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Article

Characteristics, Threats and Challenges of Shrimp Production among Small-Holder and Commercial *P. Vannamei* Shrimp Farmers in Davao Region

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Abstract: Shrimp industry in the Philippines play a vital role in the economy since its recovery from disease outbreak in mid-1990s to the present. It is now one of the major contributors to the total production in the fisheries sector (60,000 tons' production, 7,000 tons exported) with a market in countries such as South Korea, Japan, USA and others. This study aimed to describe the various cultural and operational characteristics of a shrimp farm (*P. vannamei*) in Davao region; evaluated and assessed the current risk and challenges experienced by shrimp farmers in the time of pandemic. This study made use of semi-structured questionnaire and respondents and focused on shrimp farmers, operators in the provinces of Davao Oriental, Davao del Sur and Davao de Oro with N=41 farmers. Results showed that n=39 respondents were engaged in small scale shrimp farming which has an average yield of 10 tons/ha per cropping; the highly intensive farms yielded 24 tons/ha per cropping. Most operators used generator machines as source of electricity to facilitate aeration accompanied with paddle wheel and blower in some farms; about 2/3 of the commercial shrimp farms used electricity from electric line. In terms of their expenditures, feeds got the highest cost among mentioned inputs. This was followed by fry, fuel, labor, and others that composed of fertilizers, water treatment substances and supplements. The average profit per ha of commercial farms is visibly larger than those of small holder farms. Most of the farmers mentioned that their shrimps experienced diseases such as white spot syndrome (60%), black gills (35%) and red tail (5%). They perceived that the occurrence of these diseases were caused by contamination from (3) water source or (2) agent/vector (31%); others have mentioned it was caused by poor water quality management (44%); and some have mentioned due to a changing climate condition (25%). They have also experienced threats of declining price in the market; source of fry, water disposal, overstocking, challenges brought by the pandemic, and water quality. It is advised that farmers should follow good shrimp aquaculture practices most importantly water quality management and biosecurity implementation.

Keywords: Aquaculture; Davao Oriental, management; Mati City; shrimp farms; water quality

1. Introduction

The shrimp industry in the Philippines play a vital role in the economy since its recovery from disease outbreak in the mid-1990s to the present. The rapid expansion and tremendous growth of shrimp aquaculture in the past years became significant for the Philippine's economy, as it became a major contributor in the fisheries sector. In fact, the Philippines has become one of the top producing countries in *world aquaculture production,* where shrimp valued at Php 5.31 billion pesos was exported in year 2014 [1] . Lately in 2019, the export reached 7,000 mt of the 60,000 mt of total shrimp production which was shipped to Japan, South Korea and the USA making it fourth globally in terms of value which reached up to U$42.36 million [2-3]. *Penaeus vannamei* and *Penaeus monodon* are the most cultured shrimp species and dominates shrimp aquaculture by contributing the largest percentage (60%) of the total production of farmed crustaceans in 2020 [4-6]. Shrimp farming also provides employment and food security for most Asian coastal countries that are large consumers of seafood products and with large aquaculture sector including the Philippines [7-11]. The growth of aquaculture has been a part of the most significant changes in global food production over the past 100 years [12] . Apart from being a major source of proteins, aquaculture had been considered as a sustainable alternative for wild caught fisheries in terms of seafood production [8,13]. Similar to other countries like Bangladesh shrimp farming became one of most popular aquaculture activities that have been practiced in the country today due to a high demand [14]. In Thailand, they started from traditional extensive shrimp farming until they adopted modified farming systems, semi-intensive to intensive farming to increase production [15]. The center of intensive shrimp farming in the Philippines way back in the 1990s was Negros Island, but after it was badly hit by disease outbreaks, its production dropped during 1997. Due to the incidence, development of several effective strategies such as fish-shrimp integrated culture technology also known as green water culture technique or a polyculture of tilapia and shrimp, and others were introduced. When the disease was declared to be manageable by 2004, shrimp industry slowly recovered and had been growing in many areas of the Philippines, including in the Davao region [2,5,16]. As of 2019, 4.29% of total aquaculture production based on shrimps came from the Davao region [3].

Though aquaculture has benefited the economy, this was also accompanied by detrimental effects on marine coastal ecosystems such as seagrass and mangrove ecosystems [17]. Mangrove forests are found in 121 countries around the world including the Philippines [18]. Mangrove deforestation and degradation has become one of the major impacts of aquaculture expansion particularly from intensive and extensive commercial aquaculture [19-20]. As aquaculture increases, mangrove deforestation also increased. Vast expanse of mangrove forests have been converted to shrimp farming. Aquaculture had been recorded as the largest factor – around 20% to 40% contributing to the decrease of mangrove forests globally since 1980 [17,21,22]. In 2007, the estimates of mangrove cover for the Philippines was 1,097 km^2, visibly lower than it was first recorded in 1918 where it had an area of 4,000 - 5,000 km^2 [23]. Mangrove ecosystem has a vital role in environmental and socio-economic functions [18,24]. This can be a source of wood supply and non-wood forest products, protection against storm surges, erosion and flood control [18,25,26]. It is also considered as a nursery ground for various fish, shellfish and other invertebrates, however, deforestation as a result of pond construction and other farm activities causes biodiversity loss [27-30]. It also provides livelihood to nearby local communities on whatever product that can be benefited from mangrove ecosystem [18].

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The degradation of mangroves and continuous conversion can lead to the loss of its important functions in ecosystem [18,31,32].

In terms of socio-economic impact, this mainly refers to impacts on livelihood, reduction of employment opportunities, food insecurity, social-imbalance and marginalization of coastal communities that results in social conflicts. Food security has been affected because most of the aquaculture produced are usually exported instead of being consumed at home [33-36].

Moreover, it was suspected that the emergence of new diseases is the result of the rise of intensive aquaculture. However, the rapid growth of the industry also brought threat among shrimp farmers worldwide [12,37]. Early mortality syndrome (EMS) had caused mass mortality in several developing countries, that was later named acute hepatopancreatic necrosis disease (APHND) [38]. While the white spot syndrome virus (WSSV) which was found to have originated from China, has widely affect the Philippines leading to significant economic loss [39]. There were also some viral pathogens such as monodon baculovirus (MBV), yellow head virus (YHV), hepatopancreatic parvovirus (HPV), and infectious hypodermal and hematopoietic necrosis virus (IHHNV), that caused minimal effects on growth and survival of black tiger shrimp due to its high tolerance [38-40]. Apart from the mentioned pathogenic microorganisms that caused diseases on shrimps, it can also be accompanied by nutritional deficiencies and environmental factors.

Due to the limited studies that focused on the cultural and operational practices in the production of *Penaeus vannamei* in the Philippines, this paper aimed to describe the various cultural and operational characteristics of shrimp farms (*P. vannamei*) in Davao region. In addition, it also evaluated and assessed the current risk and challenges experienced by shrimp farmers during the time of pandemic. We think this will be helpful for the development of policies that will enhance and strengthen the shrimp industry in the Davao region and in the Philippines. The study made use of quantitative and qualitative methodology to collect data from the shrimp industry.

2. Materials and Method

2.1 Study site

This study was conducted in selected areas of Davao Region (Figure 1). Davao Region is a coastal area officially designated as Region XI in the Philippines that occupy the southeastern section of Mindanao. It has an area of 204.33 km2 data as of 2013. It is composed of five provinces, the Davao de Oro (previously known as Compostela Valley), Davao del Norte, Davao del Sur (where Davao City was located, the highly urbanized city), Davao Occidental, and Davao Oriental.

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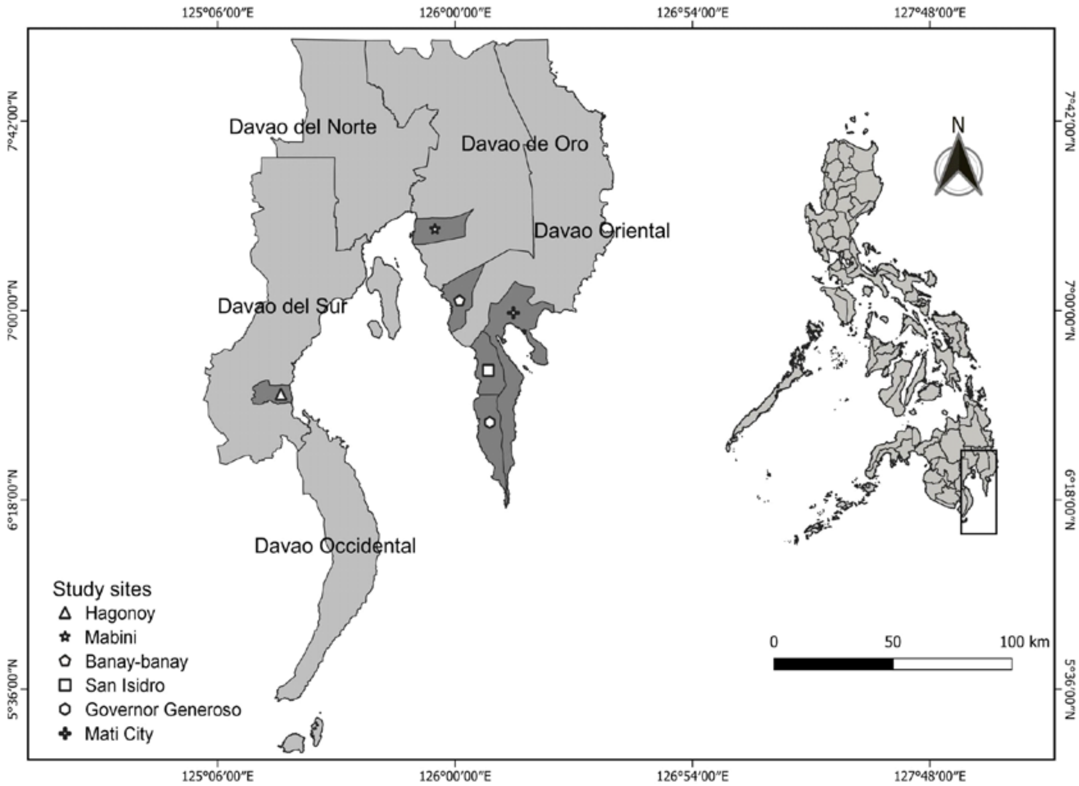

Figure 1. Map of the Philippines showing Davao region.

2.2 Data collection

Primary steps in collecting data involved the use of target respondents by gathering list of information from Bureau of Fisheries and Aquatic Resource or BFAR on the registered shrimp operators in Davao region. Key informant was also helpful during the survey in locating study respondents.

The respondents of the survey were the farmers and operators of shrimp aquaculture within the Davao region. There were N=41 respondents being interviewed using semi-structured survey questionnaire and focus group discussion. The questions were clearly explained to the respondents to enhance better understanding. While responding to the given questions, respondents were also asked further explanation to support the acquired information.

The survey questions include the assessment of farm characteristics such as land area, pond size, cultured species and diversity, culture system adapted, water supply, use of aeration, frequency of cropping, crop yield and employed individuals. Also, the cultural practices, encountered environmental problems and diseases as well as management responses were asked. Economic factors on production like cost of inputs and estimated income per production were also gathered for return of investment on both small-holder and commercial shrimp farmers. Farm owners or head managers were also interviewed about their experience during the pandemic and how it affected their production.

A focus group discussion was done before formulating the questionnaire. Data collection procedure and pilot testing of the survey questionnaire was conducted to evaluate its effectivity before the final survey. The researchers conducted the interviews and collected data from July to September 2021.

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2.3 Data Analysis

All data from interviews were encoded in Microsoft Excel 2016 and preliminary data analyses were done using Analyse-it excel add-in software. All possible dependent variables were first checked for their normality and homogeneity and plotted on graphs for visualization. Quantitative data were analyzed for relationships regarding income from the farm as response variable with other predictor variables that included farm area, socio-demographic variables (age, education, household size, number of years farming, health) and total yield. Only the data from small-holder farms (N=38) were used in the analysis as there were only three data representatives from the commercial farms. The sociodemographic variables were reduced to one variable by using PCA (principal component analysis) where the component scores were used as social variable that was later related to the response variable (income). In order to find out the best predictor for the farm income, the social, farm area and total yield variables were related to the response variable using multiple linear regression. The response variable was first transformed by using a $\log_{10}$ transformation to fulfill a normal distribution using Kolmogorov-Smirnov (KS=0.065; $P>0.15$) test then the regression was performed. All analyses were performed using MINITAB 17.0 (State College, Pennsylvania, United States).

3. Results

3.1 Socio-Demographic profile

A description of the sociodemographic variables included age, where the age of fish farmers ranged from 26-40 and 41-55 years, with 70% of the fish farmers having an average age of 41 years old mostly from small-holder farms (Figure 2A). In terms of their educational attainment, most shrimp farmers have attended schools with 39% of them finishing up to elementary level or have graduated elementary; about 9% of them studied in secondary schools and graduated; and 2% have undertaken vocational courses while 32% have pursued their college degrees (Figure 2B). Another variable included the sizes of household, where small-holder shrimpfish farmers have less than 10 individuals in every household, with size ranging from 1-6 members. Most shrimpfish farmers have a family with 3-4 members (36%) and the least with family having 7-8 members (5%) (Figure 2C). Concerning community residences, about 66% of the shrimpfish farmers have resided in the community for less than 10 years, 11% of the shrimpfish farmers have resided for about 41-50 years, 8% for both 11-20 years and 31-40 years of residency and 5% for range of 21-30 years (Figure 2D). There were some organizations of shrimpfish farmers in Davao Oriental but only 58% of the interviewed farmers were members of the organization (Figure 2E). Only 24% of the farmers have access to borrow financial or in-kind expenses while the rest reported not having access to credit (76%) (Figure 2F). In terms of the ownership of land being used for shrimp farming, 92% were owned by the shrimp farmers and 8% were renting (Figure 2G). Many of the small-holder shrimpfish farmers have started their culturing for less than a year and maximum of 21 years, but most of the shrimpfish farmers have only been farming for the past 1-3 years (26%), 4-6 years (45%), followed by 7-9 years (5%), 10-12 years (8%), 13-15 years (8%), 19-21 years (5%), and 16-18 years (3%).

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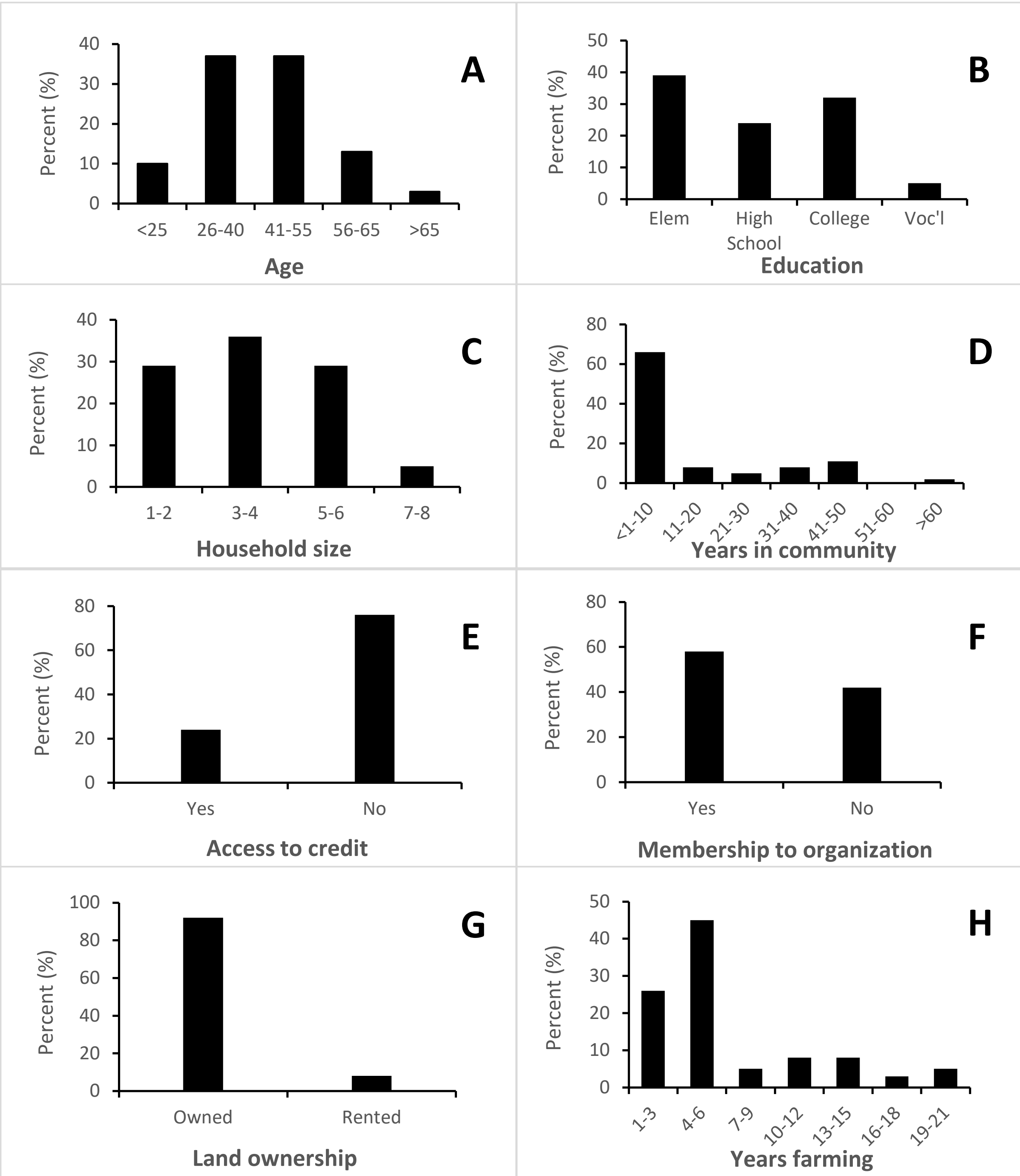

Figure 2. Age of respondents (A), their level of education (B), household size (C), years in community (D), access to credit (E), membership to organization (F), land ownership (G), and years in farming (H).

3.2 Characteristics

3.2.1 Shrimp Farms

Small holder: Farms were mostly located in Davao Oriental with an area of less than 3 hectares. Shrimp production in these farms used a monoculture of Whiteleg shrimp (*Penaeus vannamei*). Number of cropping practiced by small-holder farmers was about 1 to 3 times per year, almost the same with commercial farms. Farms were semi-intensively operated by a limited number of employee (1-10 or a maximum of two persons each pond). Stocking density was lower than the other type of farm using paddle wheel alone as means of aeration. The number of ponds cultivated simultaneously in one cropping range from 1-5 ponds, fewer compared to commercial farms but with larger pond size (4,000-5,000 m^2). Ponds were commonly rectangular and traditional irregular shapes. Farmers also used fermentation process aside from probiotic and molasses as supplements for shrimps. This fermented product is composed of rice bran and molasses. In terms of commercial feeds consumption of post larvae within the whole culture period (70-110 days), this ranges from 1,000-3,000 kg. By average of production, the harvested shrimp weighs 14-30g, the average total cost of inputs such as post larvae, feeds, fuel/electricity, labor, supplements, and other inputs during pond preparation was about 2/3 of the total revenue per cropping. Thus, half of the total cost is the gained profit.

Commercial: Most of these farms were operated by corporations with an area much larger than small-holder farms (4-50 hectares). Shrimp production in these farms focused on monoculture whiteleg shrimp (*Penaeus vannamei).* Farms are intensively operated by numerous employee (8-71 persons was recorded during the interview). Stocking density was higher than small-holder farms and utilized paddle wheels for aeration. They practiced cultivation using a number of ponds (38) in a single cropping season, compared to the small-holder farmers but in a smaller pond area/pond size (2,000-3,000 m^2); shapes of ponds are commonly rectangular and some were circular in shapes. Farmers also used supplements like probiotics and molasses for shrimps. Commercial feeds consumption of 100,000 post larvae within the whole culture period (80-100 days) ranges from 850-2,650 kgs, slightly lower than the small-holder farms consumption. Most of the harvested shrimp averaged in 27-35 g body weight, the average total cost of variable inputs such as post larvae, feeds, electricity, labor, supplements, and other inputs during pond preparation was about 60% of the total revenue per cropping. And nearly 80% of the total cost was the gained profit.

Result from the data analysis regarding farm income showed that the model was highly and positively related to the yield (df=1, MS=2.16, F=43.55, P<0.001) but not to the social factors or the farm area (df=1, MS=0.12, F=2.41, P=0.129). The overall model (df=2, MS=1.50, F=30.25, P<0.001) with an R^2=63.3% explains the variation well and there was no autocorrelation between variables.

Table 1. Comparison of small-holder and commercial farms

Variables	Small Holder	Commercial
Farm area (ha)	0.3-3.0	4.8-50
Number of cropping per year	1-3	2-3
Yield per cropping (kg/ha)	10,000	24,000
Number of employed individuals	1-10	8-71
Stocking density (PL/m^2)	25-200	60-350
Aeration	Paddle wheel	Paddle wheel, Blower
Number of ponds	1-5	3-38
Average pond size (m^2)	4,000-5,000	2,000-3,000
Shape of pond	Rectangular, Irregular	Rectangular, Circular
Use of supplements	Probiotic, Molasses, Fermentation	Probiotic, Molasses
Commercial feed (kg/100,000PL/crop)	1,000-3,000	850-2,650
Days of culture period	70-110	80-100
Average body weight (g)	14-30	27-35
Average revenue per cropping (Php)	1,408,000	21,546,000
Average total cost of inputs (Php)	957,000	12,382,000

*PL = post larvae

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3.2.2 Variable cost of inputs

The operational cost of inputs varies in an area and intensity of the production. Input cost such as feeds lead the highest contributor in both small-holder and commercial farms, occupying approximately half of the total operational cost (59%). In *small-holder farms* (figure 3A), the cost of the fry was second to the cost of feeds, around 15%, followed by fuel cost (12%) that is used to generate electricity for the aerator and other mechanical equipment within the farm. Labor cost refers to the payment for employees in a given culture period amounting mostly to 10% of the total costs. The 4% others are the supplements, limestone, tea seed, water treatment and additional expenses for repair and maintenance. For *commercial farms* (Figure 3B), unlike the small-holder farms, electricity was the second top contributor with 24% of the total cost, followed by the cost of the fry (17%), the labor cost (11%) and 3% of the total cost are from the supplements, limestone, tea seed, water treatment and additional expenses for repair and maintenance.

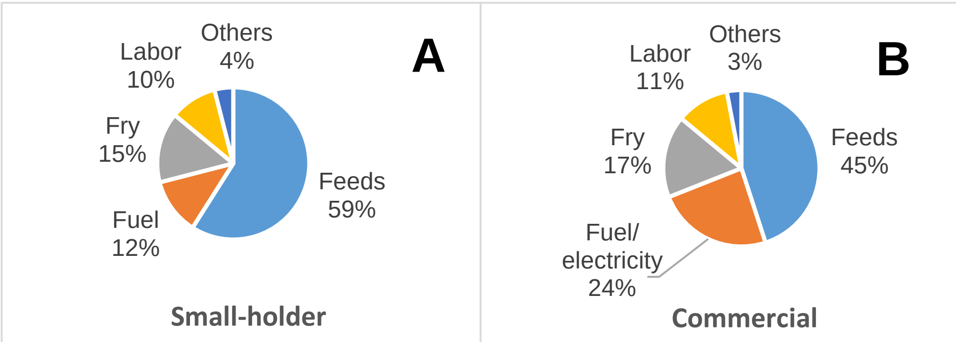

Figure 3. Distribution of variable cost of inputs of small-holder (A) and commercial farms (B).

3.3 Prevalence of disease and probable causes

According to the farmers' experience regarding managing diseases particularly in small-holder farms, white spot syndrome (WSS) is the most contagious and around 60% of the farmers that they have encountered in shrimp farming experienced WSSV, 35% of them experienced black gills syndrome and slightly 5% on the red tail or other known as Taura syndrome (Figure 4A).

Farmers have mentioned a list of probable cause of these diseases: most of them (44%) pointed to water quality problem as the main cause of the presence of the diseases such as WSSV, black gills and red tail. This water quality problem refers to the alkalinity and acidity of the water in the pond, water temperature, salinity, as well as the level of dissolved oxygen. They were also aware on the effects of climatic condition (25%) on shrimp disease such as WSS and Black gills. Climatic condition like heavy rain, hotter temperature, and rising sea level that sometimes overflows and enters the pond; these factors give stresses in shrimp because of unsuitable environment. Farmers have also mentioned cases of water contamination (19%) and agent/vector (12%) either by human or animals that causes the spread of the particular diseases (Figure 4B).

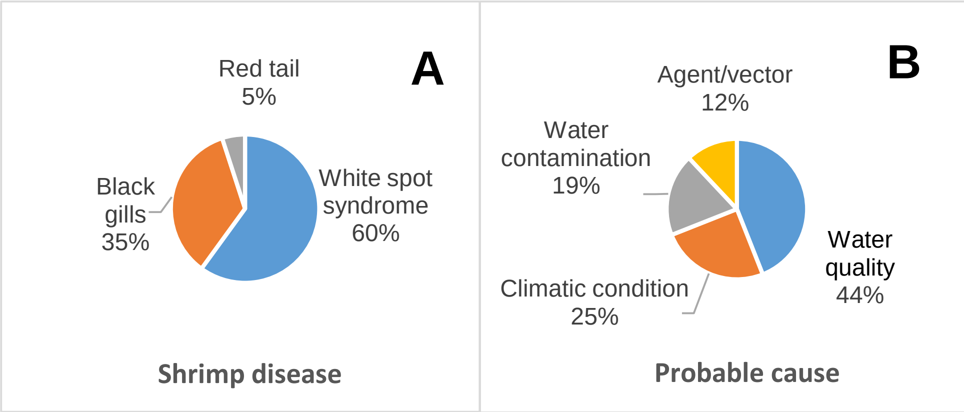

Figure 4. Encountered shrimp diseases (A) and probable cause (B).

3.4 Risk challenges and possible solution

As shown in Table 2, respondents have mentioned different challenges that affects their production such as disease, overstocking, waste disposal, water quality, pollution, source of fry, high cost of inputs, lack of capital, low market demand, and pandemic. These factors have brought corresponding negative impacts on shrimp production. Diseases have caused death on shrimp thus lowering the yield to massive loss of production. Lastly, the pandemic brought significant impact specifically on the market aspect of shrimp aquaculture, mobility restrictions have thought as the reason of the shrinking consumers in the market. The fish farmers also indicated that they have some suggested solutions to help mitigate the above-mentioned challenges. These are: having a good source of water, proper waste disposal, following the required stocking density, accessible, quality and cheap fry, processing plant for shrimp exports, proper cultural management and biosecurity, availability of water quality testing kit/lab, cheaper supply inputs, access to credit, and government intervention to help farmers surmount these challenges.

Table 2. Challenges, impacts on shrimp production and farmers suggested solutions

Factors	Impacts	Suggested Solution
Disease	Shrimp death	Proper cultural management Strict implementation of biosecurity and government intervention
Overstocking	Lack of oxygen	Following the standard stocking density suitable to the capacity of the pond area and availability of aerator
Waste disposal	Increased contamination	Total removal of excess solid or liquid waste inside the pond Construction of sludge pond/reservoir for solid and liquid pond waste Treating the wastewater before the release into the waterways
Water quality	Cause diseases on shrimp Stunted/low growth rate	Water quality testing kit/lab to regularly monitor the optimum level of water parameters in the pond.

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Pollution	Low survival rate of shrimp post larvae	Good source of water
Source of fry	Insufficient supply Potential in carrying disease	Accessible hatchery Disease-free, high quality and cheaper source of fry
High cost of inputs	Limited and insufficient supply of inputs required for better production Production declines	Access to a cheaper supply input for production Other alternatives to lessen the cost of production
Lack of capital	Disable the farmers to increase their production Unable to support the needs of the farm	Access to credit (money/in kind)
Low market demand	Low profitability	Processing plant for shrimp produced.
Pandemic	Decreasing buyer due to mobility restriction It prolongs the culture period of shrimps led to an increase in input cost Low market price	Government policy to loosen the mobility restriction to allow the people work and earn for their necessities, as well as it will enable the transportation of goods in and out of the town Government assistance to help the shrimp farmers that is affected by the pandemic overcome

4. Discussion

4.1 Farming Characteristics

There were two types of shrimp farmers in Davao region based on the intensity of production. Small-holder and commercial shrimp farms are both produce *P. vannamei* as their main cultured species in the other country, and usually has two to three cropping per year [44]. In Davao region, small-holder farms dominate the sector, similar to other aquaculture producing countries in Asia [45]. Commercial farms are more intensive in terms of cultivation method than small-holder farms. They have well-constructed ponds, a concrete one or liner that do not need prolonged period of pond preparation particularly for drying. Thus, it enabled them to proceed on the next cropping within a shorter period of time after harvesting compared to the earthen ponds of small-holder farmers. Most of the small-holder farms are local growers that have minimal hired employee, usually a family-operated farm. They tend to have smaller sizes of farm area compared to the vast hectares of land being cultivated by commercial farms. This type of farm is operated by a corporation or an export grower. Their shrimp production are exported or processed. Since these commercial farms are mass producer of shrimp in the region, they were very particular on their mode of production. Commercial farms have farm technicians that supervise the inputs and actions needed to meet maximum production. While in the case of small-holder farmers, they only have a limited access to good farm management and visits from farm technicians of the government or the Department of Agriculture, limiting their expertise and technical knowledge on farm management. In addition, the income of small-holder farmers is highly dependent on the total yield that they can produce [46]. The fact that their age, number of household sizes or even their health and farm area was not positively related to their level of income could be due to dependence on stocking density of the shrimp. The higher this stocking density and the more this can be grown and produced to desired sizes and weight would provide a better prediction for their income. This is also the reason why intensive farming produces a higher income and not necessarily the expanse of the area cultivated or farmed. While this could be good economically, the higher stocking density of the shrimps could lead to prevalence and rapid increase of diseases in highly intensive farms.

4.2 Cultural Practices

Shrimp production in Davao region employs practicing pond preparation prior to stocking. This pond preparation was very crucial throughout the culture period. It is advised that exercise of proper pond preparation before stocking must follow the requirements of biosecurity. Removal of any unwanted particles and excess organic load in the pond from previous cropping are important as well as pond drying. Complete drying is indicated with visible cracks in the soil. These practices are intended to remove dangerous organisms and other particles that may affect the quality of water in the pond that will be used for stocking, since shrimps are very sensitive to water quality parameters. In more or less than 30 days when pond preparation is completed, filling of water in the pond follows. The water (brackish/seawater) that is used will be treated with chlorine. Application of tea seed is also practiced by some farmers and liming to neutralize acidity in the soil prior to stocking of post larvae.

The seedstocks/post larvae (PL) that are used for culture are imported from other hatcheries. Currently, Pacific whiteleg shrimp is the most preferred cultured species in Davao region. Seeds are stocked at ages (PL8) 8 to (PL15) 15 days. Older seeds were observed to have lower mortality rate. However, its cost is higher compared to younger ones. Therefore, the preferable to most is PL10. Technically, the recommended stocking rate from hatcheries is 1:1 ratio, where in 1,000 m^2 pond area they should only accommodate 100,000 PLs in semi-intensively cultured farm. Thus, overstocking was known to cause higher mortality rate due to lack of dissolved oxygen [47] . As the stocking density increases, the survival rate and growth rate also decreases [48] . The lowering of production of shrimp can be due to overstocking, as it is one of the predictors for yield [49]. By having a lower stocking density, a farm can obtain maximum production and high survival rate as proven in other studies [50] . High survival rate can also be attainable in small intensive ponds with best management practices [51]. However, poor management can reduce production and profitability even when the prices are high [52]. The profitability of the farm always depends on the management practices as well as the price in the market [53].

Maximization of shrimp production with its feed efficiency, farmers have followed recommended feeding guide. Blind feeding is the term used in the first month of culture with regular monitoring on its feeding efficiency. The regular monitoring of the amount of feed consumed will help determine the amount of feeds the shrimp needs. Commercial and formulated feeds used to increase the growth of shrimp. However, improper feeding can lead to a waste of feeds. Farmers have practiced broadcasting feeds within the pond excluding in the middle part. Where feeds directly sink into the pond bottom as a solid waste with other organic loads. Application of supplements helped improved nutrition in shrimps. During rainy season production of ammonia in the pond water increases, therefore the initiation of liming and water exchange (top drain) can be a solution in maintaining the suitable water quality in the pond. Mostly in small-holder farms make use of paddle wheel for aeration, generated by fuel or electricity. It is one of the high-cost inputs of shrimp production that is different from other aquaculture production. Aeration is important all the time to facilitate oxygen for the shrimps and reduces mortality from disease [51] . The culture period of pacific whiteleg production in Davao region is usually within 90 days. Sometimes it takes up to 110 days it depends on the availability of buyer. They gradually harvested the shrimp by netting and complete draining. The marketable size of shrimps ranges from 10g average body weight (ABW) and above, but farmers preferred to harvest their shrimps around 20g to 25g ABW.

4.3 Prevalence of marine pollution and disease

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Concurrent with itsimportance in economic sector and development in many Asian countries, the shrimp farming industry has been facing various issues including itsnegative effects on the environment[29] . Concern has been expressed regarding the use of chemicals in shrimp farms, and its potential impacts on the environment and human health [54] . Liming compounds and water treatment are the common substances that help mitigate water pollution and contamination. For instance, zeolite (hydrated alkali–aluminum silicates) for the removal of ammonia and neutralizes particularly the pH level of the pond water [55]. Fertilizers were used to enhance the growth of phytoplankton that provides alternative food supply for the shrimps and improve the general environment in the pond. There were also and application of antibiotics that helps prevent and treat viralinfections; microorganism (probiotics) as treatment for the water or sediments; and vitamin products to enhance growth of shrimp and resistance to diseases [56].

Due to pollution and occurring problems on diseases, world production shrimp has stagnated even gone down over the last few years. The same with Vietnam, as they have previously used large amount of feed, pesticides and antibiotics that lead to serious water pollution. The intensification of shrimp farming has relatively results to environmental problems.[29]. In the Philippines, the prevalence of IHHNV in various wild populations of *Penaeus monodon* has been correlated with shrimp culture intensification and mangrove status [57] , associated with other disease like WSSV, MBV, HPV, YHV [40,58,59]. Accumulated pollution from watershed activities and from self-generated organic load has resulted in slower growth of shrimp, higher susceptibility to diseases, and the worst is mass mortalities [60].Presence of disease in populations and ecosystems is influenced by numerous environmental factors, including infectious organisms mostly viruses, pollutants such as chemical and biological wastes, and deficiency in essential nutrients [29].

4.4 Challenges in the time of pandemic coping strategies

Corona Virus Disease (COVID-19) pandemic has spread to almost every nation and send shockwaves to various sectors, including the aquaculture after countries are being forced into strict quarantine and lockdown [61-62]. In the Philippines, entire aquaculture supply chain and marketing system is facing multiple challenges. Many farmers have reduced their activities due to low demand and uncertainty. It brought various challenges on rural livelihoods and economic problems such as loss of income and job opportunities . Moreover, disaster-prone communities were struggling with COVID-19 restrictions and its severe economic impact [13,63].

Within the study area itself, mobility restriction showed as the main health protocol during the pandemic that negatively affect aquaculture farm as well as market disruption that hampered their marketing operations. Limited availability of fry and fingerlings, temporary rise in cost of farm inputs, limited local supply of various inputs, timing of lockdown, and reduced shrimp farmers' ability to access needed inputs. They were constraints in accessing inputs particularly when it involved crossing a municipal boundary due to pass requirements and mandatory quarantine of 14 days when one returns to his/her municipality, even if the distance travelled is only a few kilometers [64].

Market disruption, as mentioned, significantly affects the sustainability of shrimp production. For farmers that produced such high-valued commodity, reduction in its demand led to the decrease in price by as much as 50%. Shrimp were currently sold for as low as Php 160- Php 250/kg from Php 280- Php 350/kg weighing 10 – 20g ABW. Due to lacking in demand, they have to prolong their harvest until there is available buyer. In

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this case, additional cost of inputs applies as the culture period was extended. Even though the situation is difficult, most of the interviewed farmers still produced shrimp for lacking alternative livelihoods. However, there were differentiated capacities for taking advantage of this sustained demand. Large-scale shrimp farmers were more likely to have connections with resellers in urban areas. They tend to have their own vehicles and other necessary documents that enable them to transport their product accordingly [64]. Market operations were also reduced to 6 from 7 days in a week to give time in disinfection. Therefore, other vendors resorted to some alternative arrangements such as peddling their supply (fish, crabs, shrimp, etc.) in their communities and selling it in local territorial markets (called talipapa).

The closing of the educational institutions also appears to be difficult for the family that depends in fishing [65]. Digital learning that has emerged [66] and online learning has now become an alternative [67] . They could barely teach their children at home due to lack of knowledge and additional finances for internet connectivity [63]. Due to the sudden change, needy student experienced larger negative impacts of the Covid-19 outbreak [68]. Also, reduction of families' income, the limited access to digital resources and high cost of internet connectivity would cause radical change to the academic life of the student particularly in some rural areas [69] .

Aquaculture,the same with capture fisheries, were both affected by a decline of several nodes in the economy including the low demand from institutional consumers like restaurants, hotels, and tourist. The designated buying hours and physical distancing requirements for consumers also meant less traffic in the market. This compounded by widespread job losses in other sector and reduced of household income due to loss of income-generating opportunities. Sunny and colleagues (2021) estimated that the global population depends on small-scale fisheries for their livelihood that result in rising food insecurity among fishing communities. Here, importance of aquaculture in food supply could help decrease threat to food insecurity. Fisheries and aquaculture provide nutritious food for hundreds of millions of people around the world and livelihoods for over 10% of the world's population [70] . Government and industry responses are needed to address the immediate economic and social hardships that the crisis is provoking in the shrimp sector. Governments also need to maintain long-term ambitions for protecting natural resources and ecosystems, and the viability of fisheries. Transparency in policy responses probably would help build trust in the future of fishery sector and markets, and use all the lesson that is acquired from the experienced crisis to improve the sustainability and the resiliency of every sector. Economic equity and environmental considerations discussed similar best practices: support the incomes of those most in need rather than subsidize inputs and ensuring that evidence-based management are intact and implemented [71] .

5. Conclusion

Production of *Penaeus vannamei* has been continuously practiced in some parts of the region, from family-operated to company owned establishments. Small-holder and commercial shrimp farms share almost the same cultural practices of monocultured *P. vannamei*, yet they differ in the level of intensification. Commercial shrimp farms are more intensified and technology advanced. There are various challenges enumerated in this paper, but disease outbreak has remained as the main constraint in the development of the shrimp aquaculture sector. Cultural and operational management also played crucial roles in preventing possible risk along the production. Shrimp aquaculture is known as an expensive farming, hence, financial resource is important to sustain the needs of the farm. Moreover, disruption in the market has made the most impactful challenge that was experienced by shrimp farmers during the Covid-19 pandemic. Along with this challenge:

mobility restrictions, lockdown, temporary rise of input cost, lowering market price of shrimp due to lower demand also affected shrimp farming.

6. Recommendation

It is advised that farmers should follow good shrimp aquaculture practices as stated in R.A.8550 also known as "The Philippine Fisheries Code of 1998" particularly in section 47 [72]. There must be a proper management of water quality, waste disposal and strict implementation of biosecurity and access to reliable source of post larvae, to prevent any outbreak of disease. In such case, the government can immediately respond to affected farmers in terms of assistance. However, they were encouraged to use technologies that can help them improve their quality of production. For instance, greenwater system, this is capable of improving the quality of water and enhance shrimps' resistance to diseases [15]. In addition, the government intervention particularly in times of calamities and other form of crisis should provide programs (shrimp-related seminars, trainings, and financial or in kind support) to help farmers mitigate challenges encountered and further learn to adapt into it. The sector should be given attention as it contributes huge income, jobs, and food security to the country [1]. Regarding the Covid-19 pandemic that brought significant impact on marketing the shrimp produce, this implies that other alternative local market must be sought out as well as new ways of utilizing shrimp products should be investigated. Interventions should also include assisting farmers for trading their produce in other areas where demand maybe high to eliminate market threat in the shrimp industry.

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