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Economic Losses due to Disease Incidences in Shrimp Farms of India

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Abstract

Huge economic losses occur due to incidence of viral and other diseases in shrimp farms of India. To make a quantified assessment of these losses, a field survey of 1142 shrimp farms following a statistical random sampling from nine coastal states during the period 2006-08 was conducted. The gross national losses in the country due to shrimp diseases was estimated as 48717 metric t of shrimp valued at Rs. 1022.1 crores, and employment of 2.15 million man days. Epidemic seriousness among the diseases was for White Spot Syndrome Virus (WSSV), Loose Shell Syndrome (LSS) and combination of WSSV and LSS, white gut and slow growth syndrome in that order at national level. Additional price loss was also recorded on account of poor quality of final output like deformed organs, loose shell and muddy smell. In some cases, farmers resorted to premature harvest and hence the production biomass also reduced coupled with price drop according to the count per kg of shrimps.

Keywords: Economic loss, shrimp diseases, White Spot Syndrome Virus, Loose Shell Syndrome

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Introduction

Shrimp farming creates job opportunities in remote coastal villages, ensures livelihood security for coastal poor and provides valuable foreign exchange to the country's exchequer. Shrimps contributed a volume of 22% of 862021 t and value of 49% of Rs. 16597 crore of total marine product exports of India, in the year 2011-12 (SEAI, 2012). During the last decade, there has been a notable increase in annual shrimp production from 35500 t in 1990-91 to about 216500 t in 2011-2012 with an export value touching US $ 3.5 billion. There has been a remarkable increase in farm area from 65100 ha in 1990-1991 to over 121208 ha in 2011-12 (SEAI, 2012).

India occupies fifth position amongst the major shrimp farming countries in the world. The other four largest shrimp producing nations, China, Thailand, Indonesia and Vietnam (FAO, 2010) are working on bio-secure farming technology to safeguard their farms from diseases and to stabilize the share in foreign trade (Umesh et al., 2008; Arthur & Subasinghe, 2002; Briggs et al., 2004). In India, the emphasis so far has been placed on improving shrimp farming techniques to minimize their environmental impact, as well as to extend the sustainability through technology options. Now more efforts are needed to increase shrimp production with adoption of bio-secure measures for reducing production losses (Ponniah et al., 2011). For increased export earnings, private sector participation in solving the issues of quality management, inspection, monitoring and verification procedures among shrimp manufacturers/exporters is to be encouraged including implementation of Hazard Analysis and Critical Control Point (HACCP) quality system, which is required for all shrimp exported to the EU and the U.S.A.

Disease problems overshadowed the shrimp production during the last two decades in many countries (Mohan & Bhatta, 2002; Flegel et al., 2008; Flegel, 2012). There was a disease outbreak reducing the Chinese shrimp output in 1993. Diseases created a lot of problems to Thai shrimp production during 1996 and 1997. In Ecuadoria in 1999 and in Brazil in 2006, serious occurrences of shrimp diseases were reported (Flegel et al, 2008). A total loss of one billion US $ was reported due to diseases in shrimps

(Briggs et al., 2004). However, in recent years, most of the disease problems have been contained in these countries (Flegel, 2012). India has to necessarily develop cutting edge technologies in shrimp farming with more emphasis for minimized production losses due to diseases, to give a fresh lease of life to this sector. The information presently available on economic loss assessment of fish or shrimp diseases is mostly expert estimates and estimates based on data from large farm surveys is very scanty (Bhaumik et al., 1991; Barua, 1994; Mohan & Bhatta, 2002; Brown & Brooks, 2002; Chinabut et al., 2002; Faruk et al., 2004). Economic losses to shrimp farmers occur due to both market-based and non market effects. For example, market-based impacts may include partial/ complete destruction of crop and a reduction in production, employment, sales and income. Non market effects include environmental consequences and psychological effects suffered by the individuals involved. An attempt has been made in the present study for quantifying the aggregate losses in shrimp culture in India due to diseases in monetary value and other tangible measures.

Materials and Methods

Framing of questionnaire was carried out taking into consideration the probable answers from the stakeholders that involved all sections of aqua farmers and also with the help of private aqua-consultants. The target species was identified as all species of shrimp susceptible to various bacterial, fungal, viral and other biological, physical and chemical causative agents in the country. Information was collected directly by face-to-face interview.

The field survey was carried out in nine maritime States of India. A total of 1142 sample shrimp farms covering an area of 5779 ha were drawn using a simple random sampling framework. The personal interviews were held from 14th July 2005 to 13th July 2008. The survey covered both summer and winter crops to compare the effect of season on the incidence of diseases. The details of states and the districts of the respective states covered during the survey under the project are given in Table 1.

The data collected were analysed using the SPSS statistical software, version 17.0. ANOVA and two tailed independent 't' tests were performed to find out the differences between groups on the various parameters like inputs and outputs in shrimp culture operations and practices followed in shrimp culture.

Major diseases considered were WSSV, LSS and combination of WSSV along with other diseases like LSS, other bacterial diseases and fungal diseases. The disease loss is quantified in terms of price loss that could be attributed to poor quality, productivity loss per hectare, production loss, income loss and corresponding loss of employment in terms of man days were computed. The probability of occurrence factor (POOF) index was computed using the simple proportion of disease occurrence in the farms from the total of the particular state. POOF was worked out state-wise and at national level as a weighted average using the index as constructed below. The disease incidence (di) as reported for ith disease in jth farm of kth state is aggregated over summation of M farms in O states. O is the number of states from where data were collected for different crops; and N is the number of diseases for which data were collected. The POOF values were calculated using the formula given below:

$$POOF = \Sigma_{i=1}^{m} \Sigma_{j=1}^{n} \Sigma_{k=1}^{o} d_{ijk} / \Sigma_{j=1}^{m} M \ \Sigma_{k=1}^{n} O$$

Severity rankings of the disease were also ascertained state-wise and disease-wise to identify the most serious disease that occurred during the survey period. The ranking was arrived at based on averages of incidences reported. Correction factors were calculated for variations in supplementary data with base for seasons, normalizing the prices of input and output for the three year survey period. Production estimates were rationalized in correspondence with production statistics reported by authorized national agencies.

The major limitation of the present study was as inherent to any of the survey method of research like poor memory and recall biases. The other inaccuracies in the data reporting by farmers were minimized to the least by cross checking with other stakeholders like feed sellers and exporters wherever possible. Furthermore, the data collected were descriptive, not explanatory, and, therefore, cannot offer any insights into cause-and-effect relationships for disease incidences in the study area.

Results and Discussion

The types or kinds of disease losses that can occur in a supply chain of ocean to plate are depicted in Fig.1. Production to market losses could occur as

loss of production due to diseases, price loss due to diseases and quality & average farm gate price. Though some of the losses across the supply chain are quantifiable, many are not quantifiable directly. Value leakage viz., commercial loss across the supply chain is a complex, cross functional problem triggered off with 'physical production' loss from shrinkage of supply.

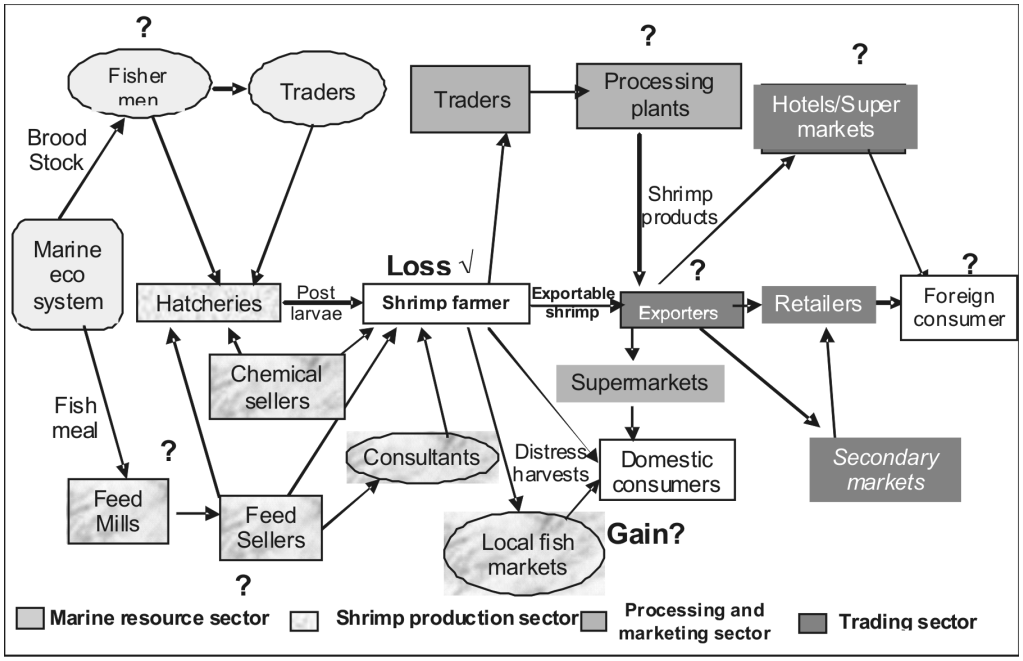

Fig. 1. Kinds of disease losses that can occur in a shrimp supply chain

Table 1. Details of states, districts, number of farmers, number of ponds and total culture area covered under the survey

Name of State	Name of Districts	No. of farmers	No. of ponds	Total culture area surveyed (ha)
West Bengal	Midnapore and South 24 Parganas	111	380	130
Orissa	Balasore, Bhadrak and Puri	117	922	598
Andhra Pradesh	Srikakulam,Vijayanagaram, Visakhapatnam, Krishna, East Godavari, West Godavari, Prakasam and Nellore	363	2817	2265
Tamil Nadu	Tiruvallur, Kanchipuram, Villupuram, Cuddalore, Nagapattinam, Tiruvarur, Thanjavur and Ramanathapuram	358	1654	1200
Kerala	Kollam, Alappuzha, Ernakulam, Thrissur, Kozhikode and Kannur	50	96	95
Karnataka	Udupi, Uttar Kannada and Dakshina Kannada	42	184	121
Goa	South Goa and North Goa	18	77	50
Maharashtra	Ratnagiri, Raigad, Thane and Sindhudurg	37	443	690
Gujarat	Valsad, Navsari and Surat	46	690	630
Total		1142	7263	5779

Severity rankings of the diseases based on rate of incidence are tabulated (Table 2) state-wise and disease-wise to identify the most serious disease that occurred during the survey period.

In terms of severity ranking, WSSV, white gut and slow growth syndrome combination, LSS and combination of WSSV and LSS were the severe hits on a national average. While Goa and Karnataka were most affected by WSSV, all other states reported WSSV as the most severe disease. LSS occupied the top position in Maharashtra while other diseases were reported across the states in varying severity as shown in Table 2. The geographic location of the farms and variations in agro ecosystems across the country could also have contributed to varying levels of severity of incidences.

Further, the probability of occurrence factor (POOF) was calculated from the simple proportion of disease from the reported sample farms from each state which was used in estimating the quantified economic losses due to these diseases, as explained earlier. The estimated probability of occurrence factor (POOF) values are presented in Table 3.

Table 2. Severity ranking among the common disease occurrences

State	No Disease	WSSV	LSS	Bacterial	Fungal	White gut & slow growth	WSSV +LSS	Other combi-nations
West Bengal	1	2	3	4	5	6	7	NA
Orissa	1	2	3	4	5	6	NA	NA
Andhra Pradesh	1	2	4	NA	NA	NA	3	5
Tamil Nadu	1	2	4	6	7	3	5	8
Kerala	1	3	NA	NA	NA	2	NA	4
Karnataka	2	1	4	NA	NA	3	NA	NA
Goa	2	1	NA	NA	NA	NA	3	NA
Maharashtra	1	3	2	NA	NA	4	5	NA
Gujarat	1	2	NA	NA	NA	NA	NA	NA
All India	1	2	4	NA	NA	3	5	6

NA= Not Available WSSV: White Spot Syndrome Virus; LSS: Loose Shell Syndrome

Table 3. Probability of occurrence factor (POOF)

State	No Disease	WSSV	LSS	Bacterial	Fungal	White gut/slow growth	WSSV +LSS	Other combi-nations
West Bengal	0.703	0.180	0.072	0.009	0.009	0.009	0.009	0.009
Orissa	0.632	0.282	0.017	0.017	0.017	0.017	NA	0.017
Andhra Pradesh	0.579	0.121	0.058	0.003	NA	0.003	0.077	0.055
Tamil Nadu	0.570	0.196	0.028	0.011	0.011	0.092	0.022	0.014
Kerala	0.560	0.120	NA	NA	NA	0.300	NA	0.020
Karnataka	0.310	0.619	0.024	NA	NA	0.048	NA	NA
Goa	0.278	0.611	NA	NA	NA	NA	0.111	NA
Maharashtra	0.703	0.108	0.135	NA	NA	0.027	0.027	NA
Gujarat	0.783	0.217	NA	NA	NA	NA	NA	NA
All India	0.590	0.196	0.041	0.007	0.006	0.048	0.035	0.018

The price of the product was also affected in many of the respondent farms. Price loss was due to poor quality of final output like deformed organs, loose shell and muddy smell etc. In some cases, farmers resorted to premature harvest and hence the production biomass decreased by reduced average body weight and prices dropped accordingly. The price losses noted are summarized in Table 4.

The productivity (production per ha) losses from the normal average due to diseases are given in Table 5. Contrary to the general trend of productivity losses with disease occurrence, there were certain cases from respondent farms where minor increase in the productivity were reported. This was due to application of curative measures and prolonging the duration of the crop. The shrimp gets higher price with increased body size and the reduced count per kg.

The economic losses caused by diseases refer to physical losses of production, employment and income, measured by measurable physical indicators. When valued in monetary terms, damages become direct losses. The Summary estimates of annual national economic losses due to disease occurrence in shrimp farming sector was attempted with above data. According to an earlier

Table 4. Price loss (Rs kg^{-1})

State	WSSV	LSS	Bacterial	Fungal	White gut & slow growth	WSSV+ LSS
West Bengal	-255.04	-46.49	-38.24	49.76	-28.24	-183.24
Orissa	-184.84	-62.72	-122.72	27.28	-90.22	NA
Andhra Pradesh	-171.14	-90.48	-73.34	NA	-3.34	-95.66
Tamil Nadu	-144.06	-75.12	-12.37	-53.62	-71.8	-16.74
Kerala	-201.9	NA	NA	NA	-116.24	NA
Karnataka	-189.23	-118.46	NA	NA	-98.46	NA
Goa	-216.27	NA	NA	NA	NA	69.27
Maharashtra	-168.46	-53.86	NA	NA	-83.46	-16.54
Gujarat	-191.81	NA	NA	NA	NA	NA
All India	-176.13	-69.03	-56.55	-22.29	-95.79	-82.55

Table 5. Productivity loss (kg ha^{-1})

State Name	WSSV	LSS	Bacterial	Fungal	White gut & slow growth	WSSV +LSS
West Bengal	1532.53	628.65	1735.53	-247.44	925.53	1225.53
Orissa	1960.98	102.04	1357.04	-217.96	2327.04	
Andhra Pradesh	1296.63	870.67	536.81	NA	819.81	824.85
Tamil Nadu	1399.16	647.40	758.95	958.20	618.82	1073.95
Kerala	678.04	NA	NA	NA	324.04	NA
Karnataka	1321.54	567.69	NA	NA	-1417.69	NA
Goa	1997.27	NA	NA	NA	-1417.69	NA
Maharashtra	1419.23	654.23	NA	NA	444.23	-455.77
Gujarat	1443.61	NA	NA	NA	NA	NA
All India	1386.66	737.01	872.25	-25.79	793.19	901.17

expert estimate made by Marine Products Export Development Authority (MPEDA), since 1994, on an average, 10 000 to 15 000 metric tonnes of shrimp production, worth about US$ 60-70 million (Rs 350 crores to 400 crores) is lost annually due to disease problems (MPEDA, 2003). The direct gross national losses estimated are: i) a national loss of 48,717 metric tonnes of product *viz.*, about 30% of present shrimp production occurred due to diseases, ii) in terms of national income, an amount of Rs. 1022.1 crores was lost due to the diseases that occurred in the shrimp farms and iii) in terms of farm level employment, 21.56 lakh man days were lost due to shrimp diseases in the country (Table 6.). The value increase in the present estimates compared to MPEDA (2003) estimates, are due to wide prevalence of shrimp viral diseases during the survey period. Epidemic seriousness among the diseases was WSSV, LSS and combination of WSSV and LSS, White gut and slow growth syndrome in that order at national level.

The estimates of huge losses arrived in the present study justifies investment in aquatic health management research. The present study quantified disease loss only in terms of price loss that could be attributed to productivity loss per hectare, poor quality, production and income loss and corresponding loss of employment in terms of man days. The estimates do not include tangible and intangible losses that occurred across the supply chain (for e.g, losses in processing sector due to reduced shrimp material availability for processing) for want of data and right unification methodology. This aspect may be looked into by conducting further studies on this line to come to grips with real losses suffered by all players and the country due to occurrence of shrimp diseases.

Methods for estimation of economic losses and quantification of the losses depend on the availability of data points and amenability to analytical techniques listed below: the actual farm data on area stocked/harvested; quantities harvested/sold/stored juxtaposed with farmers' expectations on areas expected to be stocked/ harvested and expected yields may reveal yield loss values. Objective analysis of macro level data on area, production and productivity statistics along with expert opinions of loss incurred may suffice in certain cases. Remote sensing and other mathematical production loss modelling can give sophisticated estimates of disease losses. The suggestions for future lines of works are; attempts may be made to provide a summarized estimate of physical, financial and psychological losses to the entrepreneurs across the supply chain as depicted in supply chain diagram (Fig.1) from ocean to plate; regular epidemiological surveys with larger samples will enable the use of more rigorous statistical tools like binary regression analysis. The work initiated in this direction by Leung et al. (2000) need to be continued with more rigorous data and analysis; employing advanced statistical methods like Neural net work and fuzzy logic analyses will help in identification of most influential factors that trigger diseases. The onset of a particular disease in a farm could be associated with a very complex (e.g., nonlinear and interactive) combination of changes on a subset of the variables being monitored. Neural networks have been used to recognize this predictive pattern so that the appropriate preventive and or curative treatment measures can be prescribed.

Table 6. Summary estimates of annual national economic losses due to disease occurrence in shrimp farming sector

Disease	Probability of occurrence (in 0-1scale)	National loss of production per year (in MT)	National loss of farm income per year (in Rs. Crores)	National loss of employment per year (in man days)
No diseases	0.590	0	0	0
WSSV	0.196	23 318.51	489.25	10 32 214
LSS	0.041	4 892.72	102.65	2 16 581
WSSV+LSS	0.035	4 164.02	87.37	1 84 323
White gut+ Slow growth	0.048	5 725.53	120.13	2 53 446
Other diseases	0.089	10 616.23	222.74	4 69 936
Total	1.000	48 717.01	1 022.13	21 56 500

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