魚病研究 **Fish Pathology, 51 (Special-issue), S60–S65, 2016**

Proceedings of 9th Symposium on Diseases in Asian Aquaculture

Effects of White Spot Disease and Bio-Security on Shrimp Farming in Bangladesh

Partho Pratim Debnath[1]*, Manjurul Karim[1], Hendrik Jan Keus[1], Chadag Vishnumurthy Mohan[2] and Ben Belton[1]

[1]*WorldFish, Bangladesh and South Asia Office, Banani, Dhaka, Bangladesh*
[2]*WorldFish, Batu Maung, Penang, Malaysia*

ABSTRACT—Shrimp (*Penaeus monodon*) culture accounts a large proportion of Bangladesh's aquaculture industry by value, and is the country's second largest source of export earnings. But it has encountered enormous problems due to the spread of diseases, particularly white spot disease (WSD), and has incurred significant economic losses as a result. The major factors encouraging WSD outbreaks are the production of post larvae (PL) using wild broodstock and traditional farming systems with poor farm level bio-security. Between 2005 and 2014 WorldFish tested broodstock, nauplii and PL from hatcheries in Bangladesh using polymerase chain reaction (PCR) technique, as part of a program to supply white spot syndrome virus (WSSV) free PLs to project farmers. A strong positive correlation (R = 0.743) was found among WSSV infected broodstock and WSSV infected nauplii, providing evidence of transmission of WSSV from mother to PL in hatcheries. On an average, every year almost 36.19% of hatchery produced PL was found to be WSSV positive considering positive nauplii batches from 2005 to 2014. This would be sufficient to contaminate almost the entire farming system, as 88% of farming area is under traditional farming practice. Developing commercial PCR testing facilities for ensuring supply of WSSV free seed and implementing farm level bio-security programs could reduce disease risks, improve farm productivity and contribute to country's economy.

Key words: WSSV, bio-security, shrimp farming, survival rate, Bangladesh

Shrimp farming in Bangladesh has expanded rapidly after 1980 due to huge international market demand and high export value. At this time, a big group of large companies in Cox's Bazar region were involved in establishing semi-intensive farms in Cox's Bazar in Southeast Bangladesh. Also a large area in Southwest Bangladesh (Khulna, Satkhira & Bagerhat) was used in shrimp farming, but most of this area was farmed extensively. From the beginning, only *Penaeus monodon* locally known as Bagda or tiger shrimp was cultured. Initially shrimp farming depended on shrimp post larvae (PL) collected from the wild, but after the initiation of semi-intensive culture systems the sector faced lack of sufficient PL supplies. This motivated both Government and private sector to begin development of shrimp hatcheries (Debnath *et al.*, 2015).

For meeting the PL demand for the expanding shrimp farming sector and develop the shrimp sector as an industry, the Government of Bangladesh established a hatchery in 1984 with the financial help of Asian Development Bank and successfully produced 0.2 million PL in 1988. After this time, the private sector entered the sector through the first private hatchery (Pioneer Hatchery) in 1993. This first successful venture was followed by rapid growth in the production of shrimp PL, and a total of 60 shrimp hatcheries were in operation in 2015.

In 1994, it is believed some farming groups imported shrimp PL to meet their huge demand for PL which could not be met from domestic production at that time. This is thought to have resulted in the first introduction of white spot syndrome virus (WSSV) into semi-intensive ponds in Cox's Bazar region. Some infected PL were also stocked by semi-intensive farmers in Satkhira region resulting in a catastrophic outbreak of white spot disease (WSD), which resulted all semi-intensive shrimp farms ceasing operation and switching to production of freshwater fish, the exit of all large companies from the sector, and expansion of small scale extensive shrimp farming (Karim *et al*., 2011).

With the growth of extensive shrimp farming, the area under culture expanded from 52,000 ha in 1988 to 213,617 ha in 2013 (DoF, 2014). However, every year large numbers of farmers face outbreaks of WSD which causes a huge reduction in the earning potential of the sector as a whole, and the country.

The Department of Fisheries and non-governmen-

* Corresponding author
E-mail: P.Debnath@cgiar.org

tal organizations have begun working to address this problem and identify possible solutions. Among these, one initiative funded by the United States Agency for International Development (USAID), called the Shrimp Quality Support Project (SQSP) was implemented by WorldFish Bangladesh from 2005 to 2007. Through this initiative, WorldFish started to work with shrimp farmers and shrimp hatcheries on the concept of better management practices (BMPs) for shrimp farming using polymerase chain reaction (PCR) tested WSSV free hatchery produced PL. Similar activities on a larger scale are presently implemented by WorldFish through its Aquaculture for Income and Nutrition (AIN) project.

Using working data and information on WSSV and bio-security collected through WorldFish's portfolio of projects, most importantly AIN, this paper identifies the major critical control points in the shrimp hatchery production and farming where WSSV infection can occur, provides estimates of the impact on shrimp production which could be achieved by improved management and bio-security, and identifies a number of interventions which could help to reduce the likelihood of WSSV infection and improve the sector's productivity and profitability.

Materials and Methods

The study was conducted through some project data of WorldFish from 2005 to 2014. Study was completed by using both primary and secondary data. All data of shrimp production was collected from database of Department of Fisheries, Bangladesh. All shrimp hatchery related data was used from working data of different WorldFish projects. Sample of broodstock and nauplii for WSSV test was collected from 20 shrimp hatcheries which were the partners of WorldFish projects. Information about bio-security was collected from own observation of one of the author of this study. WSSV test was done by following nested PCR method (IQ2000, Farming IntelliGene Tech. Corp.). Microsoft Excel and SPSS (Statistical Package for Social Science, Version 15) software were used to analyze the data. All data were tested for normality using a Shapiro-Wilk test. Since all data were found to be normally distributed, one way ANOVA was used to test for significant differences between means. To work out the average survival rate for the stocked PL for the industry as a whole, assumptions were made with respect to wild caught PL and also% contribution of freshwater prawn to the total shrimp production of the country. About 2 billion wild caught PL are stocked annually and this was added to hatchery produced PL for arriving at total PL stocked. Approximately 30% of the total shrimp production of the country is contributed by freshwater prawns. Hence the total production was reduced by 30% to arrive the total production of *P. monodon* in Bangladesh. Shrimp numbers were estimated assuming average harvest weight of 30 pieces/1 kg. Shrimp price was estimated by considering the average price for the last 4 years. For the years 2011, 2012, 2013 and 2014 the average prices in USD per ton of 30 count *P. monodon* were 5,000, 5,500, 6,875 & 8,860 respectively. For making projections average price of USD 6558.75/ton was considered[*1].

Results

Farming practice and production analysis reveals interesting insights into the shrimp farming sector of Bangladesh. Of the present total shrimp farming area, 87.77% is following extensive shrimp farming practices with average production of only 280–300 kg per hectare while 12% following improved traditional practices are attaining production levels of 600–700 kg/ha. Interestingly, only a very small percentage of the total area (0.23%) is under semi-intensive culture (also known as closed culture system) reaching production levels of 4–5 ton per hectare. Shrimp farming area as well as annual shrimp production (Table 1, Fig. 1) has been increasing almost consistently on a yearly basis.

In Bangladesh, shrimp farming is presently totally dependent on hatchery produced PL and the hatchery sector has enough production capacity to fulfill the farm demand (Fig. 2). But hatchery production is totally dependent on wild caught broodstock from Bay of Bengal. Our studies from 2005 to 2014, have very clearly shown that the WSSV infection rate of broodstock and nauplii is very high and is largely responsible for introducing infected PL into extensive and traditional farming systems (Table 2). Using one way ANOVA, a

Table 1. Shrimp culture area and production per unit area (Source: DoF)

Year	Shrimp culture area (ha)	Production (kg/ha)
1988	64,000	230*
1994	108,280	220*
1995	138,000	210*
1996	140,000	240*
2000	141,353	457*
2009	217,877	472*
2013	275,232	509*

* Production include all types of shrimp (shrimp, prawn and others) and all types of farming systems.

*1

$$\text{Survival rate} = \frac{\{\text{Yearly shrimp and prawn production} - (\text{total productions} \times 30\% \text{ parawn})\}\ \text{kg} \times 30}{(\text{Yearly total hatchery produced PL} + 2 \text{ billion wild caught PL})} \times 100$$

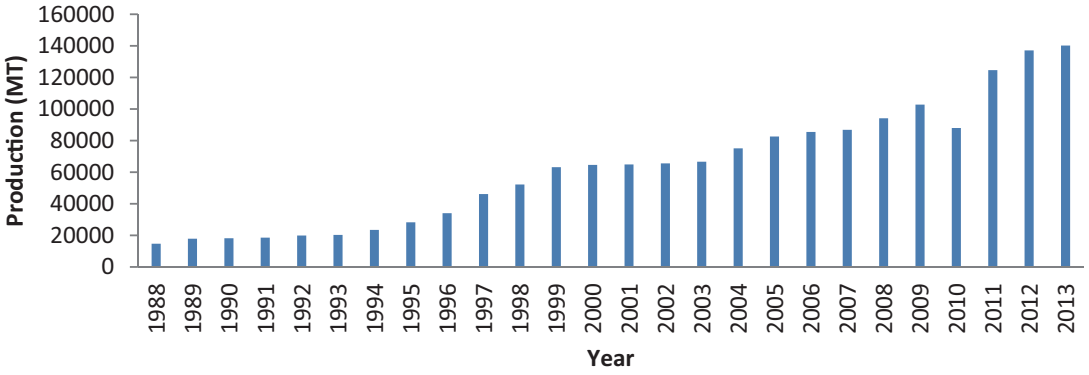

Fig. 1. Annual total shrimp production in Bangladesh.

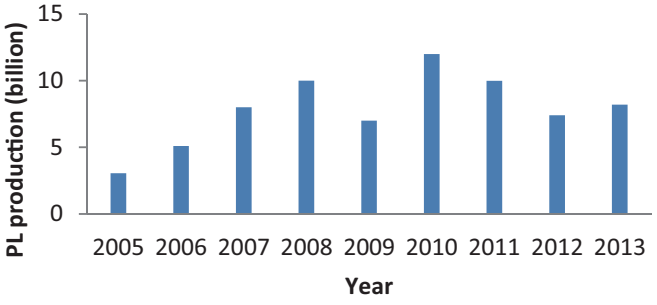

Fig. 2. Annual shrimp PL production in Bangladesh.

Table 2. Annual average percentage of WSSV positive broodstock and nauplii (Source: WorldFish Lab data)

Year	Average WSSV positive %	
	wild broodstock	nauplii
2005	34.98	23.14
2006	41.90	28.82
2007	40.80	35.76
2008	49.68	36.04
2009	45.43	36.19
2010	38.72	33.23
2011	33.38	32.12
2012	49.41	54.93
2013	55.47	51.63
2014	41.25	30.05

statistically significant difference was found (F (7, 64) = 15.374, $p < 0.001$) between the percentage of WSSV positive wild broodstock with month of broodstock collection. Interestingly, significant difference was also found (F (8, 63) = 3.7, $p < 0.001$) between percentage of WSSV positive in nauplii and year of broodstock collection, (F (7, 64) = 6.526, $p < 0.001$) and between percentage of WSSV positive in nauplii and month of broodstock collection. From the data it was observed that every year WSSV positive percentage in broodstock was high from April to June and a similar trend is reflected in the hatchery produced nauplii. Exceptionally high prevalence of WSSV was observed in broodstock and nauplii during the month of January in 2012 & 2013 (Figs. 3 & 4) and the reasons for this deviation are unclear. From the monthly WSSV infection data a clear picture of seasonal variation of WSSV prevalence in broodstock and nauplii was recognized (Figs. 3 & 4). A strong positive correlation (R = 0.743) was found among WSSV infected broodstock and WSSV infected nauplii, providing strong evidence of transmission (vertical and horizontal) of WSSV from mother to PL.

Closer examination of hatchery practices reveals the underlying reasons for high prevalence of WSSV in hatchery produced PL. Some of the key reasons include the practice of keeping all captured broodstock together for 10 to 12 hours in broodstock collection ship, using wild caught broodstock without any health screening for WSSV for breeding purpose inside the hatchery, holding broodstock together in maturation tanks, mass spawning and total larval rearing tank (LRT) management. From our data analysis between 2005 and 2014, it was found that on an average about 36.19% hatchery produced PL were infected with WSSV which was subsequently marketed to the farmers for stocking. Vertical/maternal and horizontal transmission of WSSV from the infected broodstock appeared to be the main source of PL contamination. Stocking of WSSV positive PL appears to play a vital role on WSD occurrence and spread in Bangladesh as 87% shrimp farms follow open traditional extensive farming systems with limited management interventions.

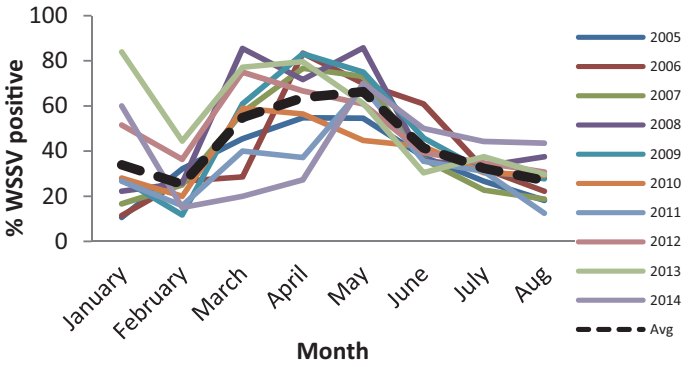

Fig. 3. Monthly positive percent of WSSV in wild broodstock (adapted from Debnath *et al*. (2015) to include 2014 data).

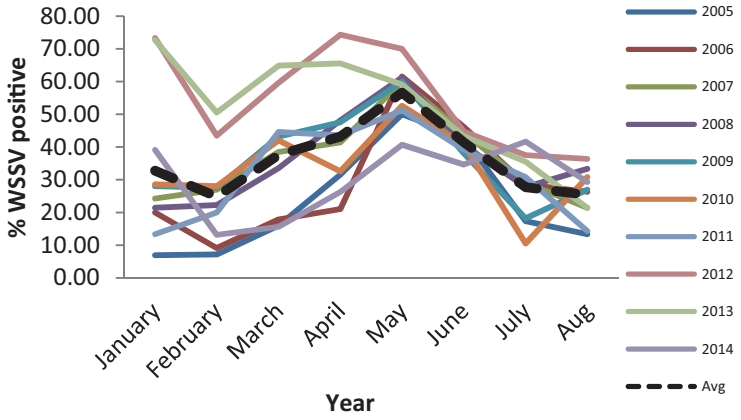

Fig. 4. Monthly positive percent of WSSV in nauplii (adapted from Debnath *et al*. (2015) to include 2014 data).

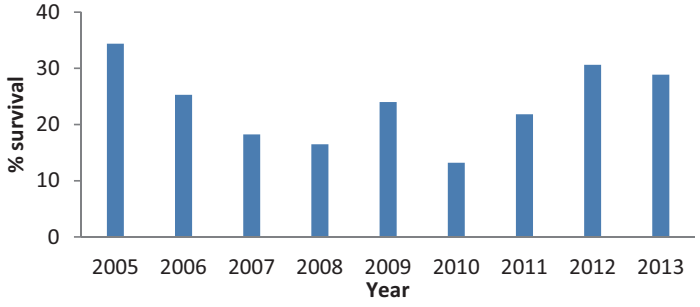

Fig. 5. Annual survival rate of stocked PL (Source: Calculated from DoF data).

From WorldFish project observations and data on shrimp farming over the years, it was found that extensive farms face WSD outbreaks almost regularly every year. The reasons for occurrence of WSD appears to be linked to the practice of multiple stocking of PL of known and unknown health status, no management of water exchange regimes resulting in exposure of stocked shrimp larvae to outside water including discharge water from disease affected ponds, very low water depth in ponds (sometimes not more than 1 to 2 feet), not following BMPs for pond preparation, no biosecurity maintenance and no health assessment during culture period.

Computing the total number of PL stocked by the farmer each year and total number of shrimp harvested it was found that on an average only 24% of the stocked PL survived up to final harvest size. Considering the total number of infected PL currently being stocked into traditional systems, WSD appears to be the major cause for this low survival rate. From Fig. 5 it was observed that there is slight improvement in the survival rate of stocked PL since 2010. Large scale capacity building and training activities by USAID funded AIN project implemented by WorldFish in cooperation with Department of Fisheries like exclusive training of 50,000 shrimp farmers on shrimp BMPs, different media

Table 3. Estimated shrimp production (ton) and earnings (USD) for every 10% increase in survival of stocked PL

Survival of stocked PL	Survival at 24%	Survival at 34%	Survival at 44%	Survival at 54%
Production (ton)	73,277	80,605	87,932	95,260
Earnings (million USD)	480.60	528.67	576.72	624.79

awareness programs (leaflet, village theater show, radio broadcasting, poster & billboard) on using PCR tested PL and ensuring supply of PCR tested WSSV free PL for the shrimp farmer appears to have contributed to this improved survival. Currently studies are underway to assess the outcomes of interventions in the form of supplying PCR tested WSSV free seed to extensive and traditional farmers.

Discussion

WSD is now endemic and is generally regarded as one of the most important constraints to the industry's sustainability and further expansion in Bangladesh (Karim *et al*., 2011). The findings presented here clearly illustrate the benefits that small farmers can get through adoption of simple better management practices and access to quality seed (WSSV free PL). Under the WorldFish program over 50,000 shrimp farmers got shrimp BMPs training from 2012 to 2013. Average production in 2013–2014 season increased from 270 kg to 402 kg/ha for farmers who received training from the AIN project. Also average production of demonstration ponds of AIN project with supplementary feeding reached 617 kg/ha.

On an average 36.19% of hatchery produced PL has been found to be infected with WSSV and therefore is a major reason for shrimp diseases outbreaks in Bangladesh. This large percentage of WSSV infection in PL could be minimized by applying some BMPs at the level of shrimp hatchery operations like following single mother in single tank system in breeding, use of only PCR tested WSSV free broodstock from wild caught broodstock, and keeping good bio-security to avoid any horizontal transmission of WSSV from infected broodstock to nauplii. There is evidence of WSSV infection in the reproductive tissue of male and female *P. monodon* (Lo *et al*., 1997; Mohan *et al*., 1997). Shrimp PL are considered as a major entry route for WSSV into culture pond (Limsuwan, 1997; Flegel and Alday Sanz, 1998; Mushiake *et al*., 1999).

We have tried to estimate the shrimp production that can be achieved for every 10% increase in PL survival from the present level of 24% survival. Increasing the survival by another 30% (average survival of 54% closer to the industry norm), through strong emphasis on stocking of only PCR tested PLs combined with BMPs and farm level bio-security, shrimp production may increase proportionately which could contribute to farmers' economy as well as country's economy by adding 144.19 million USD more (Table 3).

Shrimp culture is of central importance to the fisheries sector in Bangladesh. This sector earns a lot of export earnings but the area wise production is very low compared with other shrimp producing countries. This seems to be due to less use of shrimp farming area under semi intensive farming, less availability of good quality PL, lack of credit facilities and finally due to diseases, *e.g.* WSD. Ensuring access to WSSV free postlarvae combined with implementation of core BMPs at farm level will reduce disease risk, stimulate investment, leading to improved shrimp production and improved farmer livelihoods.

Acknowledgements

The authors would like to express their gratitude to the people who have been instrumental in the successful completion of this article; in particular, we would like to show our deep appreciation to Quazi AZM Kudrat-E-Kabir, project Manager, AIN project, WorldFish and Mr. Rayhan Sarwer, M & E manager, AIN project, WorldFish for their cordial support by providing shrimp farm production related data, Mr. Amitosh Sen, DFO, Cox's Bazar, DoF for his support to get all secondary data collected from DoF and Mr. Shamsul Hadi Khan, consultant, Harbour Aquaculture Consultancy Service Ltd, Cox's Bazar, Bangladesh for providing all types of hatchery production related information. This article is a contribution to the CGIAR Research Program on Livestock and Fish. This research was made possible through financial support provided by the U.S. Agency for International Development, for the USAID Feed the Future initiative's Aquaculture for Income and Nutrition project, implemented by WorldFish.

References

Debnath, P., S. H. Khan, M. Karim, B. Belton, C. V. Mohan and M. Phillips (2015): Review of the history, status and prospects of the black tiger shrimp (*Penaeus monodon*) hatchery sector in Bangladesh, *Reviews in Aquaculture* (in press), 1–13. DOI: 10.1111/raq.12094.

DOF (2014): Jatio Matshya Saptaha' 2014 (leaflet). Dhaka, Department of Fisheries, Bangladesh (In Bengali).

Flegel, T. W. and V. A. Sanz (1998): The crisis in Asian shrimp aquaculture current status and future needs. *J. Appl. Ichthyol.*, **14**, 269–273.

Karim, M., R. H. Sarwer, A. C. Brooks, R. Gregory, K. M. Jahan and B. Belton (2011): The incidence of suspected white

spot syndrome virus in semi intensive and extensive shrimp farms in Bangladesh: implications for management. *Aquac. Res.*, **43**, 1357–1371.

Limsuwan, C. (1997): Reducing the effects of white-spot baculo virus using PCR screening and stressors. *Newsl. Aquat. Anim. Health Res. Inst.*, **6**, 1–2.

Lo, C. F., C. H. Ho, C. H. Chen, K. F. Liu and Y. L. Chiu (1997): Detection and tissue tropism of white spot syndrome baculovirus (WSBV) in captured brooders of *Peneaus monodon* with special emphasis on reproductive organs. *Dis. Aquat. Org.*, **30**, 53–72.

Mohan, C. V., P. M. Sudha, K. M. Shankar and A. Hegde (1997): Vertical transmission of white spot baculo virus in shrimps-a possibility? *Curr. Sci.*, **73**, 109–110.

Mushiake, K., K. Shimizu, J. Satoh, K. Mori and M. Arimoto (1999): Control of penaeid acute viremia (PAV) in *Peneaus japonicus*: Selection of eggs based on the PCR detection of the causative virus (PRDV) from receptaculum seminis of spawned broodstock. *Fish Pathol.*, **34**, 203–207.