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Influence of current culture practices on disease outbreaks in shrimp farms located in North Western Province of Sri Lanka

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ABSTRACT

Shrimps have become the most important part of the global aquaculture farming and world food market. However, after the industry was severely affected by the White Spot Syndrome Virus, remedial measures that are in place have not completely eradicated the problem that is affecting the livelihood of shrimp farmers and other stakeholders. Therefore, the study was conducted with the objective of determination of farmer culture practices using an interviewer-administered pre-tested questionnaire (n= 100). Results revealed that the disease occurred first in the Karukupane area during the study period and of 5 zones affected where Zone 2 (Arachchikattuwa) was the worst affected area. It was noted that 57% of farmers who have disease affected farms aerated their ponds and around 77% of them used 50,000-100,000 per acre stocking density. 64% of the farms were located very near (<1m) to the other farms and 48% were infected with the disease after 60-90 days of culture. 95% of diseased shrimps were caught and sold by releasing water mainly to the Dutch canal where most farms which were used Dutch canal as their main water source affected with the disease. Disease occurrence had increased at an increasing rate and the introduction of best management practices is timely important.

INTRODUCTION

In recent years, shrimp aquaculture, has experienced spectacular growth in Sri Lanka. Shrimp farming was initiated in Sri Lanka during early 1980's by few multinational companies characterized by a slow period of development (**Jayasinghe, 1991**) and the black tiger shrimp, *Penaus monodon* is the main species cultured. The majority of grow out shrimp farms in Sri Lanka follows semi-intensive culture practice (**Cattermoul and Devendra, 2002**). The shrimp farming was done in 1,957 ponds in 667 farms in 2010 for export purpose and the production was 4430 Mt in 2013 (**MFARDRE, 2015**).

Narrow coastal belt of 120 km of Puttlam district in North Western province facilitates more than 90% of the shrimp farming in Sri Lanka (**Chandrarathne, 2005; Mahagamage and Jayakody, 2012**). Shrimp farming areas in the Putallam district are administratively divided by government into 34 subzones (**Munasinghe *et al.*, 2010**).
The shrimp industry in Sri Lanka can be divided into four components, post larvae production (hatchery), grow-out (shrimp farming), shrimp processing and shrimp feed manufacturing (**Senarath, 1998**).

Over the last decade there has been a rapid development of shrimp farms in North Western province of Sri Lanka, but this has been accompanied by environmental and disease problems which have led to the closing of some farms and loss of productivity in others (**Buford *et al.*, 2003**). In 1996 the industry was severely affected by *White spot syndrome virus* (WSSV) which has a wide host range among decapod crustaceans (**Lo *et al.*, 1996**).The epizootic is believed to have entered the country with the import of infected post larvae from India and Singapore (**NAQDA Country report, 2011**). However, Sri Lankan shrimp production is low due to frequent disease out breaks, anthropogenic and socio-economic factors (**Jayasinghe, 1997**).

Shrimp farms in North Western province are concentrated around Chilaw lagoon, Dutch canal, Mundal lagoon system and Puttlam lagoon with 70% of farms depending on Dutch canal for their water resources (**Jayasinghe, 1995**). Therefore, the present study was an attempt to identify the current culture practices in the North Western Province representing Puttlam district according to sub zonal variation and to identify farmers' knowledge about diseases and farming.

MATERIALS AND METHODS

Study Area:

This study was carried out in Puttlam district which is located in North Western Province. The district capital is Puttalam, which borders to Indian Ocean in the west, Ma Oya in the south, Kala Oya and Modaragam Aru in the north, Anuradhapura district and Kurunegala district in the east. Puttalam is prominent for its lagoons, popular for shallow water fishing and shrimp farming. According to National Aquaculture Development Authority (NAQDA), there are main five shrimp farming zones including the thirty two sub zones in the Puttlam district were studied (Fig. 1 and Table 1).

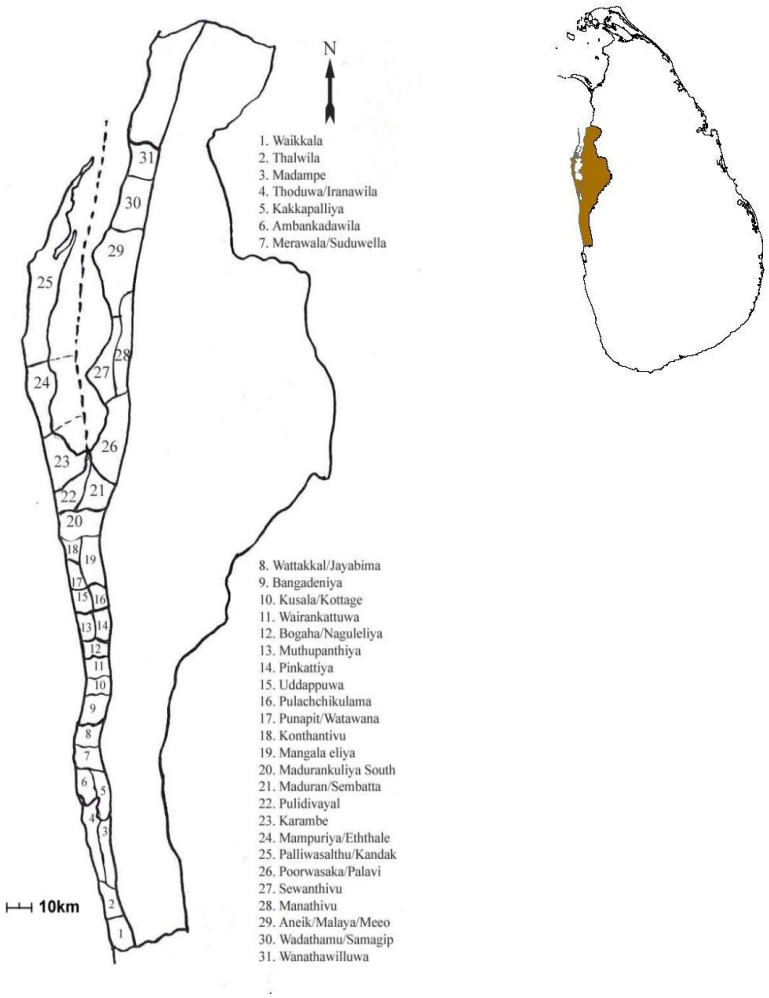

Figure 1: Thirty two sub zones in the Puttlam district (Source: **NAQDA 2011**).

Table 1: Shrimp farming zones and sub zones (Source: **NAQDA, 2011**)

Zone	Subzone
Zone 1	Thalwila
Chilaw	Madampe
	Thoduwawa/Iranawila
	Kakkapalliya
	Ambakandawila
	Marawala/Suduwella
	Wattakkalliya/Jayabima
Zone 2	Bangadeniya
Arachchikattuwa	Kusala/Kottage
	Wairankattuwa
	Bogahawetiya
	Nagul Eliya
	Muthupanthiya
	Pinkattiya
	Udappuwa
	Pulichchakulama
Zone 3	Punapitiya/Watawana
Mundal	Koththanthiv
	Mangala Eliya
	Madurankuliya south
	Madurankuliya/ Sembatta
	Pulidiwayal
Zone 4	Karamba
Kalpitiya	Mampuriya/Eththale/Palliwasathurai/Kiriyankaliya
Zone 5	Palaviya/Poorvasakuda
	Sewwanthivu
Puttalam	Manathivu
	Aneikutti/Malayamadu/ Mee Oya
	Wadathamunei/Samagipura
	Wanathawilluwa

Study design and data collection

A cross sectional and experimental study was conducted and data collection was done during 25th March to 29th September 2011.

Site selection

Shrimp farms which were affected with WSSV in all the 32 sub zones in the first season of shrimp farming in year 2011 were selected for the data collection. Farms were selected using snowball sampling system and based on the information from National Aquaculture Development Authority (NAQDA).

Data collection

Interviewer administered data collection was performed entirely throughout the study along with field visits for 100 shrimp farmers who got disease to shrimp farm. Almost all the data were collected from the owner of shrimp farm, sometimes information were provided by the farm manager or representative person. Data collection tools were

summarized in to a questionnaire which consisted of 7 sections ultimately. The format of data collection questionnaire was same for all shrimp farmers.

Section 1: Current culture diary

This section included the questions on; the day given by NAQDA for the farmer for farming in the respective area according to the crop calendar, actual start date of the farming by the farmer, extent (size) of the farm, former land type, number of inlets and outlets, prior to start practices, does farmer aerate the ponds, if it so how many paddle wheels are used, frequency of water exchange per cycle, time gap between water filling and stocking of post larvae, time gap between water stoking and filling to ponds and best color of the water for stocking and during culture period (a color chart was given to the farmer and then the best color was chosen by him).

Section 2: Post Larvae (PL)

This section included questions on; the stocking density, where farmer has purchased PL for this year and proceeding three years, age of PL at stocking, whether the farmer has done Polymerase Chain Reaction (PCR) test for PL or not, does farmer know about the food conversion ratio, transportation time for PL, whether the farmer has exchanged PL after stocking or not and how farmer has done stocking (one off stocking or several stockings).

Section 3: Bio security before stocking

Under this section; what has farmer done for crabs, birds, and fish, did farmer filter the inlet water, and did farmer use chlorine, pesticides, and weedicides for farm security before stocking PL.

Section 4: Bio security during culture period

Under this section the questions asked were; what has the farmer done for crabs, birds, and fish, did farmer filter the inlet water, did farmer use chlorine, whether farmer burrows equipment from others or not, if so does farmer disinfect them, what chemicals were used by farmer to disinfect those equipment, pesticides, and weedicides for farm security during the culture period.

Section 5: Diseases

This section included the questions on; whether the farm already got disease or not, whether farmer knows how to manage the disease or not, date of disease occurred, how many ponds were affected, type of disease, duration of the problem, what has done for the problem of disease by farmer, what happened to the diseased shrimp, fate of water, whom did farmer inform after disease occurred, previous disease information for the past three years.

Section 6: Ecological setting

Under this section questions included were on; the distance to main water body and type, distance to nearest natural ecological habitat and type, distance to nearest farm and soil type inside the pond.

Section 7: Contact details

This section included questions to set general information such as; farmer's telephone number, village and district.

Statistical analysis

All the statistical analysis was performed using Microsoft Excel and Minitab 11 statistical software package.

RESULTS

Current culture diary

All 100 farmers interviewed, were owners of shrimp farms. Each farm is represented by one pond or a cluster of several ponds. Generally, the area of each pond was about 1 acre. The survey showed that about 70% of shrimp farms which were affected by WSSV disease were of 1-5 acres category (Fig. 2).

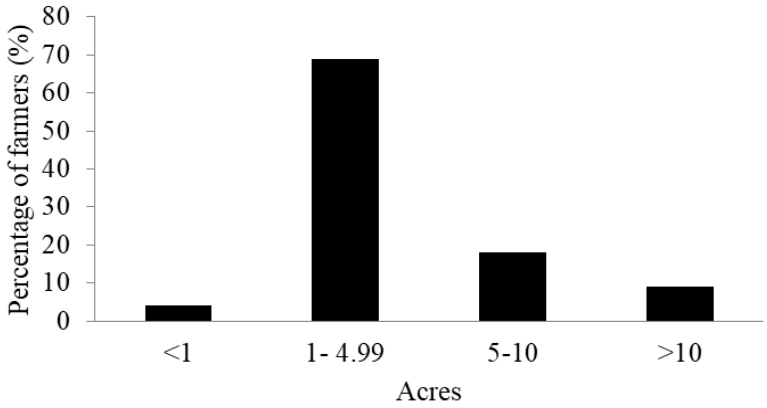

Figure 2. Percentage of shrimp farm of different size ponds affected with disease in North-Western Province

16% diseased shrimp farms waited more than six months for restocking after harvesting, 80% of shrimp farms waited two to six months, and 4% of farmers waited less than two months for restocking.

Majority of the farms were located in previous mangrove areas (Table 2).

Table 2. Former land types of shrimp farms which affected with disease in North-Western Province

Former land type	Percentage of farms (%)
Andara land	2
Coconut land	9
Lagoon part	3
Muddy land	13
Madu trees	1
Mangroves	22
Omari	16
Paddy field	12
Salt marsh	2
Sandy	12
Scrub	8

98% of farms had normal dykes and most of farmers practiced important farming practices other than fertilizing and soil pH testing (Table 3).

Table 3. Practices used by farmers prior to start farming

Type of treatment	Practiced (%)
Pond bottom removal	95
Dry the pond	97
Plough the pond bottom	91
Liming	87
Fertilizing	24
Soil pH testing	59

Most of the shrimp farmers used dolomite as main lime type, 40% of farmers used agricultural lime and 7 % of farmers used hydrated lime, quick lime and other variety of lime as their lime type.

61% of the farms tested value of soil pH was between 7.5 and 8.5. It was less than 7.5 in 36% of farms and pH was above 8.5 in 3% of farms.

57% of disease affected shrimp farms were aerated. Mostly, farmers used 2-4 paddle wheels to aerate their ponds (Fig. 3).

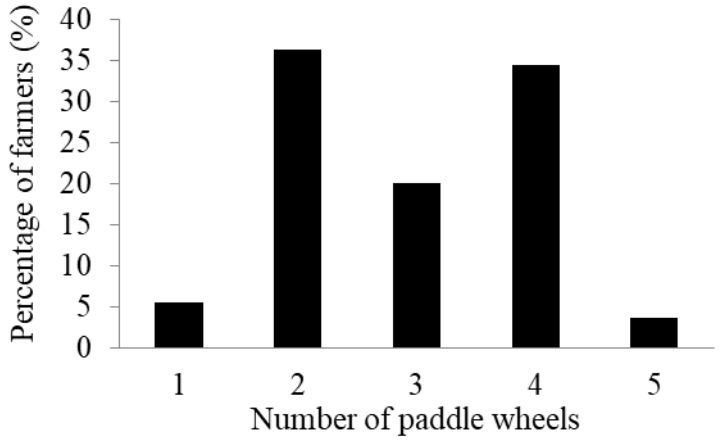

Figure 3. Usage of paddle wheels in disease affected shrimp farms in North-Western Province

10% shrimp farmers do not exchange water in ponds during the culture period, 64% of farmers exchanged water less than three times per week and 26% farmers exchanged water more than three times per week.

89% farmers took below 10 days as time gap between water filling and stocking PLs, 6% of farmers took 10 to 15 days gap and 5% of farmers took more than 15 days gap between water filling and stocking PLs.

Post larvae (PL)

89% of the farmers experienced WSSV used 50,000-100,000 per acre stocking density, 6% of farmers used more than 100,000 PL per acre and 5% of farmers used less than 50,000 PL per acre (Fig. 4).

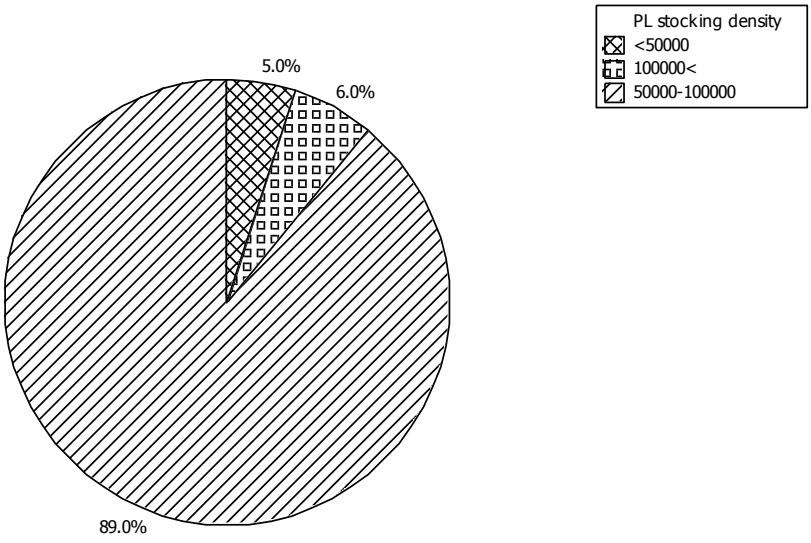

Figure 4. PL stocking density used by farmers

37% farmers stocked PL age between 10–15 days, 3% stocked PL age below 10 days and 60% of farmers stocked PL age more than 15 days (Fig. 5).

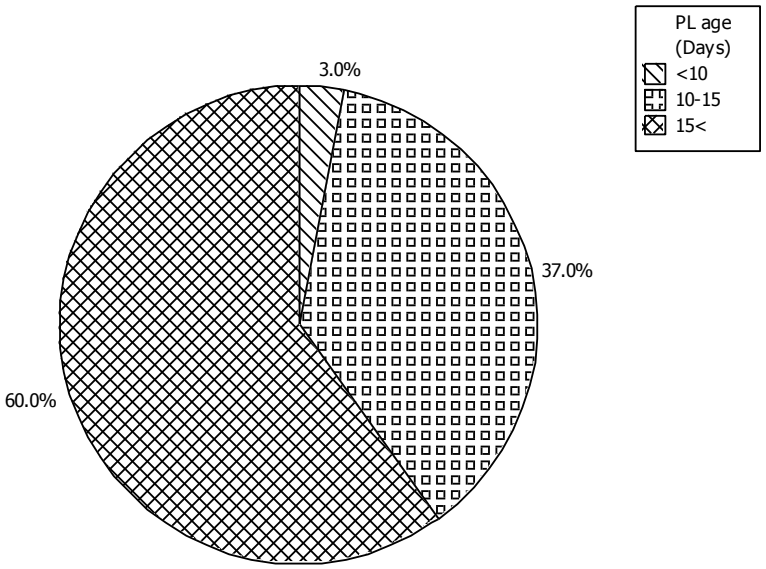

Figure 5. Age of PL (days) at stocking

78% of farmers bought PL from one hatchery and others use more than one hatchery. 98% of shrimp farmers who encountered WSSV in PLs had done PCR test before stocking in ponds. Most of the farmers (59.1%) did PCR test at NAQDA while the

others used private sector facilities. All the shrimp farmers who interviewed knew about the food conversion ratio.

72% of farmers took 60-120 minutes for PL transportation in to the ponds and 5% of farmers took less than 30 minutes (Fig. 6).

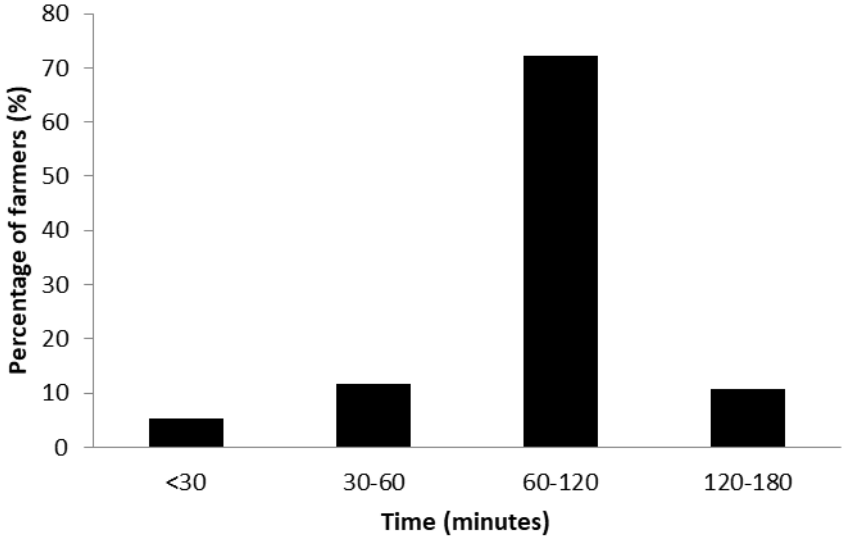

Figure 6. PL transport time by shrimp farmers in North-Western Province

Almost all the farmers did not exchange the pond after stocking PLs and 98% of farmers stocked PL at one time.

Bio security before stocking and after stocking

Most of the farmer's experienced WSSV, used bird lines and water filtration as bio security treatments before stocking as well as chlorination and crab treatment after stocking.

Considering bio-security measurements before stocking 100% used organdie net for water filtration, 100% used lines as bird lines and tea seed for fish treatment. 74% of farmers used killing method as crab treatment and 16% of farmers used decrab to treat crabs.

Bio security treatments during culture period, 100% used organdie net for water filtration, 100% used lines as bird lines and tea seed for fish treatment. 96% of farmers used killing method as crab treatment and one percent of farmers used decrab to treat crabs (Table 4).

Table 4. Bio security measurements before stocking and after stocking PL.

Treatment	Before stocking (%)	After stocking (%)
Bird lines	39	32
Water filtration	36	00
Fish treatment	09	02
Pesticides	00	00
Weedicides	00	00
Chlorination	04	38
Crab treatment	12	26

Most of the shrimp farmers were not burrowing equipment from others and among those who burrowed equipment 87% disinfected the equipment. Most of farmers used chlorination to disinfect equipment (Fig. 7).

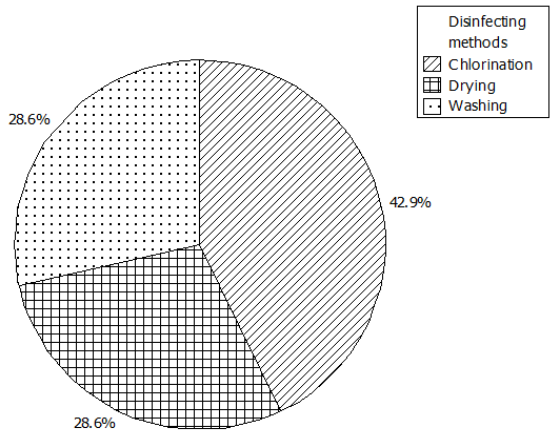

Figure 7. Disinfecting methods for burrowed equipment

Diseases

78% of farmers knew management procedure to control disease, 97% of farmers experienced WSSV and only 3% experienced gill disease.

Most of the farms were infected with disease after 60-90 days of culture (Fig. 8).

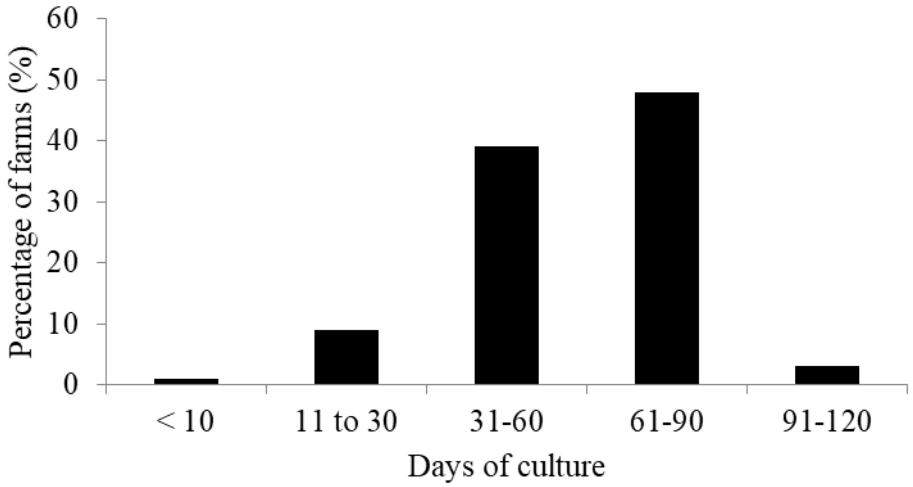

Figure 8. Percentage of farms were affected with different time periods of the culture cycle

95% of diseased shrimp were harvested and 5% of shrimp farmers did not harvest their shrimps. 79% of farmers caught their diseased shrimp by releasing water and others used netting. Only 26% of farmers checked PCR after infecting disease. After water was released, water was mainly end up in the Dutch canal. Once the disease occurred most farmers informed to the shrimp farm association.

Disease occurrence had increased in an increasing rate starting from 2008 until first season of year 2011 and graph showed highest occurrence in 2nd season than 1st season during the time period (Fig. 9).

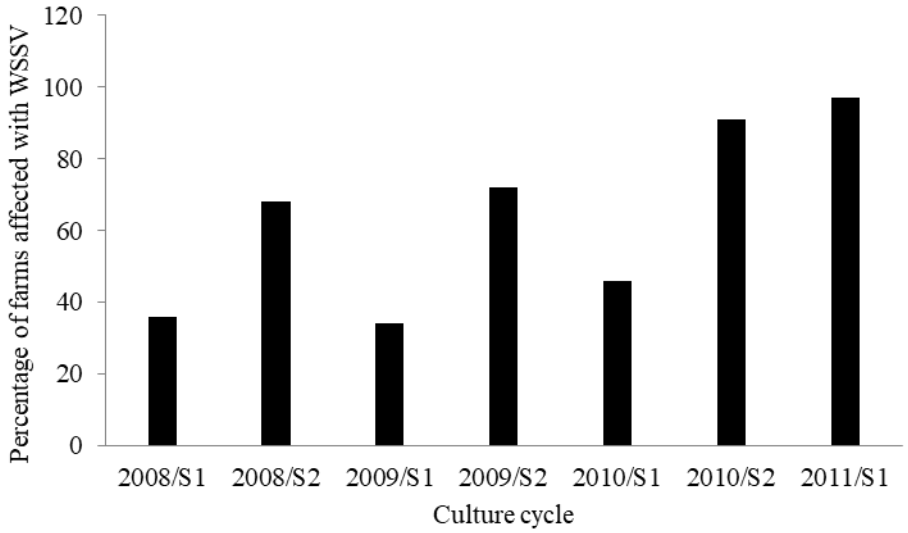

Figure 9. Percentage of farms affected with WSSV with culture cycles

Both age and size of shrimps at harvest showed a similar trend with the year (Fig. 10).

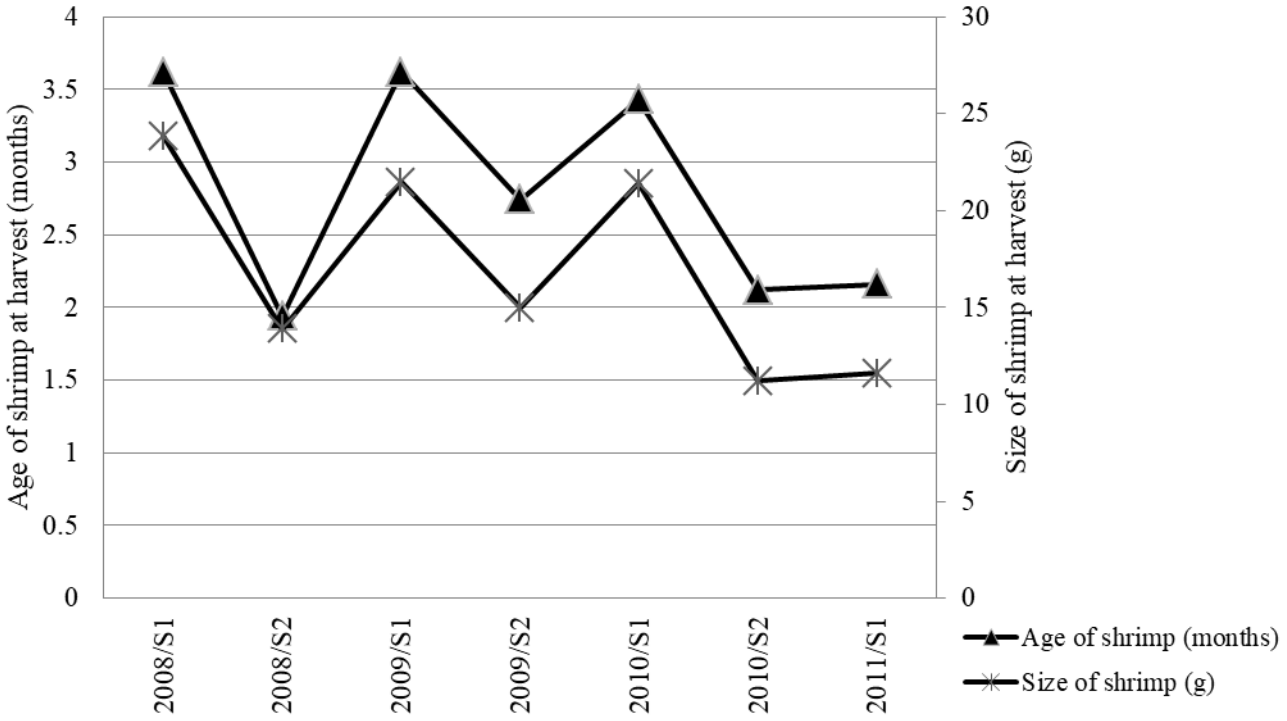

Figure 10. Age and size of shrimp harvest at different culture cycles

Ecological setting

Most of the farms were located near to main water body. 74% of farms which were affected with disease used Dutch canal as their main water source and others used lagoons. Most of the farms had mangroves as the nearest ecological zone (Fig. 11).

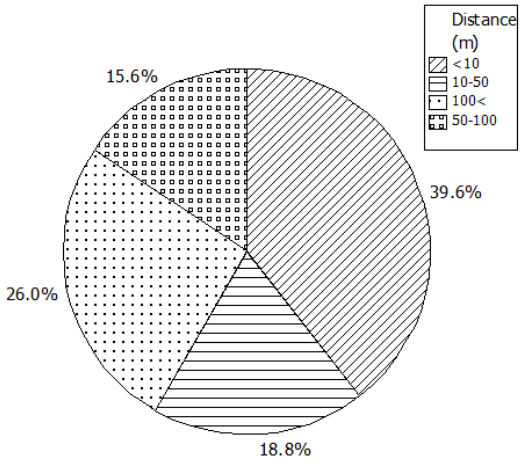

Figure 11. Distance to main water source from the diseased farm

Most of the farms were located very near to the other farms (Fig. 12).

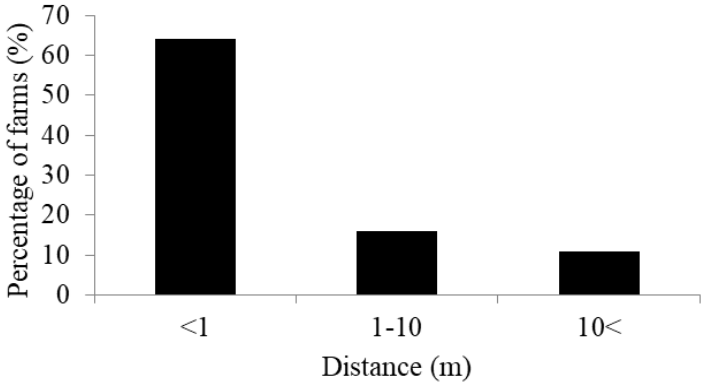

Figure 12. Percentage of farms with distance (m) to the nearest farm

Most of the shrimp farms had clay and muddy soil types (Fig. 13).

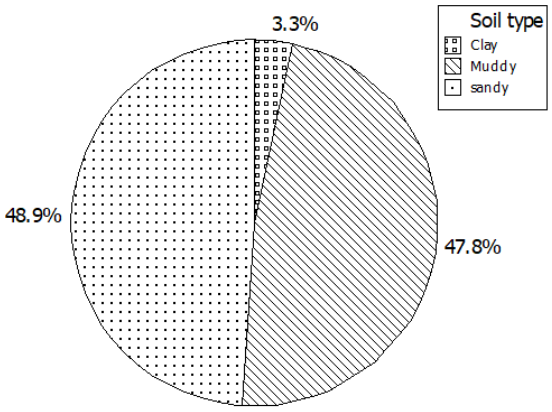

Figure 13. Soil type of diseased shrimp farms

DISCUSSION

Results revealed that almost all the farms got WSSV and disease spread can be a reason of many factors, and when the results of the study is concerned that may be mostly due to poor farming practices and inadequate bio security measurements.

Results further revealed that former land type utilized by most shrimp farmers were mangroves and muddy areas (mud flats) followed by paddy fields. **Jayasinghe (1997)** documented similar information at the initial stages of shrimp farming in Sri Lanka; the farms were located in agricultural land, wetlands and in bare lands. Where, the percentage of farms on salt marshes and mangroves were around 30%, agricultural lands 31%, bare lands 25% and others 13% during the early development stages.

Biosecurity measures were indicated that most farmers use bird lines and water filtration before stocking post larvae. However, after stocking most farmers move to chlorination of replenishing water, bird lines and crab treatment.

Further, the shrimp industry has to implement a bio secure production system to prevent the spread of infectious disease among farms and to reduce the risks of pathological events. **Khairnar *et al.* (2011)** documented that excluding vectors and

external sources of contamination and preventing internal cross contamination are the methods were suggested methods for excluding pathogens from hatcheries and farms.

Results revealed that nearly 100% of farmers did not treat the water during culture period. However, **Horowitz and Horowitz (2003)** reported that there are physical, chemical and biological precautionary measures to be taken as well as a second line of defense against potential disease outbreaks.

Providing better environmental and biological conditions to the infected population (in transition stage) will increase its ability to resist diseases (**Horowitz and Horowitz, 2003**). However, around 50% of farmers aerate the ponds and majority of them had only two paddle wheels per culture pond. It was noted that most of shrimp farmers remove pond bottom (sediments accumulated in pond bottom), keep dry ponds, plough the pond, liming, soil pH checking and fertilizing. Around 75% of farmers stock post larvae within less than ten days of water filling to the ponds. According to the BMPs fill and exchange water needs to be disinfected. However, most farmers practiced one or two times water exchange per week without any treatments. Using of raw or untreated water is responsible for continued disease problems when ponds are stocked with high-health shrimp seed. Bio secure shrimp production systems stocked with high-health seed represent an emerging technology with an environmentally sustainable and economically viable alternative to conventional shrimp culture (**Khairnar *et al.*, 2011**).

According to the results mostly disease occurred in farms during the second season which is belongs to northeast monsoon. The rains are determined by monsoons and fishing seasons are generally associated with the two monsoons, the southwest monsoon from June to September and the northeast monsoon from November to March (**Joseph, 1999**). Northeast monsoon is the rainy period for Puttalam district and that may reduce water temperature, oxygen levels and salinity levels. Low temperature triggers white spot virus disease (WSD) and that hyperthermia or hypothermia can prevent it in several WSSV-infected shrimp species (**Vidal *et al.*, 2001**).

Result revealed that 74% of diseased shrimp farms used Dutch canal as their main water source and others use lagoons. The farms are concentrated over a distance of about 120 km around Chilaw Lagoon, Dutch Canal, Mundal Lagoon and Puttalam Lagoon, where 70% of farms depending on Dutch Canal for their water resources (**Jayasinghe, 1995**).

Stocking density is to *P. monodon* 20000-50000 post larvae/ha for semi intensive farms (**FAO, 2011**) and ponds are operated in Sri Lanka are two different levels of semi-intensiveness (**Jayasinghe, 1995**). According to the results stocking density of most diseased shrimp farms are 50000-100000/acre, therefore this stocking density is too much to manage pond condition, then more vulnerable to disease.

According to the results 98% of shrimp farmers who experienced diseases had done PCR test before stocking in to ponds, but infected most farmers did not conduct PCR and released water in to main water source specially into Dutch canal. However, this increases spread of diseases and others also can be infected. Though, **Chanratchakool *et al.* (1995)** mentioned post larval stage between 15-18 days is preferred for stocking, around 62% of farmers stocked PL aged 10-15 days. Therefore they may be less tolerating to environmental conditions and more prone to diseases.

CONCLUSION

According to the table.05 insufficient paddle wheels, insufficient water exchange, less time gap between water filling and stocking, less time gap between water stocking and filling, high stocking density, stocking of PLs smaller than recommended age and low or no water filtration, less or no fish treatment, less or no chlorination, use inlet and outlet as the same water source, location of farms very close to each other and release of diseased shrimps into main water source which are not recommended practices , leads to WSSV disease and its spreading (Table 5).

Table 5. Summary of culture practices and Best Management Practices (BMP)

Farm practice	BMP recommended level	Percentage of farmers complied with recommendation (%)	Cause for disease*
Pond preparation			
Pond bottom removal	Yes	95	No
Drying	Yes	97	No
Plough the pond bottom	Yes	91	No
Liming	Yes	87	No
Check the soil pH	Yes	59	No
Aeration	Yes	57	No
Paddle wheels	4/Acre	38	Yes
Water exchange	3 times/week	26	Yes
Time gap between water filling and stocking	15 days	2	Yes
Time gap between water stocking and filling	3 Day	1	Yes
Stocking density	50000/Acre	18	Yes
PCR	Yes	98	No
Age of PLs	15 days<	35	Yes
Time gap waits before restocking	2 month <	96	No
Biosecurity before culture			
Bird lines	Yes	69	No
Water filtration	Yes	63	No
Fish treatment	Yes	16	Yes
Pesticides	No	100	No
Weedicides	No	100	No
Chlorination	Yes	7	Yes
Crab treatment	Yes	21	Yes
Biosecurity during culture			
Bird lines	Yes	83	No
Water filtration	Yes	0	Yes
Fish treatment	No	6	Yes
Pesticides	No	100	No
Weedicides	No	100	No
Chlorination	Yes	97	No
Crab treatment	Yes	66	No
Disinfect the equipment's	Yes	87	No
Inlet and outlet is same water source	No	25	Yes
Distance to nearest farm	10m <	13	Yes
Release of diseased shrimps into main water source	No	21	Yes

* It is considered that if more than 50% of the farmers did not comply with the recommendation, that farm practice may be a cause for the WSSV disease.

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