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The Effect of Climate Change to the Farm Shrimp Growth and Production: An Empirical Analysis

Nazrina Aziz[1,2*], Masnita Misiran[1], Tan Sear Yin[1], Tan Hooi Yee[1], Ng Jia Hui[1], Lu Yun Pei[1], Nor Idayu Mahat[1], Muhammad Mat Yusof[1], Amir Shah Ruddin[3]

[1]School of Quantitative Sciences, College of Arts and Sciences, Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia
[2]Institute of Strategic Industrial Decision Modelling (ISIDM), School of Quantitative Sciences (SQS), College of Arts and Sciences, Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia
[3]School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang Malaysia
**Corresponding author E-mail: nazrina@uum.edu.my*

Abstract

The shrimp growth and production can be measured through several components such as the harvest ton, mean body weight, survival rate and feed conversion ratio. According to previous studies, the shrimp feed conversion ratio should have a positive relationship with their mean body weight. Nevertheless, in real scenario, high feed conversion ratio does not necessarily implies maximum increment of mean body weight. The measurement of those components usually can be influenced by many factors such as climates, stocking density and day of culture. This study in particular explores the effect of climates on productivity of the shrimp species, *Penaeus Vannamei* and investigates whether feed conversion ratio influences the mean body weight when stocking are done at different climate season. First, the one-way MANOVA was used to measure the effect between the climate seasons and *P. Vannamei* production. Then, the regression analysis was apply to measure the relationship between *P. Vannamei* feed conversion ratio and mean body weight for different climate seasons. Finally, to find the best season for sustainable production of *P. Vannamei*, the average score of *P. Vannamei* production was measured according to their stocking climate season. Result revealed that dry season was more favorable for the growth and production of *P. Vannamei* compared to wet season.

Keywords: *Farm Shrimp; Shrimp Growth; Shrimp production; Climate effect; MANOVA; Regression analysis.*

1. Introduction

Shrimp larva rearing technique was first mastered by Dr. Motosaku Fujinaga in 1934 at Japan [1]. Later in 1964, shrimp post-larvae was successfully being produces in large quantity, hence motivates for the mass production of commercial juveniles shrimp farmed in Japan.

In the midyear of 1970s, the juvenile shrimp was available to farmers and this lead to significant increase production of farmed shrimp globally [1]. In the last 20 years, world shrimp aquaculture has expanded by 3.7 times in weight and 2.6 times in value, expanding the world production from 837,790 tons in 1991 to 3,118,971 tons in 2010 with assessed estimation of US$5.17 billion to US$13.24 billion respectively [2].

In the Eastern Hemisphere, a total of 80% of farmed shrimp was mainly produced, with most species include giant tiger prawn (P. Monodon) and Chinese white shrimp (*P. Chinensis*); while 20% produced in the Western Hemisphere mostly involved species of western blue shrimp (*P. Stylirostris*) and white leg shrimp (*P. Vannamei*) [Robert & Granvil, 2012]. In year 2010, the primary cultivated species are *P. Vannamei* (67%) followed by P. Monodon (23%), 3% of *Penaeus Spp*, 2% of *Mersupenaeus Japonicus* and 4% are other species.

Shrimp farming is also a booming industry in Malaysia aquaculture sector. Shrimp production in Malaysia increased from 3,057 tons in year 1991 to 87,202 tons in year 2010; with yearly contribution of 0.35 billion USD to domestic economy. The main farmed species are whiteleg shrimp (*P. Vannamei*) and titan tiger prawn (*Fenneropenaeus Merguiensis*) [2].

Generally, there are three shrimp culture systems – extensive, semi-intensive, and intensive. Extensive shrimp aquaculture is primarily used in areas with cheaper land price, limited infrastructure, high interest rates and less highly trained aquaculture specialists. In these type of environment, family group producers or individual are able to set up operation with few inputs and minimal technical knowledge even though they are not able to access to credit. They are able to build large ponds in coastal areas in inexpensive land. Mangrove forests or salt flats are usually used for pond construction. Therefore, extensive systems require minimal management of water parameters as they do not have to operate pump for water exchange. Operation cost for extensive system are low because only land and labor are the fundamental inputs. Extensive system can only cultivate low stocking densities of shrimp and the supplement feeding is low, therefore, disease outbreaks are rare [3].

The second shrimp culture system is semi-intensive. This cultivation depends on a reliable shrimp post larvae supply and needs better management intervention in pond's operation compared to extensive ponds. Before the post larvae are large enough to be stocked at lower densities in grow-out pond, they are usually raised in nursery ponds. The cost of semi-intensive production are higher than extensive production as it needs more complex system of pond, skilled management, more amount of feed purchased, regular water exchange installation, labor and use more energy. The water exchange rate in semi intensive ponds is up to 25% per day [3].

The third shrimp culture system is intensive shrimp cultivation which is a grow-out systems with high land costs, adequate infrastructure, ample supplies of clean sea water and well-developed hatchery and feed industries. Intensive shrimp farming introduces small enclosures, high stocking densities, very high inputs of formulated feeds, and aeration. The water exchange rate in intensive ponds is generally more than 30% per day. In Malaysia, intensive culture systems are commonly used while the rearing facilities are either earthen lakes or solid tanks [2].

2. Challenges to Shrimp Production

Diseases are the main threat in the shrimp survival especially the pond grown shrimps. The diseases normally caused by agents like bacteria, fungi, protozoa and virus. Among these agents, virus diseases considered as the largest threat to shrimp survival [4]. While the White Spot Syndrome Virus (WSSV) considered as the biggest disaster while shrimp industry was struggling with all the serious diseases in the worldwide [5]. In 1999, high mortality existed at shrimp farms in Colombia due to the appearance of WSSV. The existing of WSSV in *Litopenaeus Vannamei* caused mortalities close to 100% at shrimp farms at Colombia's Pacific coast. In 1999, white spot disease (WSD) was built up in most of the major shrimp-farming cities in the Americas and bringing huge losses for shrimp farmers [6].

Besides, shrimp farmers in country such as China, Vietnam and Malaysia experienced significant losses due to the disease Early Mortality Syndrome (EMS). In 2012, EMS was reported have affected shrimp industry in the eastern Gulf of Thailand (The Fish Site, 2012). EMS is reported to affect mainly *L. Vannamei* and is characterized by mass mortalities that reaching up to 100% of mortalities in many cases during the first 20-30 days of culture [7]. In China, the occurrence of EMS in year 2009 was at first ignored by most farmers. Yet, in 2011, the diseases became more serious and shrimp farming in Fujian, Guangdong, Guangxi and Hainan experienced around 80% losses during the first half of 2011 [8].

Climate is another serious issue in shrimp survival because human being is unable to control the nature. Here, the El Niño phenomena and monsoon will be discussed. First the El Niño phenomena, considered as the vital source of climate changes in the planet which bringing about the wrecking droughts and storms around the world. In 1991 to 1993, El Niño caused significant climate changes and spoiled shrimp farming on a global basis. It also brings major droughts in Thailand, the Indonesia and Philippines took a heavy toll on shrimp farming. Wild broodstock and seedstock were lack of supply while the epidemic and water quality issues emerged and expanded through all over Southeast Asia [9].

Besides that, the monsoon also disturbs the shrimp survival. The southwest monsoon influences the lives of 60% of the world's population and has a major controlling impact on world food production. India gets 80% of its yearly precipitation from the monsoon, which starts in late May. The rising air draws in more cool, soggy air, bringing about substantial precipitation over most of the country. Like El Niño in the Western Hemisphere, the monsoon can causing floods and damage the pond structures and brood-stock. Nevertheless, the monsoon also causes rapidly fluctuating water quality variables that can lead to diseases outbreak. Furthermore, heavy rain affected the flooding of the pond which frequently happens in West Bengal, India, Bangladesh and somewhere else. This situation definitely brings negative effect on shrimp farming [9].

Stocking density is the number of juvenile post larvae (PL) shrimps per unit area [10]. In the past, post larvae was caught in the wild and supplied by the natural environment. However, the constraints no longer applied due to the improvements made in culturing seed in artificial hatcheries. Furthermore, many farmers realized that higher stocking densities could achieved the economies' scale with land being a major cost item in many countries. However, higher stocking densities therefore will causes higher mortality rates. More shrimps per unit area translates to a 'crowding' effect which induces high stress levels in the shrimps. When shrimp are brought up in crowded conditions, this will increases their vulnerability to diseases [10, 11]. Bacteria or viruses that would not generally harm shrimp can lead to diseases and mortality when the shrimps are focused from swarming, poor water quality, and poor nutrition. Poor water quality can likewise come about because of the aggregation of waste and consumption of oxygen, which can come about because of high stocking densities and poor management [12].

For example in India, a study found that the mortality rates of shrimp in high density ponds for culturing *P. Monodon* is high. According to a study in Thailand, the culture season and stocking density can affect the growth and production of shrimp. Dry season and low stocking density was more advantageous to the growth and production of shrimp [13]. While based on a study conducted in India, the mean body weight (MBW) has positive relationship with feed conversion ratio (FCR) [14]. The FCR also founded to be related with the survival rate (SR) [15, 16].

In this study, we would like to identify whether the scenario which happened in Thailand and India are also occurred in Malaysia. The claim of relationship between FCR and SR will also be identified in this study. Hence, the objectives of the study are as follow:

- To examine the effect of climate condition towards the production of the shrimp.
- To identify the relationship between climate season and feed conversion ratio (FCR) for sustainable production of *Penaeus Vannamei.*

3. Methodology

The population in this study includes *P. Vannamei* shrimp in selected shrimp farm at Kedah. Secondary data is considered in particular the stocking date, harvest ton (HAR_TON), mean body weight (MBW), Survival Rate (SR), and feed conversion ratio (FCR) from year 2012 to January 2015. A total of 9 modules with 190 ponds are investigated in the selected shrimp farm.

First, we use one-way MANOVA to measure the significant difference on the effect of climate condition towards the production of *P. Vannamei*. Next, regression analysis will be used in order to identify relationship between *P. Vannamei*'s growth and production at different climate seasons. Finally, average score of shrimp growth and production will be measured according to their stocking climate season to determine the best season for a sustainable production of *P. Vannamei*.

4. Results and discussions

Based on stocking date, climate is categorized as dry and wet season. Dry season are months where precipitation are under average (< 60mm), whereas wet season is where precipitation are above average (>60mm). For the purpose of this study, we acknowledge dry season as January and February, while other months are wet season, as depicted in the history of weather record in Figure 1.

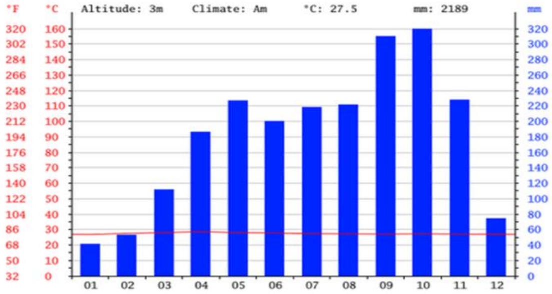

Fig. 1: Climate Graph in Kerpan, Kedah

Overall, 161 (18.21%) cycles of sample are on dry season and 723 (81.79%) cycles of sample are on wet season (see Table 1).

Table 1: Frequency of Ponds According to Climate

Climate		Frequency	(%)
Dry		161	18.21
Wet		723	81.79

Generally, *P. Vannamei* growth and production was significantly different on the different climate season (based on the Wilk's lambda with the *p*-value < 0.05). Table 2 showed that climate season has significant effect towards three (3) measurement components of *P. Vannamei* production. The *p*-value showed significant difference existed between climate season with HAR_TON, SR and FCR. However, result showed no significant difference between climate season and MBW since the *p*-value is more than 0.05 (p= 0.163).

Table 2: One-Way MANOVA Test of Effect of Climate Condition towards Production of Shrimp

Source	Dependent Variable	*df*	F	*p*-value
Climate	HAR_TON	1	53.697	0.000
	MBW	1	1.951	0.163
	SR	1	83.990	0.000
	FCR	1	7.091	0.008

Next, regression analysis was employed to analyze the relationship between *P. Vannamei*'s FCR and MBW at different climate season. Scatter plot in Figure 2 and Figure 3 show relationship between FCR and MBW. Low negative correlation existed in both dry and wet season since the values of correlation are -0.186 and -0.159, respectively, suggesting that as MBW increased, FCR will be decreased and vice versa.

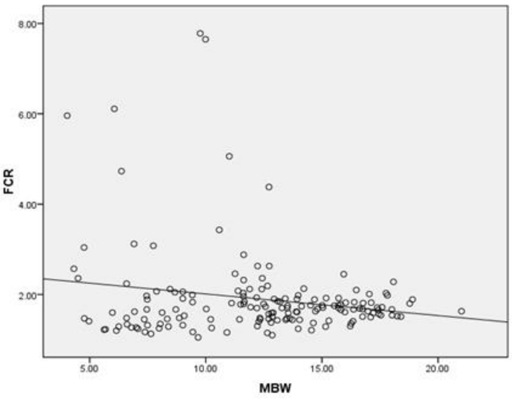

Fig. 2: Scatter Plot of FCR and MBW-Dry Season

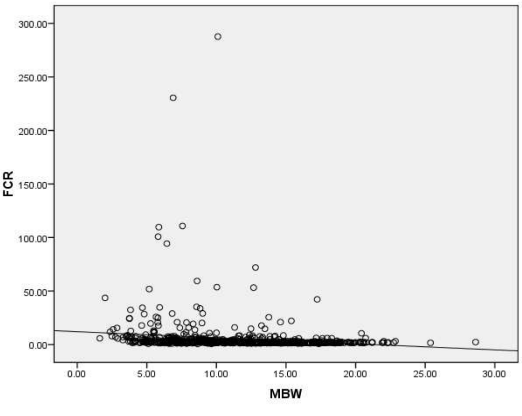

Fig. 3: Scatter Plot of FCR and MBW-Wet Season

Further analysis is conducted on these two components by using regression analysis to measure whether *P. Vannamei*'s FCR is similar at different climate season. The regression line and correlation coefficient values obtained for FCR and MBW in both climate seasons are presented in Table 3.

Table 3: Regression Line and Correlation Coefficient for Different Climate Season

Climate	Regression Line	Correlation Coefficient	*p*-value
Dry	FCR = 2.491 – 0.048MBW	-0.186	0.018
Wet	FCR = 12.040 – 0.567MBW	-0.159	0.000

FCR is influenced by MBW for both seasons since their p-value were less than 0.05. However, the correlation coefficients indicated that there was weak relationship between *P. Vannamei*'s FCR and MBW. Although FCR for *P. Vannamei* was higher in wet season, it does not reflect higher MBW.

Result from one-way MANOVA and regression analysis show that there were significant different between climate season and *P. Vannamei* production. Next, we determine the best season for *P. Vannamei* production through mean score of HAR_TON, MBW, SR and FCR for both climate seasons. Result is illustrated in Table 4.

Table 4: Mean Comparison

Dependent Variable	Climate	Mean	Std. Error
HAR_TON	Dry	4432.52	169.43
	Wet	3059.68	79.95
HAR_MBW	Dry	12.21	0.36
	Wet	11.65	0.17
SR	Dry	50.62	1.56
	Wet	34.83	0.74
FCR'	Dry	1.91	1.20
	Wet	5.44	0.57

P. Vannamei's harvest ton are higher in dry season (mean=4432.52) compared to wet season (mean=3059.68). Similar trend also present in survival rate, with higher rate in dry season (mean=50.62) compared to wet season (mean=34.83). Although harvested MBW did not show significant difference in one-way MANOVA, it showed a slightly higher value in dry season (mean=12.21) compared to wet season (mean=11.65). However, shrimp's FCR is higher during wet season (mean=5.44) compared to dry season (mean= 1.91).

The finding show that harvest ton, growth rate and survival rate for *P. Vannamei* were significantly higher during dry season compared to wet season. On the other hand, *P. Vannamei*'s FCR was lower during dry season, which indicated that although these shrimp did not consume high volume of food, they were still managed to show better growth during dry season compared to wet season. Hence, short duration of dry season was more favorable to the growth and production of *P. Vannamei* compared to the wet season.

5. Conclusion

Dry season are more advantageous to the growth and production of shrimp because of factors such less fluctuated of temperature. Survival rate and growth rate of the shrimp were much higher in dry season compared to wet season. Higher harvest ton and harvest mean body weight with lower feed conversion ratio are obtained through shrimp farming during dry season.

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