the region has an influence on the type of transport that is used to collect the feed. In Southern Viet Nam, farmers often used motorbikes to carry their feed while farmers in Central Viet Nam used several alternative forms of transport. Coaches (suitable for use on sand e.g. beach access) were only used in Central Viet Nam.

TABLE 16
Feed availability and transportation in Central and Southern Viet Nam

Distance between farm and feed shop (km)	Central Viet Nam (%)	Southern Viet Nam (%)
≤10 km	87.7	97.5
10 – ≤20 km	3.5	0.0
>20 km	8.8	2.5
Vehicle		
Lorry	40.4	25.0
Motorbike	36.8	75.0
Coach	22.8	0.0
Feed storage		
Storehouse	17.5	47.5
House	82.5	52.5

Source: Field survey (2010).

The storage of feed is an important issue since feed quality rapidly deteriorates if not stored in an appropriate manner. Depending upon their living conditions, farmers usually store feed in a storehouse or at their own houses (Figure 9). In Central Viet Nam, where the majority of shrimp ponds have been built along the beach, 83 percent of the farmers have built temporary houses in which to live and store their feed. In contrast, in Southern Viet Nam approximately half the farmers use a dedicated storehouse with the remainder storing feed at their homes (Table 16).

FIGURE 9
A typical feed store in central Viet Nam

COURTESY OF FAO/L.T. HUNG.

3.7 Efficiency of feed use and shrimp yields

The majority of farmers (79.9 percent) attain feed conversion ratios (FCR) between 1.0:1 and 1.2:1 (Table 17).

TABLE 17
Regional differences between feed conversion ratios and shrimp yields

Feed conversion ratio (FCR)	Central Viet Nam (% of farmers)	Southern Viet Nam (% of farmers)	Average (% of farmers)
1.0:1 – 1.1:1	38.6	45.0	41.8
1.1:1 – 1.2:1	38.6	37.5	38.1
higher than 1.2:1	22.8	17.5	20.1
Shrimp yield (tonnes/ha/crop)			
<10	15.8	97.5	56.7
10–20	56.1	2.5	29.3
>20	28.1	0.0	14.0

Source: Field survey (2010).

Farming yields in Central Viet Nam were higher than those recorded from Southern Viet Nam. The majority of farmers (84.2 percent) in Central Viet Nam recorded yields of 10 to 20 tonnes/ha/crop or more. In contrast, the majority of the farmers (97.5 percent) in the South reported yields of less than 10 tonnes/ha/crop. Clearly, the high stocking densities reported in Central Viet Nam (Table 13) accounted for these high yields. In addition, farmers in Central Viet Nam often locate their shrimp ponds along the beach, which facilitates water exchange rates of 5 to 10 percent of pond volume per day. In contrast, farmers in Southern Viet Nam often site their ponds far from the coast to minimize water exchange in order to reduce viral disease transmission through the water supply. As a result of higher water exchange rates in Central Viet Nam, higher stocking densities are feasible and higher yields are attained.

A comparison between the WLS farming practices in Thailand (Wyban, 2007) and Viet Nam (Table 18) suggests that while the stocking densities used in Central Viet Nam are similar to those that are used in Thailand (100–200 PL/m^2), the grow-out period in Viet Nam is shorter. As a result, the harvest size of shrimp from Central Viet Nam is smaller than in Thailand. Furthermore, farming practices in Central Viet Nam and Thailand are more intensive, produce greater yields and require longer grow-out periods than those applied to Southern Viet Nam.

TABLE 18
Comparative production parameters of WLS farming in Thailand and Viet Nam

Production parameters	Thailand[a]	Central Viet Nam	Southern Viet Nam
Density (PL/m^2)	120–200	100–200	<100
Crop duration (days)	105–120	80–100	<80
Harvest size (g)	21–25	10–12	12
Yield (tonnes/ha/crop)	24	10–20	<10

Sources: [a]Wyban (2007); Field survey (2010).

3.8 Cost-benefit analysis

Production costs in Central Viet Nam are US$32 007 per crop/ha, and are appreciably higher than those in Southern Viet Nam where they are US$16 460 per crop/ha (Table 19). The discrepancy in production costs is due to the higher stocking densities that are used in Central Viet Nam. Feed costs represent the single highest production

cost and account for 66–68 percent of total costs. Shrimp seed represented the second highest production cost accounting for 8.9–11.5 percent. The third highest production costs were for the fuel and electricity that were required for pond aeration and water exchange; these costs accounted for 8.4 percent of the production costs. Labour costs occupied a very small component of the production costs (~2 percent).

The total gross revenues and net returns per hectare per crop from farming in Central and Southern Viet Nam were US$54 000 and US$21 993, and US$28 737 and US$12 777 respectively. The benefit-cost ratios for WLS farming in Central and Southern Viet Nam were 0.69 and 0.75, respectively.

TABLE 19
Cost benefit analysis of WLS farming in Central and Southern Viet Nam

Production cost	Central Viet Nam		Southern Viet Nam	
	(US$/ha/crop)	(% total cost)	(US$/ha/crop)	(% total cost)
Variable costs				
Seed	2 832.26	8.85	1 890.58	11.49
Shrimp feed	21 921.96	68.49	10 893.74	66.18
Chemicals and drugs	1 961.77	6.13	1 095.54	6.66
Electricity and fuel	2 705.10	8.45	1 380.02	8.38
Harvesting cost	300.88	0.94	43.33	0.26
Pond preparation	448.27	1.40	261.60	1.59
Labour	623.46	1.95	336.26	2.04
Total variable costs	30 793.70	96.21	15 901.07	96.61
Fixed costs				**0.00**
Land use cost	342.06	1.07	15.04	0.09
Depreciation	871.62	2.72	543.48	3.30
Total fixed cost	1 213.68	3.79	558.52	3.39
Total production cost	32 007.38	100.00	16 459.59	100.00
Net yield (tonnes/ha)	17.1		9.1	
Production cost (US$/kg shrimp)	1.87		1.81	
Total gross revenues	54 000.00		28 736.84	
Net returns	21 992.62		12 277.24	
Benefit-cost ratio	**0.69**		**0.75**	

Source: Field survey (2010).

The production costs associated with WLS farming in Thailand are approximately double those of Central Viet Nam and triple those of Southern Viet Nam (Table 20). The higher stocking densities and longer culture periods that are applied in Thailand account for these differences. In addition, the gross revenues and net returns of farming in Thailand are very much higher than those attained in Viet Nam. However, the benefit-cost ratio of shrimp farming in Thailand is lower than in Viet Nam. Intensive farming usually results in a higher net returns per ha per crop while the benefit-cost ratio shows the opposite.

TABLE 20
Comparison of cost/benefit ratios and production costs in WLS farming in Viet Nam and Thailand

Parameters	Central Viet Nam	Southern Viet Nam	Thailand[1]
Total production cost (US$/ha/crop)	32 007	16 460	60 000
Total gross revenues (US$/ha/crop)	54 000	28 736	96 000
Net returns (US$/ha/crop)	21 992	12 277	36 000
Benefit-cost ratio	0.69	0.75	0.60

Source: Field survey (2010); [1]Wyban (2007).

4. CONCLUSION AND RECOMMENDATIONS

WLS farming represents a relatively new farming activity in Viet Nam. Over the past few years, there has been a rapid expansion of the sector, especially in the South, and in response to the removal of the Government ban on farming this species. While farmers have adopted new culture techniques that are appropriate to the species, some farmers still use culture techniques and feeds that were designed to be used for tiger shrimp culture. The survey revealed that the farmers in Central Viet Nam have more experience culturing the species than those in the South of the country, and that different culture technologies are used in both regions. This is primarily a response to regional differences in the bottom structure and topography of shrimp ponds. Shrimp ponds in the Central region are often small with sandy substrates while in the South ponds are usually larger with muddy substrates.

Farmers almost always use manufactured compound aquafeeds, and very few utilize supplemental feeds such as trash fish, small shrimp, or used fertilizers to enhance the natural productivity of the culture systems. The compound aquafeeds that were used had a protein content of 36–42 percent. The protein content of these feeds is higher than that required by the species; this was attributed to farmers using feeds that were designed for tiger shrimp. Feed conversion ratios (FCR) varied between 1.1:1 and 1.2:1.

Farmers stocked at densities up to 100 to 200 shrimp/m^2. Farmers in Central Viet Nam often stocked at a higher density than those in the south of the country. In the central region, the culture duration was longer, size at harvest smaller, and production cost per kg shrimp higher. Typically, farmers feed between 3 to 4 times per day during 30 days post-stocking, and reduce this to 3 times per day thereafter.

The production cost analysis indicated that feed costs accounted for between 66 to 68 percent of total production costs, and that production costs per unit varied between US$1.81 to 1.87/kg shrimp. At these production costs, farmers could be profitable if they attained farm gate prices of US$2.0 to 2.2/kg. However, WLS farmers use high protein feed pellets (which are designed for tiger shrimp), often in the belief that the high stocking densities used in WLS farming make their use desirable. In addition, the norm for WLS feed (Table 8) also indicated the protein levels in the finisher diets should be 32 to 34 percent crude protein; therefore, feed mills need to produce finisher feeds specifically for WLS with lower protein levels. Government extension agents need to be trained to assist farmers to recognise that reducing the use of diets with unnecessarily high protein levels would reduce feed costs and increase profitability.

Although WLS farming represents a relatively new farming practice in Viet Nam, diseases have already impacted production in some areas of the country, potentially negatively affecting the sustainability of the sector. In 2005, a study in Ben Tre province (Mekong delta) showed that a viral disease outbreak had spread to 1 190 ha of shrimp ponds and, by 2006, the area affected had increased to 1 259 ha (Kang, 2008). At present

there is considerable information pertaining to WLS viral disease outbreaks in the media (Vietnamnet, 2009).

Many farmers that previously suffered from the viral disease outbreaks that affected the tiger shrimp sub-sector have now started to farm WLS. While these farmers have benefited from the change in species, uncontrolled seed production and poor water resource management could potentially result in similar disease outbreaks in WLS farming. In order to mitigate this risk, the government should encourage the importation of SPF broodstock from Hawaii, and strictly control the illegal importation of uncontrolled broodstock from China – even though there is currently no ban on imported broodstock from China. In parallel, the government should provide support to farmers to apply Good Aquaculture Practices (GAP) to reduce the impact of disease transmission and to protect the environment.

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ANNEX 1

Feed composition and feeding schedule for whiteleg shrimp of the Uni-President Company

Feed code	N310	N311	N312	N312A	N313	N314	N315	N316
Crude protein (%)	42	40	40	40	40	37	37	36
Crude lipid (%)	4	4	4	4	4	5	5	5
Fibre (%)	3	3	3	3	3	4	4	4
Ash (%)	13	13	13	13	13	13	13	13
Moisture (%)	11	11	11	11	11	11	11	11
Growing stage	PL10–15	PL15–25	PL25–1g	PL25–1g	1–3g	3–7g	7–15g	>15 g
Feeding rate (% body weight)	25–30	20–25	15–20	15–20	10–15	5–10	3–5	<3
Feeding frequency (times/day)	4–6	4	4	4	4	4	4–5	4–5
Size of feed (cm)	40# Ø	18–40#	14–18#	Ø 1.2; L2–4	Ø 1.4; L2–4	Ø 1.7; L2–4	Ø 2.0; L3–5	Ø 2.0; L3–5

Notes: # = mesh size: 40 # = 0.42 mm; 18–40# = 0.42–1.0 mm; 14–18# = 1.0–1.41 mm Ø: diameter (cm); L = length.

ANNEX 2

Aquafeed feed type and retail price of feed from different companies in Viet Nam (2010)

Name of Manufacturer	Type of aquafeed							
	Product type	**Y110**	**Y111**	**Y112**	**Y113**	**Y114**	**Y115**	
Tongwei	Protein (%)	40	40	38	38	36	36	
	Price US$/kg	1.08	1.07	1.06	1.06	1.05	1.05	
Grobest	Product type	1	2	2M	2ML	2L	3	4
	Protein (%)	40	40	40	39	39	39	39
	Price US$/kg	1.06	1.05	1.05	1.04	1.04	1.03	1.02
Tomboy	Product type	No 1	No 2	No 2L	No 2P	No 3	No 4	No 5	No 6
	Protein (%)	40	40	40	40	38	38	37	36
	Price US$/kg	1.10	1.09	1.09	1.09	1.08	1.07	1.06	1.06
Uni-President	Product type	N310	N311	N312	N312A	N313	N314	N315	N316
	Protein (%)	42	40	40	40	40	37	37	36
	Price US$/kg	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03
CP	Product type	7700	7701	7702	7703	7703P	7704S	7704	
	Protein (%)	40	40	40	40	38	38	36	
	Price US$/kg	1.06	1.06	1.06	1.05	1.04	1.03	1.03	