PRODUCTION PERFORMANCE, DISEASES, SPF-BREEDING AND RISK ISSUES CONCERNING WHITE SHRIMP, *Penaeus vannamei*, INTRODUCTION INTO INDONESIA

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ABSTRACT

In Indonesia, the main farmed species is rapidly switching from black tiger shrimp, *Penaeus monodon*, to Pacific white shrimp, *Penaeus vannamei*. This changeover started in East Jawa and Bali in the late 1999s with imported *P.vanammei* broodstock and post larvae (PL) from Taiwan which were originally from Hawaii, and is now in full swing in Indonesia. However, major mortality in ponds stocked in 2002 were confirmed as the results of TSV infection and since 2003 onward most of mortality caused by both TSV and WSSV infection. Most of the affected farms were stocked with PL produced from pond reared broodstock that were not SPF. At present, with better understanding of biosecure, *P.vanammei* are widely cultured with production performance of 10.1-23.4 mt/ha, size 15.1-18.2 g in 90-110 days. Survival rate of 75-90 % with FCR of 1.1-1.4:1. It is driven by *P.vannamei's* faster growth, high yields, and lower production costs compared to recent results with *P.monodon*. SPF broodstock have to be produce though selective breeding and challenge with deferent strains of viruses followed by strict biosecure. Little is known about the main risk of this shrimp to native shrimps when escape to the wild

KEYWORD: production performance, diseases, white shrimp

INTRODUCTION

Pacific white shrimp, *Penaeus vannamei*, is native to the Pacific coast of Mexico and Central-South America as far south as Peru, in areas where water temperatures are normally over 20 °C throughout the year (Rosenberry, 2002). In late 1970's *P. vannamei* were transferred from natural range on the Pacific coast of Latin America to Peru. From Peru they were introduce to United state of America and Hawaii, and to the Eastern Pacific coast from Carolina, and Texas in the north through Mexico, Nicaragua, Colombia, Venezuela and Brazil. Most of these countries now have established aquaculture of *P. vannamei*.

Introduction of P. *vannamei* to Asia began in 1988, when it was introduced to the Philippines and Mainland of China from Texas, but seed production was not successful. In 1996 was the first time of commercial shipment of Specific Pathogen Free (SPF) P. vannamei broodstock from Hawaii to Taiwan. Initial success with the maturation, larval rearing and culture of this species in Taiwan led to a huge demand for broodstock. Initial production of 12 mt/ha of 12-15 g shrimp in 75 were reported (Wyban, 2002). After Taiwan, Mainland China began importing SPF broodstock of *P. vannamei* from Hawaii in 1998. Similar early successes led to huge import of broodstock both SPF from Hawaii and non-SPF from Taiwan, throughout 1999.

P.vannamei was first imported to Bali and East Jawa as broodstock and post larvae in 1999/2000. There are many reasons for the introduction of *P. vannamei* as alien species; to Indonesia. Current status of culture performance, occurrence of diseases breeding of SPF and the possible risk of introduction are discuss in this paper.

PRODUCTION PERFORMANCE OF *P. vannamei*

P. vannamei was experimentally introduced to East Jawa and Bali in late 1999. SPF of post larvae-10 (PL-10) imported from

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Hawaii were reared using facilities of SAA shrimp pond. At first, successful research trial produced yield of 10.1-15.4 mt/ha, with size of shrimp reaching 14.9-17.8 g in 92-96 days, Survival rate of 80.2-90.1 % and feed conversion ratios (FCR) were 1.1-1.2:1. (Sugama, 2000). Promising results in the first trial led to further development in private shrimp farms with various culture systems such as semi-lined or unlined ponds with close and bacterial floc systems.

At present, under commercial condition, typical growth rate of 0.14-0.18 g/d with 75-90 % survival are common in Indonesia with stocking density of 60-150 ind./m^2 (Kopot and Taw, 2004). Production performance for *P. vannamei* and *P. monodon* are presented in Table 1. The data were collected from shrimp ponds located in Lampung and East Jawa Provinces.

In the field observation *P.vannamei* are amenable to culture at a very high stocking densities of up to 150 ind./m^2 in semi-lined earthen pond, and even as high as 400 ind./ m2 in controlled recirculated tank culture. *P. vannamei* tolerates a wide range of salinities, from 0.5-45 ppt, is comfortable at 7-34 ppt, but grows particularly at low salinities of around 10-15 ppt (Wyban and Sweeny, 1991). This ability makes it a good candidate for the newer inland farms (freshwater pond) that have become common in Mainland of China and Thailand.

P. vannamei tolerate a wide range of water temperatures, it grows best between 23-30 °C, with the optimum for growth being 30 °C for small shrimp (1 g) and 27 °C for larger (size more than 12 g). This shrimp also tolerate temperatures down to 15 °C and up to 33 °C without problem, but reduced growth rates (Wyband and Sweeny, 1991; Rosenberry, 2002). The shrimp can thus be profitably cultured during the cool season in Indonesia (July to September). This greater temperature tolerance of *P. vannamei* may also be a reason why farmer have perceived this species to be more resistant to White Spot Syndrome Virus (WSSV) relative to *P. monodon*. However recent experience in Indonesia has shown that when water temperatures declined to less than 25 °C, increase problem with viral diseases such as White Spot Syndrome Virus (WSSV) and Taura Syndrome Virus (TSV).

According to Dean Akiyama (per. com.), *P. vannamei* requires a lower protein in diet (28-32 %) compared with *P. monodon* and other species of *Penaeid* shrimp (38-42%). Taw *et. al.* (2002) reported that shrimp pond culture in Lampung have shown that *P.vannamei* growth, survival and production rates all slightly increase when fed by pellet of 30-32 % compared to 38-40 % protein diets in intensive culture (100 ind./m^2) and reduce pressure on fishmeal and fish oil requirement, hence cheaper of cost production. Detail nutritional composition of shrimp feeds are presented in Table 2.

P. vannamei HATCHERY

In Indonesia, most procedures for producing *P.vannamei* post larvae are similar to those being practicing in Hawaii. Hatchery operators quickly adopted the use of bloodworms for maturation diets, and most of hatcheries using live bloodworms gathered

Table 1. Performance of *Penaeus vannamei* and *Penaeus monodon* cultured in earthen ponds

Parameters	*Penaeus vannamei*	*Penaeus monodon*
Number of ponds sampled	20	10
Stocking density (ind./m^2)	60-150	40-60
Production (mt/ha)	10.1-23.4	2.5-4.2
Culture periods (days)	90-110	120-130
Average daily gain (gm/day)	0.14-0.18	0.20-0.24
Harvest size (gm)	15.1-18.2	20.2-25.3
Survival rate (%)	75-90	38-48
Food Conversion Ratio (FCR)	1.1-1.4	1.9-2.5

Table 2. Nutritional composition of shrimp feeds (Akiyama, 2005)

	Penaeus vannamei	*Penaeus monodon*
Protein (%)	28-30	38-40
Fat (%)	6-8	6-8
Fiber (maximum) (%)	4	3
Moisture (maximum) (%)	11	11
Calcium (%)	1.5-2.0	1.5-2.0
Phosphorus (%)	1.0-1.5	1.0-1.5

from local seashores close to the hatchery. *P. vannamei* is open thelycum species, meaning that they can be induced to mate and spawn easily in captivity, unlike the closed thelycum such as *P. monodon*.

In Hawaii, most of *P. vannamei* hatcheries kept males and females together in maturation tanks. Natural mating occurs shortly before a mature female is ready to spawn. Around sunset daily, mated female are transferred from the maturation tank to spawning tanks before they spawn. During the night, the female spawn and are returned to the maturation tank the following morning (Wyban, 2003). While, in Indonesia hatcheries kept males and females in separate tanks. Mature females are transferred in the afternoon into all-male mating tanks, where they quickly mate. After dark, the mated females are transferred to spawning tanks. Many hatchery operators claim this method results in higher mating frequency than mixed systems. Hatchery managers usually using 100 pairs of broodstock produce 2.0-2.5 million nauplii/day.

Hatchery operators use a variety of microalgae as shrimp diets, including *Skeletonema, Chaetoceros*, and other marine diatoms, while artemia nauplii are used in mysis and post larvae (PL) stages. Indonesian hatcheries typically fed more artificial diets during larval rearing than Hawaii hatcheries. Most of hatcheries sell PL-8 or PL 10. The two large *P. vannamei* hatcheries are located in Lampung Province and produced over 300,000 million PL/month while other 5 medium hatcheries located in East Jawa. Some hatcheries produce nauplii only and some produce both stages nauplii and PL.

The main problems for *P. vannamei* nauplii or PL production are availability of SPF broodstock. At this time SPF broodstock still depend on import, and the government only allows import SPF broodstock from Hawaii and Florida. Indonesia has enacted a decree permitting imports of alien animals including *P.vannamei* provided that the purpose is justified and an import certificate or a license to import is obtained from The Directorate of Aquaculture, The Ministry of Marine Affairs and Fisheries. Importation from Taiwan is not permitted. It is certain that *P. vannamei* is present in Indonesia and there have been outbreaks of TSV.

Viral diseases

In 2002, it is suspected that TSV first occurred in Banyuwangi and Situbondo before spreading to other districts, through movement of infected post larvae. In 2003, TSV has also been found from Maros (South Sulawesi Province) and Sumbawa Island (West Nusa Tenggara Province) all of the sample were confirmed by-PCR based methods (Isti Koesharyani per. com.) Table 3. Shows the spreading of viruses infected to *P.vannamei* culture through out Indonesia 2005-2006 (Tauhid *et.al.*, 2006; Supriyadi *et. al.*, 2006)

P. vannamei is generally considered to be more diseases resistant than other white shrimp, although it is in fact highly susceptible to WSSV and TSV can cause high mortality and a carrier of IHHNV results in runt deformity syndrome. Injection of WSSV into *P.vannamei* was shown to results 100% mortality within 2-4 days, proving its infectivity and pathogenicity was similar to *P. monodon* (Tapay et.al., 1997). TSV can cause significant loses in *P. vannamei* culture, and can be transmitted easily through insect or avian-vectors between pond, because of this, the use of SPF post larvae in pond culture could assist production.

Table 3. Viruses detected in pond cultured *P.vannamei* from various Provinces 2005-2006

Province	2005				2006			
	WSSV	TSV	IHHNV	IMNV	WSSV	TSV	IHHNV	IMNV
North Sumatra	-	+	-	-	+	-	-	-
Lampung	+	-	+	-	-	+	+	-
Banten	+	-	-	-	+	-	-	-
West Java	+	+	-	-	-	+	-	-
East Java	+	+	+	-	+	+	-	-
Bali	-	-	-	-	-	+	-	-
NTB (Lombok)	-	+	-	-	+	+	-	+
South Kalimantan	-	-	-	-	+	-	+	-
South Sulawesi	+	+	-	-	+	+	-	+

P. monodon are highly resistant to IHHNV, but do act as carrier, so farmer must be careful to avoid cultivating *P.monodon* together with *P.vannamei* in maturation tank, hatchery or grow-out facilities. It is believed that current declines in growth rate and survival of cultured *P. vannamei* in Indonesia are due to the stress of high IHHNV viral loading in the broodstock and the passing of these viruses to their offspring.

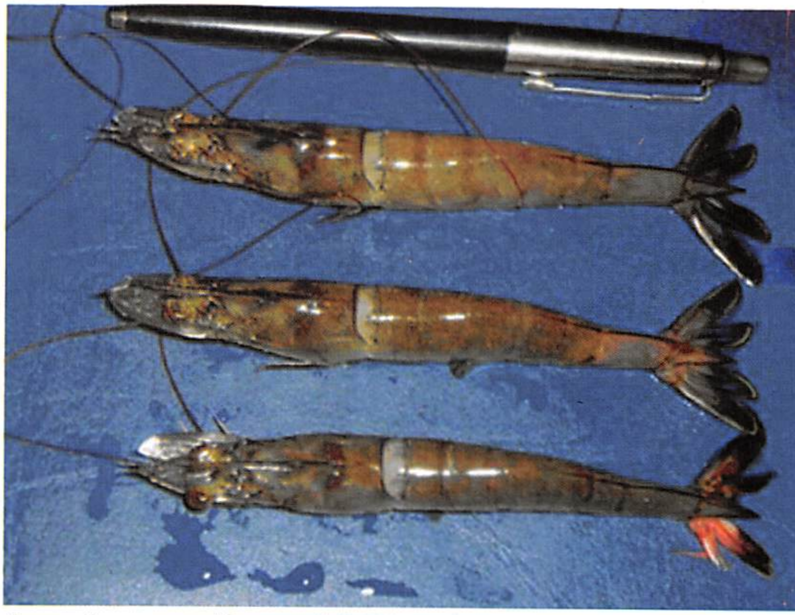
A recently (June 2006, by Purnomo and K.Sugama) discovered viral pathogen in *P. vannamei* from South Sulawei and Lombok, the clinical sign of infected shrimp very similar to Infectious Myonecrosis Virus (IMNV) found in Brazil 2003. The clinical sign of infected shrimp are part of body become reddish and white opaque (Figure 1). This virus may cause mortality up to 60% (Sunarto and Sugama, 2006)

SPECIFIC PATHOGEN FREE (SPF) PRODUCTION

In Indonesia there is significant confusion regarding the exact meaning of SPF. For instant, a widely held belief is that SPF shrimps are resistant to and cannot become infected by viral pathogens that they encounter during cultivation. This is certainly not the case. SPF means that the shrimps have been assured of being free from specific pathogens. SPF refer only to the present pathogen status for specific pathogens and not to pathogen resistance or future pathogen status (Lotz, 1997). SPF shrimps are those which are produced from biosecure facilities, have been repeatedly examines and found free specified pathogens using intensive surveillance protocols, and originate from broodstock developed with strict founder population development protocols. These founder populations are generated by extensive quarantine procedures that result in SFP-F1 generation derived from wild parents (Lotz, 1997). Only when raised and held under these conditions will produce true SPF stock.

Once the shrimps are removed from the SPF production facilities, they should no longer be referred to as SPF, even though they remain pathogen free. Once outside the SPF facility, the shrimp may be designated as High Health (HH) as they are now subject to a greater risk of infection. The primary goal of SPF is to produce strains of shrimp that are diseases free, domesticated and genetically improved for aquaculture.

Recent research work by Gondol Research Institute for Mariculture under supervisor of Central Research Institute for Aquaculture has focused effort on the development of SPF strains that are also resistant to specific pathogen. This is a long process, and focused on one pathogen at this time. Thus, although the development of pathogen resistant strains is long term goals of SPF breeding programmes, it is unlikely that they will ever results in strains that are unaffected by all diseases organism. One potential drawback of SPF shrimps is that they are only SPF for specific diseases for which they have been checked. Typically this will consist of the viral pathogen which are



Source: Purnomo and Sugama, K. (2006)

Figure 1.: *P. vannamei* infected by Infectious Myonecroses Virus (IMNV)

know to cause mortality to the shrimp culture including WSSV, TSV, IHHNV, IMNV, BPV and HPV. Thus, it is believed that SPF *P.vannamei* imported from Hawaii through Taiwan to Indonesia in 1999 was contaminated by TSV. This was because, at that time, TSV was not known Indonesia, therefore unchecked by proper protocols.

BREEDING OF *P. vannamei*

For Indonesia, when imported SPF *P.vannamei* stocks from other countries such as USA (Hawaii, Florida) and Ecuador to begin domestication programmes, is that such stocks may have been deliberately in-bred and consist entirely of siblings. This mean that next generations of shrimp based only on such lines will be probably become inbreeding within few generations. Such inbreeding has been noted in stock of *P.vannamei* being cultured in Gondol Research Institute for Mariculture (Haryanti. per.com)

There are many problems involved with the use of non-SPF broodstock. The first and foremost has already been discussed which is the possibility of importing novel pathogenic viruses and other diseases into new or clean areas. This has already been seen in East Jawa with the introduction of post larvae derived from pond cultured broodstock. The problem here is that non SPF shrimp tend to be cheaper and more easily available (pond reared broodstock in Indonesia currently sell for US$ 5-7, while SPF broodstock from Hawaii cost US$ 23-25) and are hence initially attractive, but may be long-term negative consequences. In addition, without strict checking of viruses, biosecurity and disinfection protocols for treating pond reared broodstock (non SPF), eggs and nauplii which are no aware by hatchery operators. Any pathogens infecting the broodstock tend to be passed to the larvae which increase the serious diseases problems during grow-out in ponds.

Problem in the breeding of SPF shrimp in Indonesia is that the imported SPF broodstock are almost certainly domesticated lines which have been selected for growth and diseases resistance over a long period (38-45 generations). This makes their use as founder population for genetic selection and domestication programmes undesirable. What we can do in order to avoid dependent of SPF broodstock from abroad, is that by selective breeding for increase growth rate and resistance to a variety of diseases. This work can be accomplished by challenging of fast growing shrimp from sub-lots of families and to a particular pathogen and then selecting the most fast growing and resistant families as broodstock for the next generation. Some recent work with SPF strains of *P. vannamei* challenged with different isolates of TSV has shown better survival rate either in laboratory or ponds (Clifford and Scura, 2005).

RISK OF INTRODUCING *P. vannamei*

Little is currently known about the effects of cultured shrimp on wild population and biodiversity. The fears are that alien cultured shrimp could escape to the wild and then either displace native shrimp population by out-competing them, interbreeding with them, or killing them through contamination with fatal pathogens such as viruses to which they are susceptible.

The escape P.vannamei from shrimp farm into the surrounding environment can be expected as a results accidental release during harvesting as well as mass escape during flooding event. Some release from hatcheries may also be expected unless comprehensive masers are taken to reduce escapes.

The main risk would be if competition occurs with native species where *P.vannamei* occupies the same ecological niche or in other ways cause competition for habitat or space, feed or adversely interfere with breeding with breeding behavior or breeding success. If *P. vannamei* occupies a vacant niche (which is unlikely), or the abundance of other shrimp species is limited by other factors, (which is possible), then P.vannamei has the potential to add to shrimp catches. However, if *P. vannamei* does not breed and become established in the wild any impacts re likely to be localized and limited in time.

P. vannamei is tolerant of a wide range of salinities, especially very low salinity. This means that the shrimp can be culture in both inland (freshwater) and coastal ponds. In Indonesia *P.vannamei* is commonly cultured in shrimp farms that previously produced *P. monodon*. Therefore, no significant new impacts on the habitats of coastal or agriculture areas are anticipated. Although there has been some expansion of *P.vannamei* into new farming areas, impact of such farming on the surrounding natural environment is not considered significant, provided adequate measure are taken.

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