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Research Article

Growth Performance of Green Mussel *Perna viridis* Transplanted in Buguey Lagoon, Philippines

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Abstract

The green mussel *Perna viridis*, locally known as tahong, is one of the species commercially farmed in estuarine and marine areas in the Philippines due to its least cost in production and its ability to grow fast. This research presents the feasibility of transplanting *P. viridis* in Cagayan Valley especially in Buguey Lagoon using longline method. Transplanted *P. viridis*, from UPV hatchery to Buguey Lagoon (Caroan, Gonzaga), grew by about 42 mm in SL and 21 mm in SW by the span of six months from initial size of 11.25 ± 2.20 mm SL and 6.18 ± 1.06 mm SW. Growth in SL and SW of *P. viridis* was 0.23 mm day^{-1} and 0.12 mm day^{-1}, respectively. Highest SGR was observed on the month of May (0.54 ± 0.05 mm SL, 0.30 ± 0.02 mm SW) and lowest SGR was recorded on Month of June (0.02 ± 0.04 mm SL, 0.01 ± 0.03 mm SW). Minimal fluctuations in other water parameters was observed throughout the culture period. Lowest salinity on month of June was significantly different on other months. Site suitability of the Buguey Lagoon, Cagayan has a reasonable environmental requirement to provide for the *P. viridis* culture. Further studies must be conducted in order to supplement the feasibility of P. viridis culture in Cagayan.

Keywords: Green Mussel; Feasibility; Growth; Buguey Lagoon

Introduction

High market demand for mussel produce can be observed in local and international markets. However, mussel produce in the Philippines is sometimes not safe for human consumption due to pollution and history of Harmful Algal Blooms that causes Parasitic Shellfish Poisoning. This automatically rejects mussel produce for the international market. However, in Northern Luzon, mussel culture is untested on the marine and estuarine environments. No reports of HABs have been reported from Cagayan though oyster culture is practiced and implemented by Bureau of Fisheries and Aquatic Resources Region 2.

Mussel produce in the Philippines is dependent to aquaculture. From the year 2014 to 2016, mussel production has declined by about 1,200 metric tons. In Cavite, decline in mussel production was attributed to pollution of water caused by garbage and river floods. However, in Visayas area, mussel production increased due to the assistance Bureau of Fisheries and Aquatic Resources and support of the Local Government Units. In Capiz area, mussel production increased due to increase in prize and market demand influenced by traders and brokers (Fisheries Situationer, 2016).

The green mussel Perna viridis has a wide range of tolerance to pollution [1] and environmental changes which enables them to grow rapidly in dense colonies on a range of hard substrata such as ships, buoys and pipes in midlittoral and sublittoral regions. This species have established colonies in different parts of the globe from the Indo-Pacific region, extending from Japan to New Guinea and from the Persian Gulf to South Pacific Islands [2]. They grow in layers as observed in the Little Manatee River where the population density ranged from 9,000 - 12,000 individuals per square meter [3]. In Trinidad and Tobago, the population density is described as isolated and patchy along the coast [4].

Green mussel are described with shell tapers to a sharp, downturned beak and has a smooth covered surface (periostracum) with straight or weakly concave ventral margin and finely pitted ridge. The beak has interlocking teeth with wavy posterior end of the paleal line and large kidney-shaped adductor muscle. A vivid green to dark brownish-green periostracum can be observed near the outer edge and olive-green near the attachment point. Shiny and pale bluish green on the interior of the valves [5].

Green mussel are dioecious with no visible external dimorphism. However, sexes of the species can be identified internally through colors of gonads and tissues. A sexually matured male have creamy-white colored gonads and whitish flesh while female have reddish gonads and orangey flesh (Cosling, 2003). The foot of *P. viridis*, tongue-like in shape, has a groove on the ventral surface connected to the byssal pit. Attachment is by forming extremely tough, firm, elastic, byssal threads that secure the mussel to hard substrates [6]. They settle in areas of high water flow and can withstand turbid waters. They suck in water using inhalant siphon and pump out water through exhalant siphon. They are active during night (nocturnal) [7]. Their growth is influenced by fluctuations in temperature, light intensity, food concentration and composition and water [8].

Habitats of green mussel are coastal regions at depths less than 10m (Power., *et al.* 2004). The species colonize areas with fair fluctuations in salinity [9,10] usually occupying intertidal, subtidal and estuarine environments. Salinity difference of the habitat of *P. viridis* can cause distribution variation in population density (Huang., *et al.* 1985).

Main advantage of green mussel culture is that the bivalve is a self-regulate species that requires no commercial feed intake and minimal effort for growth (Ransangan and Soon, 2014). The *P. viridis*, usually grows 80 - 100 mm for one year, is a large and fast-growing bivalve (Power., *et al.* 2004) with lifespan of approximately 2 - 3 years [4]. The species reaches sexual maturity at about 2 - 3 months old (~15 - 30 mm shell length) and spawning occurs year-round with peak on September-October and January-February [3]. Due to its least cost in production and its ability to grow fast, aquaculture development of the species is foreseen.

Mussel can be produced on large-scale basis to support an industry. Products from mussels generally considered "high-value", and unfulfilled demand in the domestics and international markets exists for this species. However, mussel produce in the Philippines are sometimes not safe for human consumption. This is because of the country's traditional culture areas are heavily polluted such as those located in Lingayen Gulf, waters of Bataan, Manila Bay [1], various areas of northern Panay, Villareal Bay in Western Samar, and Panguil Bay in Mindanao, are heavily polluted.

Developing the underutilized areas, such as the Cagayan, for the expansion of green mussel culture will enable production of safe consumable green mussel that may further become an alternate culture site for the shellfish industry. This experiment was to test feasibility of green mussel culture in Buguey Lagoon for production of export quality mussel products.

Materials and Methods

Green mussel spats *P. viridis* came from the University of the Philippines Visayas, Miag-ao hatchery. Wild spawners were conditioned and depurated with UV filtered seawater (33 ppt) to ensure safety of the fertilized eggs. Mussel spats 3 - 5 weeks old were transported (~22 hours travel via airplane and van) from UPV hatchery to Cagayan State University-Aparri Campus Multi Species Hatchery. After arrival, mussel spats were acclimatized with water from the source and were gradually acclimatized to the transplant site environment. After transport, survival of mussel spats was high (80%). However, survival of mussel spats was reduced after acclimation thus limiting experimental set-ups for transplantation.

From the survival of 10% on February batch of mussels, a total of 151 mussel spats with size of 11.25 ± 2.20 mm shell length (SL) and 6.18 ± 1.06 mm shell width (SW) were deployed in Buguey Lagoon (Caroan, Gonzaga, Cagayan; 18 15'55.73" N and 121 53'46. 90"E) after 3 days of conditioning in the CSU-A hatchery. Mussel spats were deployed without treatments but with replicate. One 2-meter line was deployed in Buguey Lagoon for temporary nursery and on-site acclimation of the mussel spats. After 2 weeks of acclimation, mussel spats were rearranged in random order into three 1-meter lines with 50 mussel spats each line forming a long-line to increase surface area of substrate for settling spats. Mussel spats were stitched to 20 mm polyethylene rope using gauze bandage and onion sack (red sack). The area was chosen for the existing oyster culture and sightings of other mussel species (brown mussel). Also, the area is near river mouth where salinity is almost stable during summer.

Growth of green mussel were monitored bimonthly. Water parameters such as dissolved oxygen (mg/L), pH, Salinity (ppt) and temperature (°C) were monitored using DO meter (LUTRON Y22DO), hand held refractometer (ATAGO) and pH meter (SUNTEX TS-1). Green mussel was measured for SL and SW using a plastic Vernier caliper.

Microsoft Excel 2013 was used to encode and transform SL and SW of the mussel and the environmental parameters. One-way ANOVA at 0.05 level of significance was used to measure monthly variations in the Specific Growth Rate in SL and SW of the samples.

Correlation and comparison of the data gathered were analyzed using IBM SPSS v20 at 0.05 level of significance. Correlation between SGR in SL and SW of green mussel were analyzed using Tukey's. The exponential relationship between SL and SW was represented by the power curve equation: $W = qL^b$. The linear equation used was expressed as: $\ln W = \ln q + b^*(\ln L)$, where W = width (mm), L = total length (mm), lnq = intercept, and b = slope. Values were expressed as mean ± SD.

Results

Figure 1 shows growth of mussel spats in terms of length and width from initial size (February) to August. After a month of deployment, 90% survival was recorded, and 50% survival was recorded between the month of June and July. Retrieved mussel spats on August have SL of 53.02 ± 7.40 mm and SW of 27.17 ± 4.06 mm. growth in SL and SW of green mussel was 0.23 mm day^{-1} and 0.12 mm day^{-1}, respectively. A sudden increase in SL and SW of sampled green mussels were observed between the month of April and May. A total of 68 individuals were retrieved after August further reducing survival of deployed mussel spats to 45% in the Lagoon.

Figure 1: Mean of shell length and shell width of green mussel Perna viridis transplanted into Buguey Lagoon (Caroan, Gonzaga) from March to August 2017.

Gathered data of length and width of deployed green mussel were used to obtain length-width correlation. Figure 2A shows regression line derived from the gathered data from March to August. There is a positive correlation between length and width of mussel grown in Buguey Lagoon with correlation coefficient of 0.962 ($r^2 = 0.962$; $P < 0.01$) rendering the equation ln W= (-0.214) + 0.962*(lnL). Power curve of mussel length-width correlation ($W = 0.654L^{0.513}$) is shown in figure 2b ($r^2 = 0.965$; $P < 0.01$).

Figure 2: Correlation of shell length (SL) and shell width (SW) of green mussel Perna viridis transplanted in Buguey Lagoon (Caroan, Gonzaga). Linear correlation equation was $\ln W = (-0.214) + 0.962(\ln L)$ ($r^2 = 0.962$; $P < 0.01$) and power curve equation was $W = 0.654L^{0.513}$ ($r^2 = 0.965$; $P < 0.01$).

Growth of *P. viridis* transplanted in Buguey Lagoon was highest on the month of May (0.54 ± 0.05 mm day-1 SL, 0.30 ± 0.02 mm day^{-1} SW) and lowest growth was observed on the month of June (0.02 ± 0.04 mm day^{-1} SL, 0.01 ± 0.03 mm day^{-1} SW) (Figure 3). Growth in size of the transplanted mussel compensated on the month of July and August. SGR of transplanted green mussel on the month of May is significantly higher than any other months.

Figure 3: Specific growth rate (SGR) in terms of shell length and shell width of transplanted green mussel from the month of March to August. Bars with the same letter were found to have no significant difference using Tukey's multiple range test at ($P < 0.05$).

Figure 4 shows that salinity fluctuates throughout the culture period (22 - 33 ppt). Minimal range of fluctuation can be observed in DO and temperature of the area. Significantly higher salinity was recorded on the month of April (33.00 ± 0.01 ppt) and significantly lower salinity was recorded on the month of May (22.75 ± 0.35 ppt) ($P < 0.05$). Salinity increased from March (29.00 ± 0.95 ppt) to April and a sudden decrease on the month of May with an increasing trend towards July (29.17 ± 1.65 ppt) and a decrease on August (27.17 ± 3.06 ppt). Though minimal fluctuation was observed on other water parameters (pH, DO and temperature), significant differences was observed on temperature and DO ($P < 0.05$) except for pH. A slight curved pattern can be observed to temperature readings peaked on the month of June (31.25 ± 0.92°C) and lowest on April (28.70 ± 0.57°C).

Figure 4: Water quality of transplant site in Buguey Lagoon (Caroan, Gonzaga) from the month of March to August 2017. Points with the same color and letter has no significant difference ($P < 0.05$) based on Tukey's multiple range test.

Discussion

For the duration of six months culture period of green mussel transplanted in Buguey Lagoon 45% survival was recorded from the month of March to August from the initial number of 151 pcs. The transplanted *P. viridis* grew by about 42 mm in SL and 21 mm in SW by the span of six months. Growth of mussel samples in Buguey Lagoon exhibited fastest growth in SL and SW on the month of May which can be attributed to favorable conditions during the period. Heavy rain poured to the Lagoon during the last week of May and on the early of June decreasing salinity of the site. In relation to the water quality of the transplanted site (Figure 4), salinity also decreased on the month of May which may have caused mortality and slow growth on the transplanted green mussel.

Transplanted mussels in this present study conforms to the marketable size (50 - 60 mm) at the least time of growth as reported on other researches. In comparison to the study conducted by Rajagopal., *et al.* [11], young mussels settled in April have a higher initial growth rate as compared to those settling in October-November, which was found to be statistically significant, due to favorable conditions such as higher salinity, temperature and food availability during summer months. However, it was also observed in his study that mussel attained SL of 85 mm for the duration of 1 year or 12 months which may be due to the two seasons of the tropical environment, wet and dry season. He also added that during early May, meat weight decreased by about 20% and a similar drop was observed during September which denotes spawning period of the green mussel. Mamon., *et al.* (2016) attributed the slow growth and development of green mussel in Manila Bay to the water quality specifically by oxygen depletion.

Fluctuations of salinity was observed in the Lagoon which may impose stress and may further cause mortality to the transplanted green mussel. The slow growth of green mussel on the month of June as observed in the present study may indicate spawning of the species and/or compensatory response to the sudden salinity drop during the month of April to May and slow growth compensation towards the month of July. However, many studies on *P. viridis* show it to exhibit a broad temperature tolerance (10 - 42°C), and fast growth rates [3,12-14]. In addition, *P. viridis* can successfully adapt over the long term to salinities between 19 ppt and 44 ppt while *M. charruana* has a slightly wider range (2 - 31 ppt) skewed toward lower salinities [15]. Salinity below 5 ppt is also lethal to *P. viridis* if exposure exceeds two days (Coeroli., *et al.* 1984). Segnini de Bravo., *et al.* (1998) reported that lethal salinity of *P. viridis* was 0 ppt and ≥ 64 ppt and lethal temperature was ≤ 6°C and ≥ 54°C further supported by her lone study in 2003 reporting that *P. viridis* is physiologically tolerant to environmental changes such as salinity and temperature.

A lower DO (2.65 ± 0.43 mg/L), unstable salinity (22.5 - 33 ppt), and a fair temperature (28 - 32°C) and pH (7.5 - 8.41) was observed in the Lagoon compared to the ideal DO (> 8mg/L), salinity (27 - 32 ppt), temperature (26 - 32°C) and pH (7.9 - 8.2) [9,16,17].

Mussels are well suited for commercial culture in sub tidal biotopes. The mussels do not need additional feed, as they filter phytoplankton, and only require a continuous supply of high productive saline water to grow. It also seems to be relatively free from mass mortality due to diseases that often affect other molluscs (Sallih, 2005). The tropical and subtropical marine mussel *P. viridis* has the ability to achieve marketable size within a relatively short culture period of about 6 months [11,18], confers the potential advantage of P. viridis as a perfect candidate for culture purpose [19-21].

Conclusion

The most critical step in venturing into culture is site selection with considerations to some biological background on assessing the site suitability. On the other hand, the economic return of the venture is the prime factor that always become the decision factor in all businesses (Sallih, 2005). Site suitability of the Buguey Lagoon, Cagayan has a reasonable environment to provide for the green mussel culture. In addition, transplanted green mussel grew into marketable size at the traditional culture period of six months.

Based on the growth performance of green mussel in Buguey Lagoon, it can be inferred that green mussel culture is feasible in the area and can provide marketable green mussel within the span of 6 months. However, heavy rainfall causes run-offs to the transplant site which may degrade water quality that may result to slow growth and mortality thus can be limited to the seasonal culture for mussel. However, the survival of green mussel in the Lagoon can prove the tolerance of green mussel to environmental changes especially in salinity change.

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